Understanding the Role of Institutional Incentives in Shaping Data Quality and Information Use in Devolved Health Systems: A Case of Health Information System Implementation in Kenya.

By

Ayub Shisia Manya

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Dedication

What we do for ourselves dies with us. What we do for others and the world remains and is immortal (Albert Pine).

I dedicate this dissertation to my Scandinavian foster father, Rolf Westling. Rolf started supporting my academic pursuits in 1983 when he offered to be my sponsor at Starehe Boys' Centre and school in Nairobi, Kenya. He not only provided educational support but also played the father figure role; providing an extra home for me in Sweden. As a retired teacher, he is very excited that the educational seeds he planted have contributed to the attainment of this level of academic achievement.

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List of Abbreviations

AMREF	African Medical and Research Foundation
AR	Action Research
CDC	Centres for Disease Control and Prevention
CHAI	Clinton Health Access Initiative
CHMT	County Health Management Team
DHIS2	District Health Information System Version 2
DHMT	District Health Management Team
DHRIO	District Health Records and Information Officer
DQA	Data Quality Audit
EMRs	Electronic Medical Records
EPI	Expanded Program of Immunization
FTP	File Transfer Protocol
HIS	Health Information System
HISP	Health Information system Project
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome
HRIO	Health Information Records and Information Officer
ICT	Information and Communications Technology
IDSR	Integrated Disease Surveillance & Response
IS	Information system
IT	Information Technology
KEMRI	Kenya Medical Research Institute
KNBS	Kenya National Bureau of Statistics
LAN	Local Area Network
M & E	Monitoring and Evaluation
MCA	Members of County Assembly
MNCH	Maternal, New born and Child Health
MoH	Ministry of Health
NGO	Non-Governmental Organization
SARAM	Service Readiness Assessment Mapping
TB	Tuberculosis
UiO	University of Oslo
UNICEF	the United Nations Children's Fund
USAID	United States Agency for International Development
WHO	The World Health Organization

Abstract

Devolution, which is becoming common in developing countries, refers to the creation of sub-national governments that are substantially independent of the national level. Devolved entities have a clear legal status, recognized geographical boundaries, elect their leaders and raise their revenue. Potentially, the process of devolution generates or modifies existing institutions. Arguably, the new institutions, the incentives they create, and the behaviour of agents in the face of these incentives affords or constrains the implementation of Health Information Systems (HISs). Identifying these incentives and proposing remedies to improve the HISs is the theoretical motivation of this study. The empirical foundation for this thesis comes from studying the implementation of the District Health Information Software (DHIS2) in Kenya. During its implementation, the country adopted a new constitution, which introduced the devolution of decision making to the lowest levels of the government systems. The study attempts to answer two research questions.

RQ1: What institutional arrangements arise from the interactions between devolved health systems and the health information systems implementation in the context of advanced information technology?

RQ2: How do the institutional arrangements generated by the devolution of health systems create institutional incentives that shape the effectiveness of health information systems in terms of data quality and information use?

Using a longitudinal case study design, I collected data for this thesis from extensive desk reviews, participant observation notes from the implementation of the DHIS2 and key informant interviews. To understand the implications of devolution of health systems to the implementation of HIS, I drew upon concepts from institutional theory, particularly those relating to institutional incentives. Taking an interpretivist epistemological position, I used both qualitative and quantitative analytic approaches to understand the role of institutional incentives in shaping the effectiveness of the health information system in terms of data quality and information use in devolved health systems of developing countries.

The key findings from this study show that the use of advanced Information Technology (IT), specifically central server and cloud computing enhances data access, information sharing across all levels of government and facilitates the integration of fragmented HISs. By enabling data sharing between national and devolved governments, technology becomes a centralizing factor in a decentralized environment. Concerning the role of institutional incentives, I argue that simple and practical incentives improve accuracy, timeliness and completeness of data in information systems. For instance, in the free maternity project in Kenya, the national government reimburses hospitals for deliveries using HIS data. The number of hospital deliveries are therefore important to all stakeholders, explaining the observed high accuracy of data transfer from maternity registers to DHIS2. The quest for re-election of the local leaders is a major institutional incentive driving data demand and use for planning. This thesis contributes to the institutional theory, specifically the concept of institutional incentives by claiming that successful devolution of power and authority from national level to sub-national levels creates institutional arrangements, which generate institutional incentives that facilitate multiple

individuals to utilize their time, skills and knowledge to jointly, create valued HIS outcomes such as high data quality for informed decisions. However, while there are many incentives at play in a devolved health system, it is also important to step back and examine how some of these incentives might impede rather than enhance HIS outcomes. For instance, elected local leaders receive more recognition from the electorate when they implement visible projects like constructing roads, buying ambulances and building new hospitals than by printing reporting tools for HIS.

1 Chapter One: Introduction and Background

In this chapter, I start with the background of the research project, introducing the main concepts in the thesis, which include health systems, devolution, the role of Health Information Systems (HIS) in health systems, data quality, information use for decision-making and the application of advanced technology in HIS. Section 1.1 introduces the components of health systems, while section 1.2 gives an overview of devolution within health systems. In section 1.3, I discuss the roles of HIS in Health systems and in section 1.4; I discuss the roles of HIS in Devolution. In section 1.5, I provide the empirical setting and 1.6 explains the motivation of the study. Section 1.7 gives the theoretical overview, giving the theoretical motivation of the study and the theoretical framework that guides the study respectively. In Section 1.8, I give the objectives and research questions for the study. The foundation of this thesis comes from the findings from peer-reviewed papers, which I presented in conferences or published in journals. I have listed the papers in this thesis in section 1.9. Section 1.10 highlights significant contributions arising from these publications and the entire study.

1.1 Health Systems

Health systems are complex socio-technical networks comprising organizations, institutions, people and actions, which culminate in the delivery of health services to the population (Berg, 2001; WHO, 2000). The World Health Organization (WHO) defines health systems as systems whose primary purpose is to promote, restore, and maintain health (WHO, 2000). They are not only operationally and technically complex, but also highly institutionalized in countries in terms of regulatory authorities and professional roles. According to the WHO, health systems have six building blocks: Health Information Systems (HIS), Service Delivery, Health Workforce, Medical Products (Vaccines and Technologies), Financing and Leadership/Governance (WHO, 2007). Each of these building blocks contributes to health systems strengthening in diverse ways. For instance, health workforce is the backbone of a strong and resilient health system in achieving universal health coverage (WHO, 2016). Some crosscutting components, such as leadership /governance provide the overall policy and regulation for the other building blocks. Sound and reliable information is the foundation of decision-making across all health system building blocks, and is essential for health research, human resources development, health education, service delivery, financing, policy development and implementation, governance and regulation (Mucee, Kaburi, & Kinyamu, 2016; WHO, 2007, 2009). Since these building blocks are interlinked, major structural changes in governance such as the devolution of service delivery functions from the national government to sub-national units has an impact on all of them.

Compared to other social systems, health systems faces particular challenges, including their complexity, high costs for health care, the threat to people's health and socioeconomic well-being. Figure 1 shows the six building blocks for health systems.

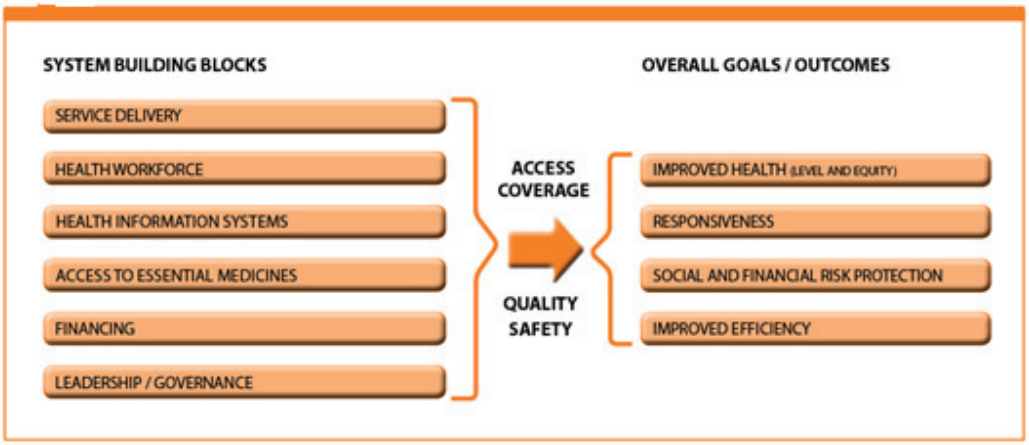

Figure 1: The Six Building Blocks for Health Systems. Source: (WHO, 2007)

1.2 Devolution within Health Systems

There is a worldwide trend towards devolution of health systems for varied political and institutional reasons. To understand the concept of devolution, one has to understand another commonly used term, decentralization, which involves shifting power and authority over the management of public resources from national to sub-national levels of government (Litvack, Seddon, & Ahmad, 1999; Rondinelli, Nellis, & Cheema, 1983). Dissertations on decentralization suggest that it is associated with increased citizens' participation in decision-making processes (Brosio, 2000; Ndegwa, 2002). Five main types of decentralization have been identified: devolution, delegation, de-concentration, market decentralization (privatization) and fiscal decentralization (Rondinelli et al., 1983). These reflect different degrees of decentralization and approaches. Today, many developing countries including Kenya are pursuing decentralization policies (Massoi & Norman, 2009).

Devolution, which is the main concept used in this thesis, refers to the creation of sub-national levels of government that are substantially independent of the national level with respect to a defined set of functions. Devolved entities normally have a clear legal status, recognized geographical boundaries, designated functions to perform and statutory authority to raise revenue and make expenditures (Madon, Krishna, & Michael, 2010). The process of devolution has far-reaching effects on political, administrative and financial aspects of the affected organizations, with direct implications on finance and human resources aspects of health systems (Collins & Green, 1994; Jeppsson, 2001; Tsofa, Molyneux, Gilson, & Goodman, 2017). There is limited literature on the socio-organizational effects of devolution on health information systems (HIS), which is the focus of this thesis. The study draws upon concepts from institutional theory, especially relating to institutional incentives to understand the interactions involved in the devolution of health systems and its implications on HIS, with a focus on data quality and data use for informed decisions.

1.3 Health Information System Role in Health Systems

Health systems require accurate and timely information at all management levels, from the periphery to the centre. In essence, the role of HIS is to provide high quality and timely data that are critical for strengthening health systems through facilitating policy formulation and

resource allocation (Carla AbouZahr & Boerma, 2005; Worku, 2012). Information is not only required by policymakers and managers for decision-making but also by care providers, including doctors, health technicians, and community health workers. Doctors need complete medical information of their patients to make a diagnosis and provide appropriate treatment. At the same time, public health managers require data about the population to plan for the health care needs of the population they serve (Wolf et al., 2004). To be able to play its role in health systems adequately, HIS performs the following four key functions: data generation, compilation, analysis and synthesis, communication and use (WHO, 2009). Regarding data generation, health providers, managers, and planners regularly collect information about many aspects of health care delivery, management and financing through the routine HIS. More data come from surveys, research and census. An effective HIS brings together information system professionals (data people), health systems managers (action people), development partners and technology to ensure that users of health information have access to reliable, timely and comparative data (Aqil, Lippeveld, & Hozumi, 2009). Designated personnel process and disseminate these data using appropriate paper reporting tools and technology. In developing countries, due to shortage of staff, professionals whose job description is different from record keeping, often help in data gathering at service delivery points.

One of the practical ways of understanding the role played by HIS in health systems is to evaluate data quality. Studies have shown that data quality is a multi-dimensional concept (Wang & Strong, 1996), contributing to its multiplicity of definitions. The most common and easily measurable way of understanding data quality is to use various attributes and conditions: accuracy, relevance, timelines, completeness, accessibility and coherence (Herzog, Scheuren, & Winkler, 2007). Other scholars posit that data are of high quality if they are fit for use in their intended operational, decision-making and other roles (Juran & Godfrey, 1999), suggesting that data quality is a function of the characteristics of intended use. This is in keeping with findings by Braa and others in 2012, who showed that data quality is intrinsically associated with information use for public health decisions. They argue that data of questionable quality may not be used, and because they are not used, they remain of poor quality (Braa, Heywood, & Sahay, 2012). Many publications on data quality in developing countries focus on higher administrative levels of HIS, putting less emphasis on the lower levels where data generation occurs. Arguably, the point of data generation has huge consequences on data quality of the whole system. If quality of data fails from the start, it is very difficult and costly to restore it later on, consequently diminishing the role of HIS in health systems.

Technology is a key component of HIS. Rapid technological advances in Information Communication Technologies (ICTs), including the explosive growth of the Internet are constantly changing and shaping HIS. This has led to the emergence of health information infrastructures in many organizations, especially in fields that deal with immense amounts of data (Tilson, Lyytinen, & Sørensen, 2010; Yoo, 2010). Many developing countries like Kenya are investing in ICTs and personnel (Kihuba et al., 2014; H. Kimaro & Nhampossa, 2007), and adopting cloud computing infrastructures, mobile phone applications and electronic reporting systems. The question has become not whether, but how ICTs can be beneficial. Advanced ICTs have the potential to enable HIS to process large volumes of data, facilitating access to

valuable information from all levels, including rural villages, playing a crucial role in health systems strengthening.

1.4 Health Information System Roles in Devolution

The HIS roles in health systems are influenced by many factors including the design of the government structure, whether centralized or devolved. With an increasing number of countries adopting devolved health systems, it is important to understand the role HIS plays in these new administrative dispensations. Successful devolution of power and authority from national level to sub-national levels generates new administrative units, which require data from HIS for planning, allocation of resources and evaluation of implementation of planned activities. My argument is that the new administrative units may generate institutional arrangements (North, 1990) that may facilitate multiple individuals to utilize their time, skills and knowledge to jointly, create valued HIS outcomes such as high data quality for informed decision. An understanding of these institutional arrangements are crucial for the improvement of HIS in the devolved governments.

An important component of HIS is the adoption of ICT. Unfortunately, the application of ICTs has not always been successful to date, and indeed, there are many examples of failures or partial failures (Heeks, 2002; Walsham & Sahay, 2006). A further challenge with respect to ICTs is to address issues of the "digital divide" between those people with access to the technologies and the ability to use them effectively, and those without (Steyn, 2010). My argument is that the adoption of these technologies in a devolved health system will play a critical role in the implementation of an effectiveness of HIS. Advanced technology such as cloud computing can have both centralizing and decentralizing possibilities in supporting devolved systems. An improved HIS will inevitably justify the considerable opportunity costs involved in its set up and maintenance.

1.5 Motivation for the Study

My practical motivation for the study is to promote the practice of using information from HISs for evidence-based decision making in health systems. As a medical doctor, I have witnessed many public health decisions taken without reference to available data. Globally, data requirements from governments and their development partners have grown exponentially to a point where some health workers have big registers and many forms to fill daily. They collect an overwhelming amount of data related to the services they deliver and management activities. On a regular basis, the data are summarised and sent to the next level of administration, sometimes with threats of dire consequences for those who do not comply within the stipulated deadlines. Despite all these efforts, data from majority of the HISs contribute little to the decision-making processes due to poor data quality (H. Kimaro & Nhampossa, 2007).

To illustrate this point, I wish to use a personal case that I witnessed some years ago. As a District Medical Officer of Health (DMOH) in one of the districts in Kenya, part of my job description included reviewing and forwarding summarised district reports to the next level (Province) before the 10th of every month. In short, data were destined for the national government and the greatest achievement of the districts and provinces was achieving high

reporting rates (irrespective of the data in the report). In one month, I did not notice that my district had reported 22 cases of yellow fever (a rare notifiable disease). One morning, I received a call from the Director of Medical Services (DMS) informing me that the reports from my district had indicated an outbreak of yellow fever disease. Scientists from the Centres for Disease Control (CDC) had seen these reports and offered to assist the Government with the outbreak investigations. The Director instructed me to meet the scientists and accompany them to the affected health facilities. On reaching the health facilities, we discovered that there were no laboratory or clinically confirmed cases of yellow fever but in the said month, some patients had complained of having yellow colouration of their eyes; most probably misreported as yellow fever. I was embarrassed that I did not peruse through the reports before sending to the next level, clearly suggesting lack of scrutiny of reports before transmission. This case outlines two important points: questionable data quality and lack of use of information at the point of collection.

Development partners support HISs in many developing countries. Spending a lot of donor money and people's time in collecting data that remain on shelves or fill the databases is not good. Considering that centralized institutional arrangements do not seem to encourage local information use, the recent implementation of devolution of the health system in Kenya (Kenyalaw.org, 2010) provides an opportunity to study its effects on HIS, forming a strong practical motivation for the study. Another practical motivation stems from the use of advanced technology. In this study, we note that the HIS adopted advanced technology in terms of utilizing cloud-computing infrastructure. Granted that the adoption of modern Information Technology (IT) has been shown to improve access to information systems (H. Kimaro & Nhampossa, 2007), it would be important to understand the role of technology in the whole process of devolution and implementation of an effective HIS.

1.6 Overview of Empirical Settings and Approach

The empirical foundation for this thesis comes from studying the implementation of a web based HIS, based on the District Health Information Software (DHIS2) platform in Kenya. I have been involved in this project as the leader of the implementation team since its inception in 2010. The project received financial support from the Government, bilateral implementing partners, and technical support from the University of Oslo (UiO). The DHIS2 was rapidly pilot tested and rolled out to the entire country within one year (2011), making Kenya the first country in Africa to adopt a large-scale web-based HIS using a central server and cloud computing infrastructure (Braa & Sahay, 2012). This implementation was a breakthrough for the HIS, since users in and out of Kenya could access data online through mobile telephone modems and Local Area Networks (LAN). During the implementation of the project, the country adopted a new constitution (Kenyalaw.org, 2010), which introduced many drastic changes, including the devolution of government functions to lower levels, abolition of the eight administrative provinces and the creation of 47 counties (Kramon & Posner, 2011; Nyanjom, 2011). This study attempts to understand the socio-organizational perspectives of the implementation of HIS in a devolved health system.

In this research, I adopted a longitudinal case study design. Data came from three sets of processes: (a) In-depth analysis of the DHIS2 database (b) key informant interviews and health facility visits, including Data Quality Audits (DQA) and (c) Participant notes from the implementation of the DHIS2. The study takes an institutional theory perspective, which is good for understanding various interactions in institutions. Several scholars describe institutions as all the formal and informal rules that groups of individuals build and or use to facilitate their joint activities in organizations (Cole & McGinnis, 2014; Collins & Green, 1994). Formal rules include written laws, rules and regulations while informal ones include traditions (North, 1990). In the study, I relied heavily on the concept of institutional incentives, which Ostrom (1993) describes as the positive and negative changes in outcomes that individuals perceive as likely to result from actions taken within a set of rules in a particular physical and social context (Ostrom, Schroeder, & Wynne, 1993). I took an interpretivist epistemological position, since it was the best approach for gaining an in-depth understanding of the routines and work ethics surrounding the devolution of health systems and their effects on the implementation of a web based HIS in Kenya. Even though qualitative analysis was the main method, I used quantitative analysis to address data quality calculations such as accuracy, reporting rates and completeness.

1.7 Theoretical Overview

Given that HIS is a key component of the health system, one needs to consider the entire health system and the government structure to understand the effects of devolution. Furthermore, HIS is part of a wider government and social system, which places limitations and creates opportunities, shaping social behaviour. Since the devolution of health systems has the potential to modify the social behaviour of agents, I turn my attention towards theories of social behaviour, or more specifically institutional theory in organizational sociology, to help me better understand and explain the effects of devolution on the effectiveness of HISs in terms of data quality and information use for informed decisions.

Institutional Theory

Institutional theory has emerged as a dominant theory of organizations (Greenwood, Oliver, Suddaby, & Sahlin-Andersson, 2008). The basic building block of institutional theory is the concept of institutions, which refers to the humanly devised constraints that structure political, economic and social interactions (Jepperson, 1991; North, 1990). They consist of both formal rules (constitutions, laws, property rights) and informal constraints (sanctions, taboos, customs, traditions, and codes of conduct). The basic logic of institutions is to create predictability and stability for individual behaviour and within the structures themselves (Kaldis, 2013). DiMaggio et al (1983) posit that institutions influence the behaviour of individuals in an organization while at the same time individuals shape institutions (DiMaggio & Powell, 1983). Due to this, members of an organization tend to act like one another, thereby appearing homogenised.

The concept that best captures this process of homogenization of organizations is institutional isomorphism, which manifests in three forms: coercive, normative, and mimetic. Coercive isomorphism represents both formal and informal pressures e.g. regulations and culture

(DiMaggio & Powell, 1983). Professional associations that define professional rules for the organizations create normative isomorphism. In most situations, the professionals go to similar learning institutions and so produce similar normative pressures to all organisations where they are deployed (Greenwood, Suddaby, & Hinings, 2002). Mimetic isomorphism results from innovations. Organizations are influenced by their competitors in the field and tend to imitate them, expecting similar success (DiMaggio & Powell, 1983). This explains why organizations adopt similar practices or structures to gain legitimacy and support (ibid). Some authors have observed that institutions are firmly rooted in taken-for-granted rules, norms, and routines and those institutions are so powerful that organizations and individuals automatically conform to them (Friedland, 2013).

Even though organizations position themselves towards achieving their technical objectives, they are also subject to broader social pressures from their organizational fields like constitutional changes (Meyer & Rowan, 1977; Oliver, 1991). These pressures are responsible for changes in organizations. Such changes are normally driven by field changes, which are described by Scott (2001) as "a community of organizations that partakes of a common meaning system and whose participants interact more frequently and fatefully with one another than with actors outside the field" (W. R. Scott, 2001) p. 84. Organizational fields occupy a middle level between organizations and the society and are instrumental in the processes by which activities and practices are reproduced and disseminated (W. R. Scott, 1995). Examples of independent organizations that form organizational fields include; consumers, professionals, producers and any groups that may impose coercive, normative or mimetic influences on the organizations (DiMaggio & Powell, 1991; W. R. Scott, 1991). Confronted with these pressures, changes in outputs can occur. Considering that devolution is part of the pressures initiated by constitutional changes, formation of new organizational units are likely to occur through the organization field changes.

Institutional Incentives

The practical objective of the study is to understand how devolution of the health system affects the implementation of HIS. Identifying these effects and proposing remedies to improve the HIS is a daunting task. One cannot point to poor design of HISs, lack of resources, inadequate training, lack of coordination, or overly centralized /decentralized institutions as the single source of the challenges, even though all these factors are involved in one way or another. This calls for a different way of thinking, hence the adoption of institutional incentives theoretical approach.

The theoretical foundation is therefore to uncover the interactions between a devolved health system and the implementation of HIS, and show how these interactions shape the effectiveness of HIS. To determine the effectiveness of HIS, I use data quality and information use as proxies. This is because the success of HIS is directly associated with the quality of data; errors in data in HIS have been associated with low information use (Braa et al., 2012). Investigators working with health records, almost wherever such records exist, experience data quality challenges (Braa et al., 2012; Hogan & Wagner, 1997). The fact that some data quality challenges are persistent, and reproduced from one system to another suggests that reporting procedures are

linked to other routine and valued practices of the health system. This suggests an interaction between the records and the social system that benefits from these records, meaning that there are socio-organisational factors at play. This leads to the concept of institutional incentives.

I draw from Ostrom's studies (1993) which reveal that many actors are influenced by institutional incentives for performing their activities (Ostrom et al., 1993). Incentives may come from many sources and are more than just financial rewards and penalties. They can be positive or negative changes, which the individual associates with an action. Ostrom (1993) argues that for any action taken by an individual or groups of actors, it is assumed that the actors confront a set of incentives or disincentives that reward them (or not) for actions that produce the observed results (Ostrom et al., 1993). Disincentives may take the form of explicit penalties for deviating, such as fines or imprisonment, or even the seizure of the agents' endowments and the forceful reallocation of assets. It may also take the form of staff transfers.

Therefore, understanding institutional arrangements, which provide institutional incentives, can help enhance performance in organizations. The assumption is that people who invest resources (including their own time and labour) in activities of the organization, must perceive that the benefits they obtain (including the benefits they share with others) exceed the costs of the resources they devote to this effort. In other words, we assume that there are reasons why individuals involved in the development, maintenance, and use of HISs do what they do. When incentives favour the situation, individuals make decision that produce outcomes that are both personally and socially rewarding (Ostrom et al., 1993). In such cases, the advantage that one individual derives also produces benefits for others. However, while incentives support the enhancement of the system, it is also important to step back and examine how these incentives might impede rather than enhance HIS outcomes. Incentives created by extant institutional structures can lead even well intentioned individuals to produce results that are unintended and even counterproductive (Vitale, 2010). Identifying these incentives and proposing remedies to improve the HISs is the theoretical motivation for this study.

Theoretical Perspective

Devolving power and authority from national level to lower units generates or modifies institutions. The changes in the institutions occur because of advanced technology, the institutional mechanisms of change (organizational fields) and the reaction of agents towards the changes. To enhance my understanding of these changes, and how they affect HIS outcomes in terms of data quality and data use, I came up with a theoretical perspective. My theoretical conceptualisation assumes that HIS outcomes are a function of the institutions put in place, the incentives they create, and the behaviour of agents in the face of those incentives. Taking a case of devolution of health systems, there are many changes involving human resources, infrastructure and processes involved. My argument is that the interactions between devolved health systems and HIS implementation processes including its devolution will provide institutional arrangements that generate institutional incentives, which affect the HIS outcomes. The theoretical objective of this study is therefore to uncover or identify the institutional arrangements and the associated institutional incentives or disincentives that shape the HIS outcomes. Instead of attempting to develop a comprehensive list of incentives/disincentives, my focus is to understand how these affect data quality and promote information use, reflecting

the effectiveness of HIS. Figure 2 shows the theoretical perspective, suggesting how the interactions between devolved health systems and HIS implementation shape the HIS outcomes in terms of data quality and data use.

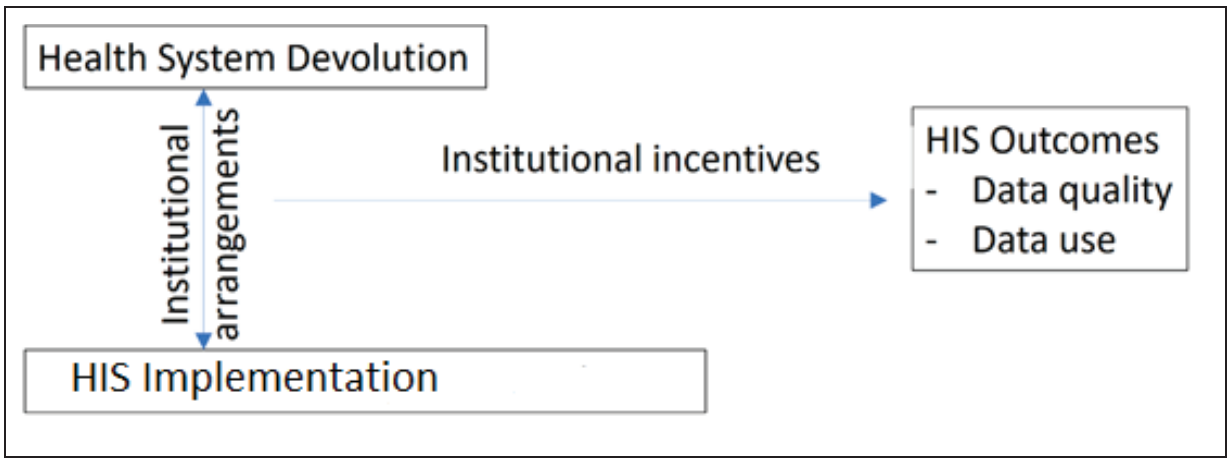

Figure 2: The Theoretical Perspective

1.8 Research Questions and Objectives

Broadly, this thesis seeks to provide an understanding of the effects of devolution of health systems on the implementation of HIS in the context of developing countries. The main objective of the study is to understand how the institutional arrangements created by the interactions between the devolved health systems and HIS implementation generate institutional incentives, which shape the HIS outcomes in terms of data quality and information use for decision making. The results can inform stakeholders on how to improve data acquisition, storage, sharing and use for evidence based decision making, ultimately improving health systems. The specific objectives for the study are to understand:

a. The institutional arrangements created by the devolution of health systems
b. The institutional incentives and disincentives generated by these institutional arrangements
c. The role of the institutional incentives in shaping the HIS outcomes in terms of data quality and data use
d. The role of advanced technology in the implementation if HIS in a devolved institutional arrangement

The research aims to answer two questions:

RQ1: What institutional arrangements arise from the interactions between devolved health systems and health information systems implementation in the context of advanced information technology?

RQ2: How do the institutional arrangements generated by the devolution of health systems create institutional incentives that shape the effectiveness of health information systems in terms of data quality and information use?

1.9 Published Papers Included in this Thesis

The results of this study come from five papers presented in peer-reviewed conferences and published in journals. In all these papers, I was the first author. The following is the list of the papers that form the basis of this thesis.

I. Manya, A., Braa, J., Øverland, L. H., Titlestad, O. H., Mumo, J., & Nzioka, C. (2012). "National roll out of District Health Information Software (DHIS 2) in Kenya, 2011–Central server and Cloud based infrastructure". Paper presented at the IST-Africa 2012 Conference Proceedings, Dar es Salaam, Tanzania. .

II. Manya, A., & Nielsen, P. (2015), "The Use of Social Learning Systems in Implementing a Web-Based Routine Health Information System in Kenya". Paper presented at the Proceedings of the 13th International Conference on Social Implications of Computers in Developing Countries, Jetwing Blue, Sri Lanka.

III. Manya, Ayub; Nielsen, Petter; and Pundo, Raphael (2016), "Cloud Computing as a Catalyst for Integrated Health Information Systems in Developing Countries". Selected Papers of the IRIS, Issue Nr 7 (2016). 3. http://aisel.aisnet.org/iris2016/3

IV. Manya, A., & Nielsen, P. (2016). "Reporting Practices and Data Quality in Health Information Systems in Developing Countries: An Exploratory Case Study in Kenya". Journal of Health Informatics in Developing Countries, 10(1).

V. Manya Ayub, Sundeep Sahay, Braa Jørn, Shisia Belina. (2018). "Understanding the Effects of Decentralization on Health Information Systems in Developing Countries: A case of Devolution in Kenya". Paper presented at the in IST-Africa 2018 Conference Gaborone, Botswana, Proceedings.

1.10 Research Contributions

This research falls within the domain of Information Systems (IS) and contributes to the implementation of HISs in developing countries. The contributions are both to theory and practice.

Contribution to Theory

This thesis contributes to institution theory, specifically to the concept of institutional incentives. The findings show that while most HISs in developing countries are plagued with poor data quality, simple and practical institutional incentives can improve data quality and information use. My claim is that successful devolution of power and authority from national level to sub-national levels creates institutional arrangements, which generate institutional incentives that facilitate multiple individuals to utilize their skills and knowledge to shape the HIS outcomes in terms of data quality and information use.

Contribution to Practice

a. The study shows that advanced technology, specifically the use of central servers and cloud computing infrastructure makes information available to both the national and county

governments. By having the web based health information software hosted on a commercial cloud, the counties were happy with the arrangements since they did not have to pay for the hosting costs. The national level could easily get data from the system without the bureaucratic ways of asking data from the counties. In essence, the use of advanced technology became a centralizing factor in a devolved health system. This thesis argues that neither a centralized system nor a devolved system are the answer to the successful implementation of HIS, rather a polycentric approach or a hybrid system of governance, utilizing both centralized and devolved approaches is appropriate.

b. Devolution reduces the national level control on sub-national units weakening the overall governance of the health systems, which negatively affects the implementation of HIS

c. Devolving functions to the lowest feasible level of decision making increases local demand for information, optimizes information flow and ultimately enhances data quality and information use.

d. Devolution necessitates massive staff movements both from national level to sub national and sub national to another. To function well in their new postings, they require training, opportunities of career progression and regular salaries. The thesis argues that if not well managed, the redistribution of human resources during the devolution process can negatively affect the implementation of HIS.

1.11 Outline of Thesis

Chapter 1 of this thesis has given the background of the project, including the motivation, empirical settings, research objectives and research questions. Chapter 1 has covered the theoretical overview with emphasis on institutional theory and institutional incentives. Chapter 2 covers relevant literature of the main concepts covered in the thesis. The chapter starts by giving the status and challenges of HIS in developing countries. In this regard, I reviewed literature on data demand and information use for decision-making, data quality and fragmentation of information systems. As devolution is a key concept used in this thesis, I reviewed literature on the general decentralization of health systems in developing countries and the effects on HIS. In so doing, I paid attention to the role of advanced technology. The chapter ends with review on institutional incentives. Chapter 3 provides the empirical settings, the Kenyan country context. This chapter describes the country's profile with emphasis on the political, economic and health system contexts. It also shows the new government structures after devolution. The chapter gives details of the implementation of the DHIS2 as basis of the case studies. Chapter 4 provides the methodology of the study. It shows the study design, data collection and analysis. The chapter also responds to ethical issues. Chapter 5 provides the results of the project. Besides providing a list of published papers, the chapter further gives a summary of each paper and its relationship to the theoretical perspective. In chapter 6, I make discussions concerning the entire study with the emphasis on the results and their implications. I also provide the responses to the research questions, and give a list of limitations of the study. The chapter ends with suggested further research. At the end of the thesis, I have all the published papers and the annex.

2 Chapter Two: Related Literature

This chapter evaluates literature relating to devolution of power and authority from national levels to sub-national levels and understanding how this affects the implementation of HIS. The chapter focuses on HIS in developing countries giving the status and challenges. In section 2.2 of the chapter, I discuss literature on data demand and information use. Sections 2.3 and 2.4 have literature on some of the common challenges of HIS, which include data quality and fragmentation or proliferation of parallel information systems. Section 2.5 has literature on the role of technology in HIS. Sections 2.6 and 2.7 discuss the devolution of health systems and its effects on HIS. At the end of this chapter, I discuss the role of institutional incentives.

2.1 Status of Health Information Systems in Developing Countries

The WHO describes HISs as comprehensive and integrated structures that collect, process, store and disseminate health and health-related data and information for use by all stakeholders (Carla AbouZahr & Boerma, 2005; C AbouZahr & Commar, 2008). Routine HISs, such as those operated through health information departments or national statistics offices, provide information on risk factors associated with disease, mortality and morbidity, health service coverage, and health system resources (Lewin et al., 2010) with the aim of influencing policymaking, programme action and research, which are essential for the effective functioning of health systems. Health information systems bring together data from different sources; routine and non- routine data (WHO, 2009). The routine collection methods gather data regarding special health programmes, routine services, epidemiological events as well as semi-permanent data about the administration and the population served (Heywood & Rohde, 2001). These data help us to answer specific questions and frequently provide us with information that can help us to improve our programs. Non-routine data come from vital statistics, the census, surveys, surveillance, management statistics and research. Non-routine data enable decision makers to use information generated by other systems to identify factors, outside the health system, affecting the health of the population.

Collection of routine data starts when health care providers record data of their patients/clients while performing their daily health care activities. In most developing countries, health care workers record routine data on paper but recently electronic formats are increasing. Designated officers working at each level of the health care system then aggregate these data for transmission to the next level. Officers working at each level of healthcare have the responsibility to analyze the data, ensure their overall quality, relevance and timeliness, and convert the data into information for health-related decision-making. This is how the community / facility-level data eventually make their way to the national level to form the basis of national policy. However many scholars have observed that analysis and presentation of data for use by decision makers in developing countries is not commonly done. According to Lippeveld et al, (2000), large part of the data collected passes to the national level without being analysed and used, and frequently ends up on the dusty shelves of an office in the MoH or recently, in databases (Lippeveld, Sauerborn, & Bodart, 2000). Furthermore, since health services supervisors and peripheral health workers rarely receive feedback on the data reported

to the higher levels (Lippeveld et al., 2000), they have little institutional incentives to ensure the quality of the collected data and to comply with reporting requirements.

Recent years have witnessed major developments in HIS in developing countries, including the application of ICTs. Many countries have started shifting from paper-based to computer-based processing and storage of data as well as the increase of data. There is a steady increase of new technologies including ubiquitous computing environments and mobile-based technologies for health monitoring. A number of universities are now using databases for clinical and epidemiological research. Despite all these developments, HIS faces major challenges including lack of data use, poor data quality and fragmented systems. Most experts agree that routine HISs in most developing countries, are woefully inadequate to provide the necessary information support to individual care and public health activities (Lippeveld, 2001). In fact, poor use of information for evidence-based decision-making is probably one of the main causes of the poor health systems (WHO, 2007).

2.2 Data Demand and Information Use

The concept of information use has multiple meanings, but most people describe it as the use of information in policy making, program planning and management, or service provision, even if the final decision or actions are not based on that information (Foreit, Moreland, & LaFond, 2006). Since raw data are seldom useful for decision-making and usually require transformation into information, evidence of data analysis can signify data use. In order for stakeholders and decision makers to place value on information, they should have some incentives or motivation to use it. An increase in information use creates a demand for more data, which then promotes data collection to avail the required data. Data demand occurs when decision makers specify what kind of information they want to inform a decision and proactively seek out that information. Evidence of data demand could include managerial or policy directives to collect specific data, new or increased resource allocation for data collection and analysis (e.g., budget line items, establishing or strengthening statistical units inside ministries or programs), and requests for special analyses (Foreit et al., 2006). Figure 3 shows a diagram depicting data demand and use, adopted from MEASURE evaluation.

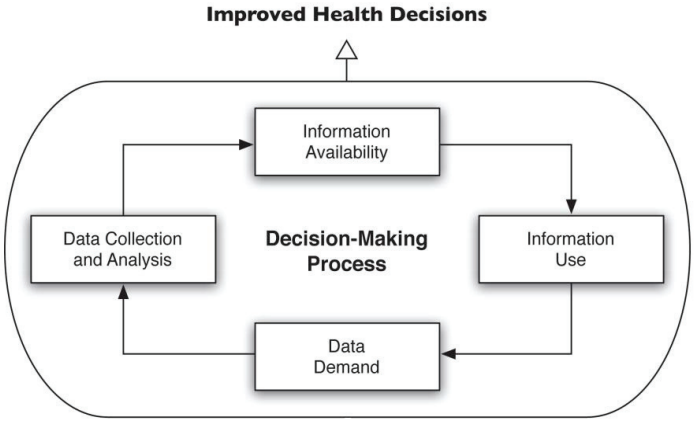

Figure 3: Data Demand and Use Conceptual Framework

Source: MEASURE Evaluation www.cpc.unc.edu/measure (Foreit et al., 2006)

Developing countries are witnessing substantial investments in HIS but the recurrent complaint is that the managers do not regularly use the data to inform decisions (Belay, Mbuya, & Rajan, 2009; Damtew, Kaasbøll, & Williamson, 2009). There are many reasons for this observation. In some countries, managers tend to work based on their tacit knowledge of their population and other related information such as knowing the different villages, communities, households or even patients in small clinics (Damtew et al., 2009). Other scholars have found that decision-making in health is sometimes based on political opportunism, expediency or donor demands and at times on infrequently repeated national studies like the demographic health surveys (DHS) which are insensitive to changes occurring over shorter time scale (Gething et al., 2007). Scott (2005) also points out that factors other than data can influence decisions, especially in the public domain. These include power and influence of sectional interests, corruption, political ideology, arbitrariness, and anecdote (Scott, 2005). This is a huge lost opportunity, since data are critical to the program improvement and decision-making process. As expressed by the Nigerian Director of Policy, National Action Committee on AIDS, *"... without information, things are done arbitrarily and one becomes unsure of whether a policy or program will fail or succeed. If we allow our policies to be guided by empirical facts and data, there will be a noticeable change in the impact of what we do"* (Ikamari, 2005). This statement perfectly summarizes the importance of information. There is need for improving the value and use of health information by developing policies and offering incentives to enhance the dissemination and use of such data at local, regional and global levels. In this context, the right data, when available for use, are considered necessary for the promotion of better health, all other conditions remaining equal (Mucee et al., 2016).

Several authors have shed light on the complexities and the contexts associated with programmatic decision-making (Tara Nutley, 2006). Mindful that there are different types of decisions at the levels of individual, health facility, district, regional and national sub-systems, information must be available in formats that meet the needs of these multiple stakeholders (policy-makers, planners, managers, health care providers, communities and individuals). Most systems have faced technical capacities and other challenges in availing the requisite information (Mucee et al., 2016). Apart from the technical capacity, there are some social mechanisms involved in decision-making, for instance the people making decisions have desires, and aspirations known and unknown to those charged with the responsibility of analysing and presenting the information. Without clear understanding, misinterpretation of data may lead to reduced use.

2.3 Data Quality in Health Information Systems

Data quality has continued to be an important aspect of HIS. Discovering whether data are of acceptable quality is a measurement task, and not a very easy one. This is because scholars define data quality in different ways (Elvers & Lindén, 1997; Juran & Godfrey, 1999; Orr, 1998; Pipino, Lee, & Wang, 2002; Strong, Lee, & Wang, 1997). The common definition of data quality takes a multidimensional approach described using various attributes and conditions. Literature lists many attributes, but the following are the seven commonly cited: relevance, accuracy, timeliness, accessibility, comparability, consistency and completeness (Herzog et al., 2007; Strong et al., 1997). Different authors and organisations have cited accuracy, timeliness,

completeness and consistency, reflecting their elevated status in assessing data quality. While many authors support the continued use of accuracy as a single measure of data quality, Tayi and Ballou (1998) highlight the limitations of 'accuracy', as data may be accurate but unfit for use if untimely (Tayi & Ballou, 1998). Interestingly, only a limited number of authors mention the component of relevance when discussing data quality (Strong et al., 1997). For this thesis, I focus mainly on accuracy, timeliness, and completeness. Table 1 shows some of the commonly cited data quality attributes.

Table 1: Data Quality Attributes

Accessibility	The extent to which data are available , or easily and quickly retrievable (Strong et al., 1997)
Accuracy	The degree to which data correctly reflects the real world object or an event in question (Batini, Cappiello, Francalanci, & Maurino, 2009; Elvers & Lindén, 1997; Lewin et al., 2010; Strong et al., 1997)
Comparability	Are data fields (e.g., unique patient identifier) present within the databases that allow us to easily link individuals across the databases? How accurate are these identifying fields (Elvers & Lindén, 1997)
Completeness	No records are missing and that no records have missing data elements. The extent to which the data are sufficiently up to date for the task at hand (Batini et al., 2009; Strong et al., 1997)
Consistent	Data have a uniform format for recording the relevant information (Batini et al., 2009; HMN, 2008; Strong et al., 1997)
Relevance	Do the data meet the basic needs for which they were collected, placed in a database, and used? The extent to which they are applicable and helpful for the task at hand (Strong et al., 1997)
Timeliness	Reflecting the extent to which the age of the data is appropriate for the task or the extent to which the data is sufficiently up to date for the task at hand (Batini et al., 2009; Elvers & Lindén, 1997; HMN, 2008; Strong et al., 1997)

Source: adopted from (Strong et al., 1997)

Data quality problems, however, go beyond the dimensions mentioned above; reflecting a form of information culture. In some information cultures, health managers choose to use other criteria to make decisions instead of relying on data from the HIS. A study conducted by Damtwe and others (2009) showed that some managers make decisions based on their embedded knowledge learnt through their interactions with the community (tacit knowledge) instead of relying on data from HIS (Damtew et al., 2009). While the need to satisfy the community is a good institutional incentive for making decisions, this leaves the data in information systems unused. Taking the concept of unused data a step further, some data managers insist on collecting large numbers of unused data elements on the premise that one day someone might want to use them. This may appear cheaper at the time of collection but it creates other problems. Even with adequate supervision, it becomes very hard to maintain the motivation of the personnel to collect the information in a regular fashion for future unknown purposes. If an organization is not using data, then over time, errors in capturing the data will occur because there are no mechanisms for comparing the data in the system and the actual value. In biological systems, scientists refer to this as atrophy. If one part of the body is not used, it atrophies. Something similar to atrophy happens when data are not used (Orr, 1998).

This reinforces the argument of Braa et al (2012) who claim that reduced data use leads to poor data quality (Braa et al., 2012).

Some people view data quality through the lens of data usability or fitness for use. Juran (1999) posits that data are of high quality if they are fit for use in their intended operational, decision-making and other roles (Abate, Diegert, & Allen, 1998; Juran & Godfrey, 1999). This suggests that data quality is a function of the characteristics of the intended use, or 'fitness for use', which implies that the concept of quality is relative and that data with quality for use in one type of situation might not have quality in another. This can lead to modification of data to suit the user and may partially explain why most authorities are aware of poor data quality but do not seem to complain. The fact the data quality problems are persistent, and reproduced from one system to another suggests that reporting procedures are linked to other routines and valued practices of the health system. This suggests an interaction between the records and the social system especially in cases where incentives or rewards are associated with certain achievements like a case of free maternity care project in Kenya (Pyone, Smith, & van den Broek, 2017). In June 2013, the government of Kenya introduced free maternity services (FMS) services at all levels of care in the government health system (primary, secondary and tertiary) and health facilities received financial reimbursements based on data captured in HIS. This project became an incentive to use data from HIS. The financial incentives came from the central government as part of the efforts to reduce maternal mortality ratio in Kenya.

Problems of data quality become more visible in countries that have adopted electronic systems in reporting and analysis. In such instances, the HIS uses complicated paper collecting tools from which data are extracted to electronic formats, creating possibilities of transcription errors. Results from paper IV of this thesis (Reporting Practices and Data Quality in Health Information Systems in Developing Countries: An Exploratory Case Study in Kenya) show that transcription errors occur when transferring data from registers in health facilities to summary reporting tools. In developing countries, due to shortage of staff, professionals like nurses, often help in data gathering at service delivery points. This affects data quality because they view data gathering as not being their core duty (Chilundo & Aanestad, 2005), yet it takes a lot their time. In this case, the remedy would consist of obtaining enough resources to hire and train many staff as records keepers.

The type of information sought from the patient/client influences data quality. Some people might be inclined to argue that collecting details such as age, sex, race, annual income, marital status, education, occupation and telephone number, might not be worth the cost and time. Information required by the health care provider may not be readily available but as an incentive for prompt service, the client might be tempted to guess a figure just to proceed with the service. Although the importance of health facilities as the entry points of HIS is acknowledged widely, little research on the heterogeneous clinical information systems (especially in the less regulated private sector) and data quality at health facility level in developing countries has been conducted and published to date.

Fear of repercussions of sending untimely and incomplete reports is another possible source of poor data quality. This may occur especially if there are some unpredictable repercussions under

which the record may be used as part of the ongoing system of supervision and review. Inevitably, some form of official cheating may occur, as in case of deaths due to possible negligence. This leads to informal practices, which are known about everyone, that may contradict officially depicted and openly acknowledged practices (Estrin & Prevezer, 2011). Characteristically, the specifics of who, what, when, and where are well-guarded team secrets of cliques in bureaucratically organized settings. In other words data remains poor because institutional disincentives may involve punishment (Ostrom et al., 1993).

2.4 Fragmentation of Health Information Systems

Fragmentation and development of parallel HISs, which is associated with data quality, is one of the most commonly cited challenges affecting HIS in developing countries (Galimoto, 2007). Braa and others (2007) posit that faced with poor data quality, managers easily form parallel systems leading to fragmentation of national HISs (Braa, Hanseth, Heywood, Mohammed, & Shaw, 2007). Often international donor agencies reinforce the development of parallel information systems by promoting their own indicators while providing financial assistance in order to develop routine reporting systems for capturing data necessary for their programs (Braa et al., 2007; Braa & Sahay, 2012; Chilundo & Aanestad, 2005). Personnel at local and state health departments, therefore, are required to use distinct, incompatible applications to enter and analyse data. The advantage of parallel or vertical information systems is that they can provide real information support for central programmatic decisions, and the quality of information generated is often better than that of a generally managed information system (Shidende, 2005). However, the net result of HIS fragmentation is catastrophic as it creates duplication of work, training, poor information sharing, and often produces different conflicting results (Galimoto, 2007; Shidende, 2005). Due to this, it is difficult to link data or use them to evaluate problems according to person, place or time. Consequently, many health programs fail to link evidence to decisions. Indeed some researchers posit that the health systems' most avoidable shortcomings can be linked to data, information, or knowledge that are inaccessible or of poor quality (Carroll, 2002; Human, 2000; WHO, 2007).

In order to solve this fragmentation problem, countries seek to integrate existing information systems into a flexible, accessible, comprehensive HIS capable of feeding back useful information on a timely basis to those in need of it most (Braa & Sahay, 2012). To this end, remarkable achievements have been made in many developing countries that have started the implementation of the District Health Information Systems (DHIS2) initiated by the Health Information System Program (HISP) in South Africa (Hisp.org, 2016) and maintained by the University of Oslo through global collaborations.

2.5 The Role of Technology in Health Information Systems

This section looks at the potential role of advanced ICTs in strengthening HISs, specifically in developing countries. ICT for health refers to any tool that facilitates the communication, processing or transmission of information by electronic means for the purpose of improving human health (Bukachi & Pakenham-Walsh, 2007). In the past decade, many information infrastructures have been innovated. Tilson (2010) and others describe information infrastructures as shared, unbounded, heterogeneous, open and evolving socio-technical

systems comprising an installed base of diverse information technology capabilities (Hanseth & Monteiro, 1998; Tilson et al., 2010). In developing countries, the decisions on what ICTs to adopt have often been made without evidence of their effectiveness; or implications on information use, although it is assumed that appropriate adoption of these technologies can increase the quality and speed of information (Lewis, Hodge, Gamage, & Whittaker, 2012). Cloud computing infrastructure, the DHIS2, Electronic Medical Records (EMRs) in various major hospitals are some of the new information infrastructures that countries are adopting. The use of appropriate technologies can increase the quality and reach of both information and communication. ICT can aid in data sharing; provide visual tools linking population and environmental information with disease outbreaks (Lewis et al., 2012). Such possibilities are especially important in the developing countries characterised by low resources and limited human resource capacity.

The use of advanced technology comes with both technical and organizational challenges. The technical challenges are related to the acquisition and support of the technology, while organizational challenges revolve around the accompanying social and educational transformations of people and processes that need to accompany the new ICTs including concerns of confidentiality and privacy (Koo, O'Carroll, & LaVenture, 2001). Specific challenges include: costs associated with hardware and software, electricity systems, the development of user interfaces, availability of broadband and mobile networks, (Wootton, 2009). Introduction of advanced technology brings new ways of working, new staff skills, new roles and may require organisational restructuring and so local human resource capacity-building is a core part of the process of adoption (Lewis et al., 2012). There are also important hidden costs associated with technology, including maintenance, upgrades and replacing broken equipment, which need consideration. Furthermore any ICT initiative that is heavily reliant on external funding is unlikely to be sustainable over the long term (Lewis et al., 2012), so assessment of the affordability of the technology in the long-term (after donor funds have expired) is important.

To maximize the use of technology, it is important to solicit the commitment of the senior management to rely upon during the anticipated changes. Drawing on empirical material from the Indian healthcare system, Noir and Walsham (2007), argue that incorporating advanced technology in HIS does not always translate directly to efficiency gains (Noir & Walsham, 2007). This is because many stakeholders give limited attention to how institutions change. An information system is a complex socio-technical structure consisting of hardware, software, data, people, and procedures (Mucee et al., 2016; Silver, Markus, & Beath, 1995). A well-functioning information system requires well-balanced interrelationships between technical and social aspects of the system. For example, technical problems may have organizational roots, and result in organizational conflicts. Therefore, an understanding of this socio–technical approach is important for the success.

2.6 Decentralization of the Health System in Developing Countries

Decentralization, defined as the transfer of authority and responsibility from central to lower levels of government (Ascher & Rondinelli, 1999), has been a recurring theme for several decades (Tsofa, Goodman, Gilson, & Molyneux, 2017) and an increasing number of countries are adopting or considering to adopt it (Collins, 2001). Historically, it dates back in the era of the Alma Ata declaration in 1978, which advocated for participation and involvement of communities in managing their health affairs (WHO, 1978) through the primary health care approach. Decentralization played a key role in the primary health care concept, providing a mechanism of increasing community empowerment with the ultimate aim of increasing equity. However, this approach was later critiqued for its inability to increase equities in service provision between rich and poor regions (Collins & Green, 1994). In later years, decentralization emerged through the introduction of user fees in health service delivery. Involvement of local leaders in the management of collected fees enhanced the concept of decentralization. This observation was reinforced by Bossert (2003) who argued that decentralization enhanced local level internal health system resource mobilization by allowing districts to make local decisions on user fees (Bossert, Chitah, & Bowser, 2003).

The World Bank categorizes decentralization into five types: devolution, de-concentration, delegation, fiscal decentralization and privatization (World-Bank, 2017). Table 2 summarizes these types and their characteristics.

Table 2: Types and Characteristics of Decentralization

Type of Decentralization	Characteristics
Devolution	Power, responsibility, and budgetary authority are shifted to locally elected or appointed officials
De-concentration	National institutions place staff at the local level but retain decision-making power. This shifts responsibility for decision making, finance and implementation of public functions from officials of the central government to those in existing districts under direct control of the central government
Delegation	Management passes down responsibility to semi-autonomous organizations (parastatals) not wholly controlled by the central government, but ultimately accountable to it. It involves the creation of public-private enterprises or corporations
Fiscal decentralization	Local governments are given the power to raise and retain financial resources to fulfil their responsibilities.
Privatization	Tasks transferred from public into private ownership- merely contracting out services to private companies also relinquishing totally all responsibility

Source: World Bank: http://www1.worldbank.org/publicsector/decentralization/admin.htm

Devolution, which is the theme of this thesis, is characterized by the legal transfer of power to locally elected political bodies that are substantially independent of the national level with respect to a defined set of functions (Mills, Vaughan, Smith, Tabibzadeh, & Organization, 1990; Omar, 2002). Although the devolved sub-national bodies are rarely 'completely autonomous', they are largely independent of the national government in their areas of responsibility e.g. raising revenue and staff appointment. Policy formulation is usually the only function retained by the central government. The primary rationale for devolution is political; increasing both local autonomy and the number of actors holding political power may defuse ethnic and regional tensions and improve service delivery (Sihanya, 2012). Other reasons for adoption of devolution include: bringing authorities in more direct contact with citizens, improving the poor quality of public services and a way of resolving the tensions arising from the unequal pace of growth and improvement in standards of living in different regions of the same country (Dethier, 2000; Sasaoka, 2008). Devolution has also been seen as a better way of governing since it reduces the monopoly of power by spreading it towards the peripheries and to the minorities (Saideman, Lanoue, Campenni, & Stanton, 2002), especially in the public health system.

Devolution affects all aspects of health systems including governance, political, administrative and financial (Nyanjom, 2011). Many scholars have tried to compare centralized and devolved forms of governance. Those who favour devolution argue that:

a) Putting decision-making in the hands of those who have the local information that outsiders lack, gives a strong incentive advantage. At the same time, they argue that local leaders may identify cheaper and more appropriate ways to provide public goods (Bardhan, 1997),

b) Local managers have more control over results because centralized authorities may not be able to collect information and monitor local conditions or the needs of the local populations.

Those who argue against devolution commonly state that in devolution:

a. Managers tend to look at their administrative units and lose sight of the overall country goals,
b. There can be costly duplication of services,
c. A centralized government is presumably better able to take into account economies of scale in the provision of public goods, and coordinate fiscal policy (Rondinelli et al., 1983) and so devolution might increase costs.
d. there is both empirical evidence and economic theory indicating that devolution can increase corruption and reduce accountability (Rose-Ackerman, 1997) and it is also possible to transfer national level corruption to sub-national levels (Fjeldstad & Tungodden, 2003).

The success of devolution depends on its implementation. Thus, while devolution assumes greater involvement of and participation by target communities, such participation may remain merely symbolic if not well implemented. There is the need to get the correct or optimal amount of decentralization or devolution lest the measure becomes a means of decentralizing inefficiencies (Faguet, Fox, & Poeschl, 2014). Nyanjom (2011) posits that it is vital to have an eclectic design and implementation of devolution that considers the initial circumstances of the

prospective devolved units, rather than employing a single national framework and timetable that are insensitive to variations in circumstances (Nyanjom, 2011). Fundamentally, devolution needs to be in the context of a specific framework – preferably Constitutional- that specifies relationships among devolved units as well as with the centre. The frameworks should ensure the existence of an adequate human resource capacity to manage the devolved responsibilities and should include the scope for capacity building where necessary (ibid).

Considering that the act of transferring power from one set of actors to another is a political process, its effects and outcomes are heavily influenced by many factors and not easy to generalize (Collins, 1989). In some cases, devolution has met with major resistance and obstacles and has not been implemented effectively (Collins, 2001; Jeppsson & Okuonzi, 2000). While Kenya, Tanzania and Papua New Guinea showed some success in the 1980s, the majority of devolution processes have not brought any significant improvements in health status of the communities (Frumence, Nyamhanga, Mwangu, & Hurtig, 2013; Madon et al., 2010). In Uganda for instance, staff employed by the local authorities suffered delayed salaries while those whose salaries originated from the central government had prompt payment, causing major resistance and obstacles in the devolution process (Jeppsson & Okuonzi, 2000; Okuonzi, 2004). The Ugandan study further showed that, faced with competing priorities in education, agriculture, infrastructure development, and trade and commerce, the government did not usually rate health high on the priority list as reflected in the budgets (Jeppsson & Okuonzi, 2000). The same study also found that it was difficult for the central government to offer technical supportive supervision to 45 decentralized units in Uganda (ibid). Recent studies from Kenya found that the implementation of devolution created an opportunity for local level prioritisation and community involvement in health system planning and budgeting hence increasing opportunities for equity in local level resource allocation (Tsofa, Molyneux, et al., 2017).

2.7 Effects of Devolution on Health Information Systems

The first attempts to devolve HIS were associated with the primary health care concept in which HIS were charged with the responsibility of producing monthly reports to higher levels of administration and funding bodies in order to account for monies spent. Madon and others (2010) argue that HISs play a pivotal role in supporting and sustaining primary health care activities and processes by acting as a repository for information generation and analysis at the local level to support elements of primary healthcare planning in developing countries (Madon et al., 2010). Besides the primary health care approach, Braa & Hedberg (2002) present a relatively successful story of the "bottom up" development of the decentralized HIS, the DHIS in South Africa under the HISP initiative (Braa & Hedberg, 2002). The same system was adopted by Sierra Leone, where the DHIS2 was found to improve health for communities by using technology to share data with stakeholders in the communities, such as paramount chiefs, civil society, and NGOs (Kossi, Sæbø, Braa, Jalloh, & Manya, 2012). The DHIS2 thus contributed both indirectly and directly in enabling communities to improve their situation. With the software being adopted in more than 50 countries, decentralisation via technology is likely to give good results (Dhis2.org, 2017)

Generally, devolution of HIS has been problematic because of the complex interlinking with various administrative, political and financial process (Honest Christopher Kimaro, 2006). Some authors have found out that there are problems of linkages between the central and local grass root levels (Chilundo & Aanestad, 2005). The existence of these gaps in the linkages contributes to ineffective results obtained through the decentralization process. The need for both vertical and horizontal alignment is recommended as an approach to addressing these gaps (H. Kimaro & Nhampossa, 2007).

2.8 Institutional incentives

This study uses the concept of institutional incentives. Incentives come from many sources. Some of the common incentives include: opportunities for distinction, prestige and personal power, desirable physical conditions in the workplace, including staff tea, a private office (Ostrom et al., 1993). Some people are even happy with personal comfort and satisfaction in social relationships. Institutional arrangements drive institutional incentives. When joint outcomes depend on multiple actors, it is possible that not all individuals involved in the transactions will have equal access to the same information. Those with information tend to behave opportunistically. This type of incentive tends to improve one′s own welfare at the expense of others and therefore affects how individuals can achieve their objectives (Ostrom et al., 1993). Therefore, institutional arrangement that help to generate information or distribute it serve crucial roles in increasing information use from health information systems. It is therefore important to develop institutional arrangements that reduce information problems.

The internal and cultural values that an individual shares with a community can act as a strong motivation. The following is a list of possible incentives ((Ostrom et al., 1993) p. 8):

a. Pride in workmanship, service for family or others, patriotism, religious feelings,
b. Conformity to habitual practices and attitudes
c. A feeling of participation in large, important events

Regarding public officials, for one to understand the type of incentives applicable, it is important to examine the context of the generally low salaries they receive, their limited career advancement opportunities, their poor working conditions and types of work assignments. In the context of devolution, jobs at sub-national units are thought to be in the countryside. Many officers posted to smaller rural communities tend to maintain two households, one for their family living elsewhere and a minimal living arrangement for themselves on site. Given the low salaries and prohibitive costs of keeping two households, the officials' incentive to search out opportunities to earn extra funds in the countryside is understandable. In information systems, opportunities for additional income may arise when data can be withheld from potential beneficial unless side payments are made. Once assigned to the countryside many devote considerable time and energy to arranging for traveling to the city.

Summary of Chapter 2

Chapter 2 has evaluated literature on HIS in developing countries, giving the status and some of the common challenges facing the systems. Among the challenges evaluated are data quality and fragmentation of HIS due to the emergence of parallel donor driven systems. The chapter highlights the important role played by ICT in HIS. Of interest is the implementation of DHIS2, which has the potential to solve some of the challenges faced by HIS in developing countries. The chapter notes that many countries are adopting decentralized forms of government for various reasons. A review of literature on decentralization and devolution in particular, shows that this form of government affects health systems and HISs in different ways. With this background, I turn my attention to Kenya, the country of my research. The next chapter looks at the background information on Kenya, giving the new structure following devolution. It also provides the implementation of DHIS2, which forms the basis of case studies in the thesis.

3 Chapter Three: Empirical Setting, the Kenyan Context

In this chapter, I describe the country's profile, the government structure and the organization of health services. In section 3.2, I provide the country's health profiles showing the common health indicators. Section 3.3 dwells on the devolved government structure. The section provides details of both national and county governments, highlighting the relevant changes brought by the new constitution. Section 3.4 gives the organization of health service delivery in Kenya, while sections 3.5 to 3.7 show the organization and management of health care at various levels of care in the country. Section 3.8 gives a summary of the evolution of the country's health information system, culminating in the development and deployment of the DHIS2.

3.1 Demographic Profile

Kenya is a sovereign state in the African Great Lakes region of East Africa and a member of the East African Community. The country lies astride the equator, with the Indian Ocean to the Southeast, Tanzania to the South, Uganda to the West, South Sudan to the Northwest, Ethiopia to the North and Somalia to the Northeast. The country occupies an area of 580,370 sq. km and has a projected population of nearly fifty million people for the year 2018 (Countrymeters.info., 2018). There are more than forty indigenous languages in the country but Kiswahili is the national language. Although Kiswahili is widely used by nearly everyone for communication, English is important in trade, commerce, and higher learning and in government offices. Table 3 below shows the country's basic demographic profile including population estimates for the year 2018, based on the latest United Nations Data (Countrymeters.info., 2018).

Table 3: Population Estimates for Kenya, Based on the Latest United Nations Data

Projected population for 2018	49,460,096
Total area	580,370 km^2 (224,082 mi^2)
Population density	85.2 per km^2 (220.7 people/mi^2)
Sex ratio	1.00 (24,705,451 men to 24,757,442 women)
Median age	19.0 years
Life expectancy(2016)	59.5 years (64 - men, 69 - women)
Literacy rate	78 %

Source: Population data for every country as of 2018. Available at: http://countrymeters.info/en/ [Accessed 24 Mar. 2018].

3.2 Health Profiles

Like most developing countries, Kenya has a high prevalence of communicable diseases. Since these disease conditions are preventable, the country has formulated various preventive health programs. These efforts towards improving the health of the population continues to produce good results. For instance, over the past three decades, the country has witnessed impressive progress in tackling priority diseases such as malaria, Human Immunodeficiency Virus Infection and Acquired Immune Deficiency Syndrome (HIV/AIDS) and tuberculosis (TB). There has also been significant progress towards addressing childhood diseases such as measles, diarrhoea and respiratory infections, largely through the expansion of key health

interventions, including vaccines and other preventive health technologies. In addition, the country continues to focus on Maternal, New born and Child Health (MNCH), by expanding health services to ensure that lives are not lost due to pregnancy-related complications. International organizations like the United Nations Children's Fund (UNICEF) and the World Health Organization (WHO) usually work with the government to improve the MNCH indicators (knbs.or.ke, 2017).

Despite the impressive progress in tackling communicable diseases like malaria, respiratory infections, maternal and childhood diseases, the burden of non-communicable diseases (NCDs) is growing steadily in Kenya and across the region. Some of these diseases or conditions form part of life style diseases (including high blood pressure, diabetes and more recently cancers). The MoH has collaborated with various stakeholders with the aim of stemming the tide of NCDs and making further progress in improving health outcomes in the country. However, progress towards reducing the country's NCD burden is slow. Collectively, these efforts are geared towards the attainment of Kenya's Vision 2030, the county's vision of becoming more prosperous and healthier by 2030 (Vision2030, 2007).

The demand for evidence towards the achievement of the SDGs, coupled with the increasing need for both multilateral and bilateral donors to demonstrate their contribution towards health development has also created increased demand for information. This information is generated from many sources – individuals, health facilities, disease surveillance sites, the community and geographical (spatial) areas or units. In general, the key statistical constituencies for gathering information include:

a) civil registration system-whose vital events include registration of live births, deaths, marriages, divorces, adoptions
b) The Kenya National Bureaus of Statistics (KNBS)-as the custodian of all Government Statistical information that maintains a database for all national surveys including national population and housing censuses and population based health surveys

On a regular basis (every five years), the country carries out demographic health surveys (Kenya Demographic and Health Survey (KDHS)), which give progress of some of these indicators. The latest survey was in 2014, which was designed to provide detailed information on aspects of health across Kenya, and in each of the 47 counties. The 2014 KDHS was the sixth survey of its kind in Kenya, following those carried out in 1989, 1993, 1998, 2003, and 2008-09, and it was the first KDHS to provide information at the county level. In the 2014 KDHS, information was collected on household characteristics, education and employment, marriage and sexual activity, fertility levels and preferences, awareness and use of family planning methods, maternal and child health and survival, nutritional status, ownership and use of mosquito nets, knowledge and behaviours regarding HIV, domestic violence, female circumcision, and fistula. A comparison of the latest two surveys showed a significant improvement. Apart from malaria and immunization indicators that were on a slight downward trend, the rest of the indicators showed improvement from 2009 to 2014. Table 4 shows the key indicators highlighted from the Kenya demographic health survey of 2014 (K.D.H.Survey, 2014).

Table 4: Key Demographic Health Survey Indicators for Kenya

Indicator	KDHS 2014	*KDHS 2008/9*	% change
Under-5 mortality (per 1,000)	52	*74*	29.7
Infant mortality (per 1,000)	39	*52*	25.0
Total Fertility Rate-# of children ever born to women 15-49yr	3.9	*4.6*	15.2
Current use of contraceptives – all women 15-19 %			
Any method	65.4	*45.1*	45.0
Modern	60.9	*50.3*	21.1
Ante-natal care: skilled personnel	95.5	*92*	3.8
Delivery in health centre, %	61	*43*	41.9
Delivery assisted by skilled personnel, %	62	*44*	40.9
Immunization % [children aged 12-24 months]			
All basic vaccinations	71.1	*77.4*	-8.1
BCG	96.7	*95.6*	1.2
Nutrition – % U5 children			
Stunted: height-for age <2SD	26	*35.3*	26.3
Wasting: Weight-for-height- <2SD	4	*6.7*	40.3
Underweight: Weight-for age <2SD	11	*16.1*	31.7
Exclusive breast feeding 0-5 months	61.4	*31.9*	92.5
Prevalence of Malaria and treatment - % U5 children			
Experienced a fever in previous 2 weeks	24.4	*23.7*	-3.0
Took anti-malarial drugs	27	*23.2*	-16.4
Households with at least 1 mosquito net – ITN	58.7	*55.7*	5.4
Use of a mosquito nets %			
U5 children treated net	54.1	*46.7*	15.8
Women 15-49 years – treated net	50.5	*41.1*	22.9

Source -Kenya National Bureau of Statistics (KNBS)-(knbs.or.ke, 2017)

3.3 The Devolved Government Structure

Devolution has been in the pipeline since Kenya gained independence in 1963, adopting many decentralization policies and strategies (G.O.K, 2013). In 1983, the government introduced an innovative approach called District Focus to address emerging inequalities between socioeconomic strata as well as within the households. Although this had the theoretical potential for addressing these issues, it ended up being centralisation in a new guise (Anderson, 2005). In another attempt at decentralization, Kenya introduced user fees in the health sector in 1983 and established District Health Management Teams (DHMTs) and District Health Management Boards (DHMBs) to oversee the management of these fees. However, this had minimal impact because of its potential to allow increasing inequities in service provision between more and less wealthy areas (Mackenzie & Taylor, 1987; Tsofa, Molyneux, et al., 2017). A major decentralization policy came in existence in 2010, when Kenya adopted a new Constitution that had far-reaching provisions for democratization including the devolution of powers and authority from national Government to counties.

Drafting of a new constitution considered the different ethnic groups in the country. The country consists of over 43 different ethnic groups, which tend to occupy exclusive territories. People in each ethnic group (sometimes referred to as tribe) possess the heritage of a common culture, such as historical traditions, customs, languages values and beliefs. At times, the ethnic orientations drive the country's political and economic processes, often bringing tensions especially during the general elections. Indeed, it is from such tensions that the country adopted a devolved system of governance. The aim of devolution was to prevent ethnic based chaos similar to those that had erupted following the disputed presidential elections of 2007 (Sihanya, 2012). During this change, the new constitution abolished the previous eight administrative provinces, paving way for 47 sub-national units, referred to as counties. The boundaries for the counties were similar to the districts of 1992 (Kramon & Posner, 2011; Nyanjom, 2011), a reflection of the ethnic territories. Elected politicians and civil servants got new mandates to steer the counties.

One of the landmark provisions of the Constitution is the creation of two levels of governance: National and County Governments. The two levels of government have been assigned clear mandates as detailed in the fourth schedule of the Constitution (Kenyalaw.org, 2010). The two governments are distinct and inter-dependent and conduct their mutual relations based on consultation and cooperation (Kenyalaw.org, 2010). The national government is responsible for the defence and security, the courts, the environment, and land policy among other responsibilities (Kramon & Posner, 2011). Three main bodies do the work of the national government: Parliament, the Executive and the Judiciary. The Parliament is bicameral i.e. it consists of two houses: The National Assembly and the Senate. The National Assembly represents the constituencies while the Senate represents the counties. Parliament makes laws in line with the Constitution. The National Executive comprises the President, the Deputy President and the Cabinet. The Cabinet consists of the President, the Deputy President, the Attorney General and not fewer than 14 and not more than 22 Cabinet Secretaries. The executive implements the laws in line with the Constitution. The judiciary ensures that parliament and the executive use their power according to the law and that everyone obeys the law. At the national level, there is a central administration responsible for the overall government functions including overseeing the functions of the lower administrative units (Kenyalaw.org, 2010).

Schedule 4 of the Constitution assigns to the County Governments the function of delivering essential health services. County Governments comprise the County Executive and County Assemblies. The County Executive Committee is composed of the Governor and County Executive Members appointed by the Governor. The County Assembly is the legislative arm of the County Government. The election of the county head (the governor) and the Members of County Assemblies (MCAs) occurs during the national elections held after five years. The MCAs represent a unit called the Ward, which is composed of two to three villages, bringing power right to the lowest level in the community. The main function of the county governments is service delivery. For example, they are responsible for health services, agriculture and livestock sale, markets, water and sanitation. Apart from generating money from local taxes to

pay their workers and run other functions, the counties receive formulae driven grants from the national government. They can also negotiate for grants from donors (Kenyalaw.org, 2010).

At the onset of devolution, there was minimal clarity on the health workers' distribution and management. Similarly, majority of health system actors had little information about their roles and responsibilities in either the national or the county governments. Data for planning within the counties were scanty. To make initial plans the counties relied on the Service Availability and Readiness Assessment Mapping (SARAM)(G.O.K, 2014), County Health Fact Sheets, the Kenya Health Sector Strategic Plan (M.O.H, 2014), and the draft Kenya Health Policy (M.O.H, 2013b). With these, they created county-level health strategic and investment plans, which in turn, provided them with justification for their budget requests to county assemblies (Sihanya, 2012). It was evident from the start that quality data from the HIS would play a critical role in the devolved governments and hence the relevance of the study.

This being a new system, there was need for the citizens to understand how the system worked to participate in governance, including public affairs and national development. Article 33(1) a of the Constitution states that every person has the right to freedom of expression which includes freedom to seek, receive or impart information or ideas. Both governments have the mandate to provide civic education for the success of devolution. Figure 4 shows the Geographical distribution of the counties in Kenya.

Figure 4: Geographical Distribution of the Counties in Kenya.

Source: Available at: https://commons.wikimedia.org/wiki/File:Kenya_counties_map_Labelled.jpg [Accessed 24 Mar. 2018].

3.4 Organization of Health Services Delivery in Kenya

The Kenya Health Sector Strategic and Investment Plan (KHSSP III) 2012 – 2017 defines the organization of health care in four levels or tiers: Tier 1: Community level; Tier 2: Primary Care level, Tier 3: County level and Tier 4: National level (M.O.H, 2014). At each tier, there is an organized referral system, which transfers clients or patients to respective levels according to the service needs. The tiers, not only have differences in the levels of trained personnel but also differences in diagnostic and technological capacities.

Tier 1- Community level: Each individual and or household has the responsibility of taking care of the health of its own population. By extension, communities too have an obligation to take care of their own health using available local resources. They choose their own community health workers to be the main link between the community and the nearest health facility. The community health workers' responsibilities include health education, advice and counselling on child care, pregnancy and family planning, HIV/AIDS prevention, data collection and assisting in relevant public health interventions. This is well spelt in the country's community strategy (M.O.H, 2014).

Tier 2: Primary Care level: The dispensaries are at the lowest level of the public health system and the first point of contact with patients. Nurses, public health technicians, and subordinate staff manage these units. Nurses provide basic outpatient curative care, antenatal care and treatment for simple medical problems during pregnancy such as anaemia, and occasionally conduct normal deliveries. Dispensaries serve around 5,000 people, referring complicated cases to health centres and other institutions with more facilities and staff. The dispensaries are also responsible for collecting and utilizing data to provide feedback to various levels including the community (Muga, Kizito, Mbayah, & Gakuruh, 2005).

Health centres are primary health facilities superior to dispensaries, which offer outpatient, in-patient services, maternity care, laboratory, and dispensing (pharmacy) services. The health centres also act as referral centres for dispensaries. Staff mix at health centres include: midwives or nurses, clinical officers, and occasionally doctors. They provide a wider range of services, such as basic curative and preventive services for adults and children, as well as reproductive health services. They also provide minor surgical services such as male circumcision, stitching of cuts and dressing of wounds. They augment their service coverage with outreach services, and refer severe and complicated conditions to the appropriate level, such as the sub county hospital. They serve a population of around 50,000 people and are supposed to have appropriate transport and communication facilities for referral of patients to hospitals and supervision.

Tier 3: County level: This level provides hospital services to geographically well-defined regions. Their catchment area can be over 200,000 people. They provide specialized care, involving skills and competence not available at primary care facilities, which makes them the next level of referral after primary care facilities. Their personnel include medical professionals, such as general surgeons, general medical physicians, paediatricians, general and specialized nurses, midwives, and public health staff. They make referrals to other health facilities including the national referral hospitals when need arises.

Tier 4: National level: At national level, referral hospitals are the highest level of hospital services in the country, which acts as the referral centre for the entire country. There are two referral hospitals, Kenyatta National Hospital and Moi Teaching and Referral Hospital (Muga et al., 2005). Referral hospitals provide preventive care and participate in public health programmes for the local community and the total primary health care system. They are centres of excellence and provide complex health care requiring more sophisticated technology and highly skilled personnel. These hospitals offer specialised services in psychiatry, surgery, child health, obstetrics and gynaecology, among others. They also support the training of health workers at both pre-service and in-service levels. Patients with complex diseases or conditions that are difficult for the referral hospitals go overseas for further management (depending on the availability of funds). The referral hospitals have a specific role in providing information on various health problems and diseases. They provide extra-mural treatment alternatives to hospitalisation, such as day surgery, home care, home hospitalisation and outreach services. With their concentration of resources and personnel, teaching and referral hospitals contribute to providing solutions to local and national health problems through research, as well as contributing to policy formulation.

Figure 5 illustrates the organization of health service delivery in Kenya.

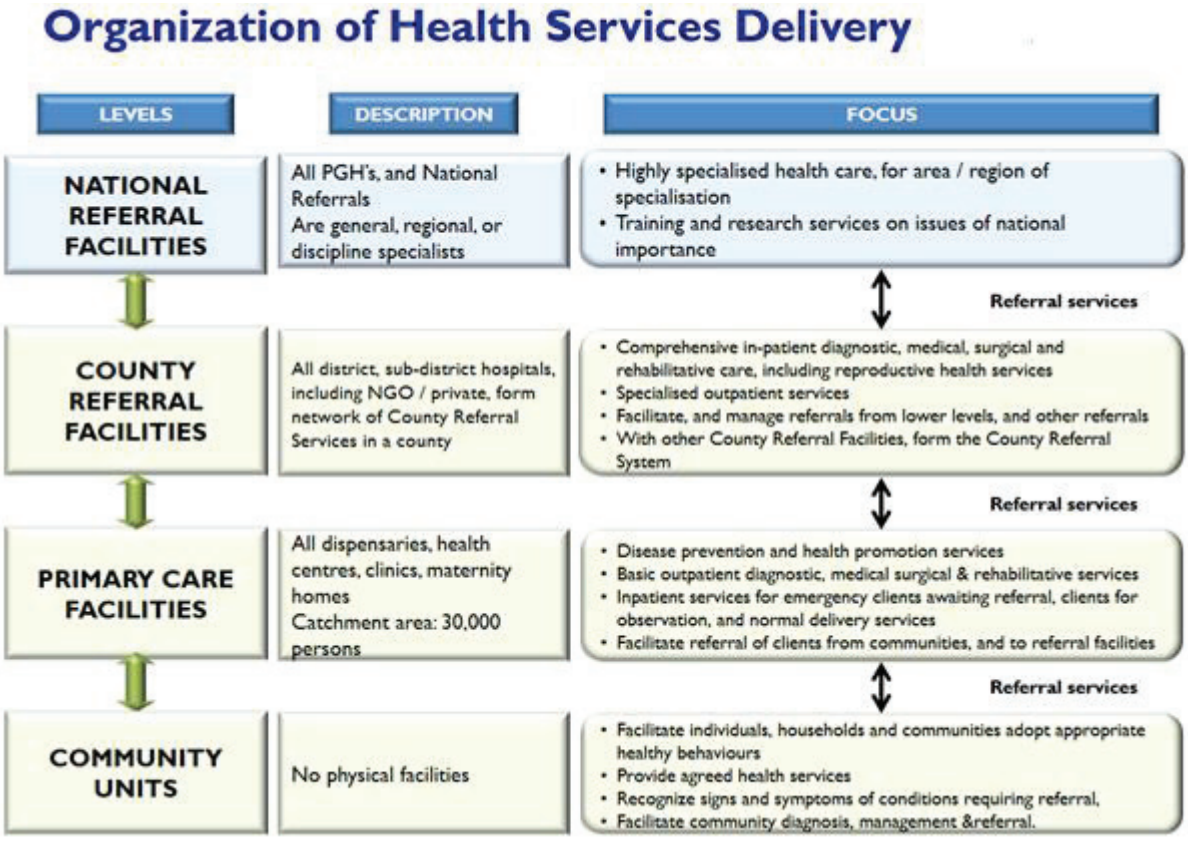

Figure 5: Organisation of Health Services Delivery

Source, Kenya Health Sector Strategic and Investment Plan -KHSSP July 2014-June 2018(M.O.H, 2014)

3.5 Management of Health Care at Various Levels of Care

There are elaborate governance structures created at all levels of care aimed at providing an oversight role to the levels of care. These include; Community Health Committee, Primary Care Facility Management Team, Sub County Health Management Team, County Hospital Management Team and County Health Management Team. The County Health Management Team (CHMT) is responsible for all health services in the county irrespective of the provider. The county director is the head of the CHMT and is the overall responsible person for the provision of county health services. The CHMT is responsible for the supervision and monitoring of the activities of the sub county and health facilities. For example, when there are abnormal numbers of maternal deaths, they need to determine their causes and identify resources needed to control such problems in the future. They are also responsible for supervising, coordinating and supporting the public health activities. The CHMT in collaboration with the county executive, plan and budget for the activities needed to manage, control, coordinate and support health services in the county on a quarterly basis. The quarterly reports gathered from each health facility include details of health services offered, efficiencies and deficiencies of the health facility (e.g. the number of staff present and missing), and infrastructure constraints. Based on these reports and priorities of disease burdens (guidelines from MoH), the CHMT prepares comprehensive county health plans which are submitted to higher levels for assessment with respect to compliance to national guidelines, implementation status, appropriateness of interventions, adherence to procurement and financial regulations and quality. In addition to the preparation of the work plans, the CHMT also prepares a diseases and activities report for reporting to the MoH headquarters. Although, the county has been the focus for implementation of health programs, we still have some planning that is "top-down" with minimal involvement of beneficiaries, or even the CHMT. For example, a development partner with health officials from national government may make plans related to vertical health programs such as HIV/AIDS, TB, Malaria and Expanded Program of Immunization (EPI), where the CHMT is only involved in the implementation.

3.6 Organizational Structure of National Health Services

The MoH is a government agency that, through its various departments, sets the agenda for health in Kenya in collaboration with other stakeholders. The national level formulates policies, sets service standards, assures quality, provides training and human resources, and develops technical guidelines. Other roles include provision of technical supervision, management of the national referral health facilities, medical schools and research bodies (e.g. Kenya Medical Research Institute (KEMRI)). In addition, the national MoH is also responsible for spearheading health systems reforms; regulating, responding to epidemics and other disasters, developing annual plans which include mobilization and allocation of resources for the health system and ensuring that these are communicated to lower level institutions. To function well the MoH receives external support through implementing collaborators who support various departments at all levels of care. The following are some of the partners: African Medical and Research Foundation (AMREF), Population and Health Integrated Assistance Plus (APHIA Plus); Centres for Disease Control and Prevention (CDC); Clinton Health Access Initiative (CHAI); Family Health International (FHI); Intra-Health International; Management Sciences

for Health (MSH); National AIDS Control Council; Palladium; and the WHO. These partners provide technical assistance and mechanisms to support a harmonized health system aimed at improving health indicators.

During the implementation of devolution, the management structure at the headquarters changed drastically. To fill up new openings in the counties, many staffs moved from their stations. At the national level, the mandate for managing HIS falls in four different units: the HIS Unit, the e-Health Unit, the Monitoring and Evaluation (M&E) Unit, and the Research and Development Unit. Other administrative units which handle HIS include the Civil Registration Department (CRD), under the Ministry of Immigration and Registration of Persons, which processes, analyses, and disseminates vital statistics from birth and death records, and the Kenya National Bureau of Statistics (KNBS) which disseminates official vital statistics on births and deaths and computes annual vital event indicators by province (knbs.or.ke, 2017). In addition, the MoH has a separate unit in charge of ICT which assists in HIS processing, though the staff are part of the ICT Authority in the Ministry of Communication and Technology (Icta.go.ke., 2017). The ICT Authority works directly with the ICT unit in the MOH to draft governance manuals that establish security, mobility, and web technology standards, while the e-Health unit oversees the enterprise architecture of electronic health records and releases guidelines for the development of EMR systems (M.O.H, 2011) . The fact that many units support HIS at the national level leads to confusion and overlap in functions. Figure 6 shows the organizational structure of national health services.

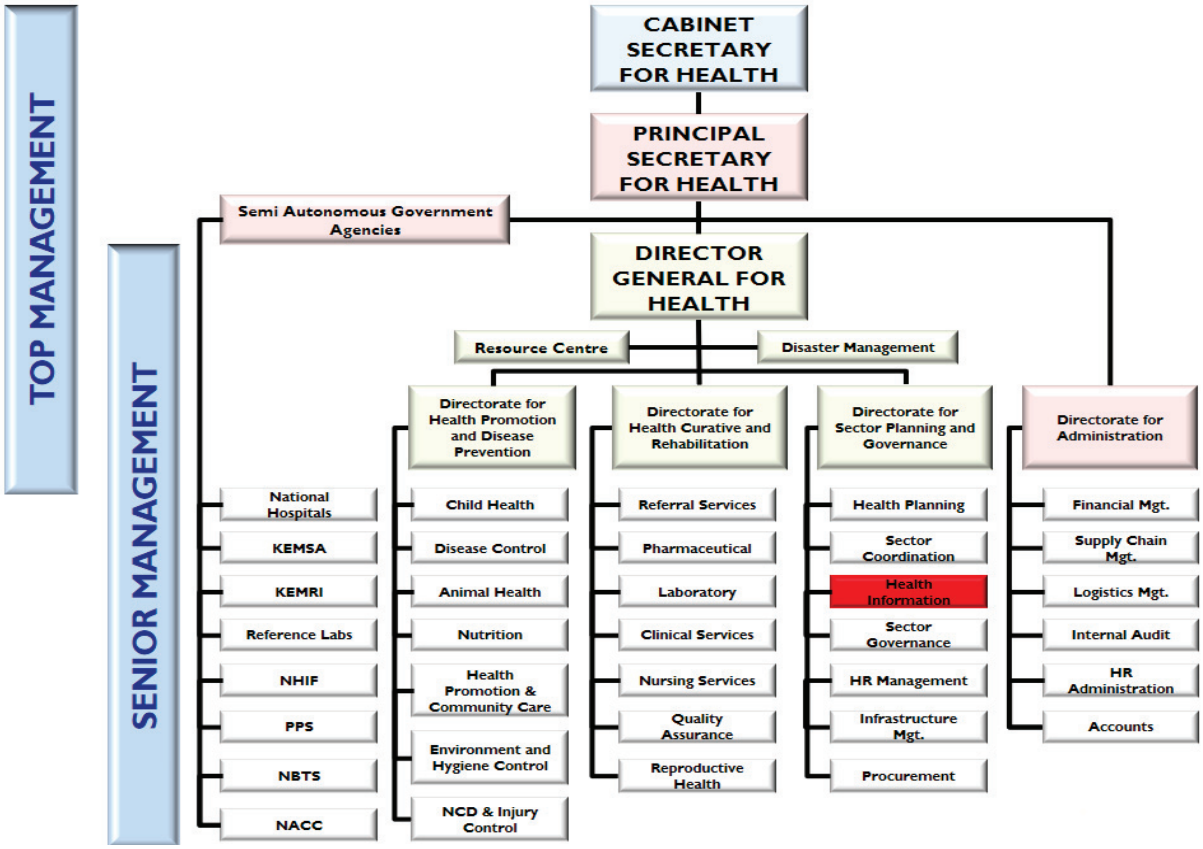

Figure 6: Organizational Structure of National Health Services

Source, Kenya Health Sector Strategic and Investment Plan -KHSSP July 2014-June 2018(M.O.H, 2014)

3.7 Organizational Structure of County Health Services

The county health managers are responsible for adopting the policies developed by MoH, making county specific policies and providing health care services. The funding for these health services comes from a variety of sources including government funding (for example for the purchase of medicine and equipment, to pay salaries and support training), centrally funded vertical health programs, local tax collection and cost sharing (user fees) in health facilities. However, in some counties revenue collection is low and underfunded. Sometimes revenue from the national level is late, leading to delayed salaries of staff at the county levels. This has led to a number of industrial actions by health workers particularly doctors and nurses. Apart from service delivery, the county health services have other responsibilities including licensing and approving county special partnership agreements (Kenyalaw.org, 2010). In collaboration with national government, the county health services gazette regulations for community managed health suppliers. The counties are therefore charged with a big responsibility of developing an investment plan to support article 43(1 a) of the Constitution which states that "Every person has the right to the highest attainable standard of health, which includes the right to health care services, including reproductive health care;"(Kenyalaw.org, 2010) p.31. Figure 7 shows the organizational structure of county health services.

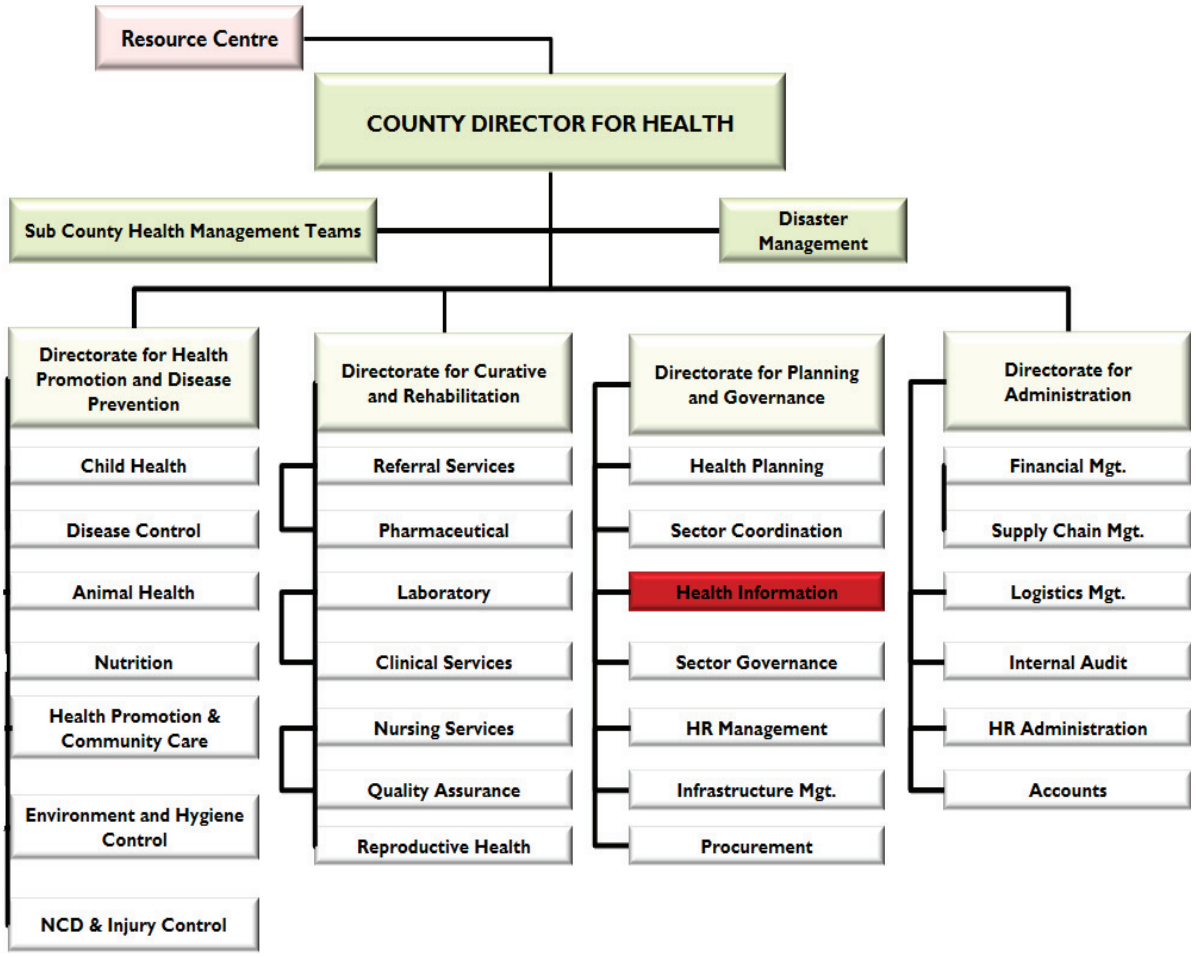

Figure 7: Organizational Structure of County Health Services

Source, Kenya Health Sector Strategic and Investment Plan -KHSSP July 2014-June 2018(M.O.H, 2014)

3.8 Evolution of the Health Information System

Historically, the idea of forming HIS in Kenya dates back to 1972. Since then, HIS has seen massive changes and developed from a pure paper-based system to a hybrid paper and digital system. In 1984, in response to the national policy on district focus for rural development, the MoH decentralized its reporting activities by establishing HIS offices in all districts where all data from all health facilities were processed (Barkan & Chege, 1989). With the growth of HIS, came the attendant problems of data quality and formation of parallel systems. At the national level, there were standalone information systems that supported various vertical programmes with little integration. Similar findings were observed at provincial and district levels. With this, essential information was largely unavailable for effective planning, monitoring and evaluation at all levels. Several government policy documents such as the health policy framework paper (1994 - 2010), HMIS needs assessment report (2003) and the National Health Sector Strategic Plan II (NHSSPII) 2005 – 2010 (Reversing the current trends) outlined integration of parallel information systems as an important activity (Muga et al., 2005). These documents suggested integrated data collection and reporting tools, improvement of data flow mechanisms, support districts in supportive supervision, provision of clear policy guidelines on HIS and improved feedback mechanisms at all levels. Recommendations from the evaluations argued that investing in the development of effective HIS would have multiple benefits and would support decision- making at all levels (Luoma et al., 2010).

In an attempt to improve performance monitoring of the health system, the country adopted File Transfer Protocol (FTP) in 2007/08. FTP is a standard network protocol used to transfer computer files from one host to another host over the Internet (Rani, Narula, & Panchal, 2014). The introduction of FTP was a major success especially in terms of increased reporting rates. Health workers captured service delivery data at health facilities and sent to districts. The districts summarised the data in standardized excel formats and transferred them through FTP to a central server at the MoH headquarters. During this process, the facility identity was lost, making it difficult to compare data across health facilities. With the growth of data, FTP started being problematic especially in synchronising data. In addition, the central server at the MoH headquarters was small and not able to allow for quick delivery of data from all districts. At times district level staff transmitted their data after midnight when the traffic to the central server was low. To improve the HIS, the Government commissioned various reviews that revealed that the system was not meeting its objectives and a modern database platform was recommended as a matter of urgency (Luoma et al., 2010). After considering many options, the MoH selected DHIS2. By selecting DHIS2, Kenya was moving from a simple system to a more complex one.

The DHIS2 is a free and open source software, with no license costs for the health departments that adopt it. Developed in South Africa in 1997, the first version of DHIS application focused on action research, user participation and local involvement in the development of the system. This empowered local health managers to use data for decision-making. The relative success of the first version of DHIS in South Africa led to the development of version two which is a modular web-based software package that runs on any web server that supports Java Servlets (Oracle.com, 2017). It is a data warehouse application which supports data collection,

management, analysis, and presentation of aggregate statistical data, tailored to integrated health information management activities (Dhis2.org, 2017). It is based on an open meta-data model (e.g. data elements and data sets, types of facilities and the hierarchy of the health system, indicators, and validation rules) and a flexible user interface that allows the HIS team to design the contents of the system and to add new data sets and modules without the need for programming. Cloud computing facilities support the DHIS2 installations by connecting the servers to the Internet, allowing users to access their data online using a web browser (Dhis2.org, 2017). So far more than 50 countries are using it (Hisp.org, 2016). In addition to DHIS2, the country started implementing other information systems including Human Resources Information System (HRIS) and EMRs to facilitate effective patient management especially in large volume hospitals. Other initiatives include; disease outbreak monitoring through Integrated Disease Surveillance & Response (IDSR) and a number of projects using mobile technology for reporting.

3.9 Overview of the Case Study: Implementing the Kenyan DHIS2

Since June 2011, the Kenyan MoH has been working towards improving the HIS through the implementation of DHIS2, a web based health information software. The Danish International Development Assistance (DANIDA), through the Health Sector Programme Support to Kenya Phase II (HSPS II program), funded the initial adoption and deployment of DHIS2. For the implementation of the Kenyan DHIS2 project, the MoH recruited technical assistants from the University of Oslo. This was because they were the developers of the system and were likely to offer more support after the installation. As a first step, the director of the MoH constituted a DHIS2 core team to work with the consultants during the entire period of the project, and appointed me as the team leader. The priority of the team was to customize the system and pilot test in one region. At the time of setting up the software on a central server, the server at the MoH headquarters was not sufficient for the work. The internet connectivity was not good and so the Ministry authorised the team to get a temporary solution by engaging commercial hosting services at the Linode. The University of Oslo managed the day-to-day server management process at Linode remotely through the internet. During the setup of the system, the consultants had two options, either to speed up the customization of the system by setting up the system by themselves or spend time on training the DHIS2 core team and let them do the customization under supervision. They adopted the latter option, also known as learning by doing. The Kenyan team under the supervision of the consultants performed all the required customizations of the system. Figure 8 shows the diagrammatic shift from FTP to DHIS2.

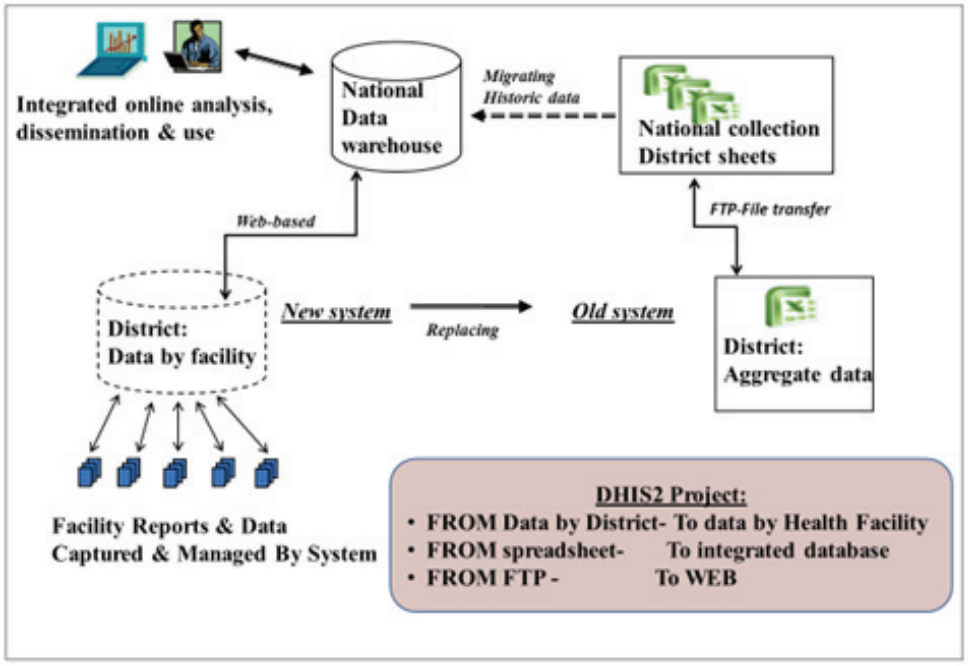

Figure 8: Diagrammatic view of shift from FTP to DHIS2 in Kenya in 2010

Following customization, the MoH drafted an elaborate roll out plan and funded it through bilateral donors. Training of users was one of the main activities of the roll out plan. The training occurred through face-to-face seminars followed by visits to the health facilities for mentoring and coaching. During capacity building, we utilized the principle of learning by doing with the aim of converting the trainees into trainers for continued work once the trainers left. The DHIS2 core team together with technical assistants from Health Information System Program (HISP) of the University of Oslo coordinated the project culminating to its launch in 2012. Figure 9 shows a picture taken during the launch of DHIS2 as the official reporting system for Kenya in 2012.

Figure 9: The launch of DHIS2 in Kenya, 2012

At the end of DANIDA's project in 2012, the United States Agency for International Development (USAID) took over the funding through a local NGO called Afyainfo. Apart from supporting other processes of HIS, Afyainfo also paid for the hosting of the database on the cloud. Managing a national and robust system such as DHIS2 requires highly specialized ICT experts to facilitate 99.9% access and availability of the system to all the users 24/7. However, the staffing structure and infrastructure of MoH does not support such big national multi-user web applications. Specialized staff are therefore required, so Afyainfo hired four ICT officers to oversee the smooth running of day-to-day of the DHIS2 database through the cloud computing technology. These ICT specialists worked closely with selected government workers from the MoH, providing on-job training. Afyainfo also collaborated with a local university (University of Nairobi) on issues of software development, management and sustainability. The ultimate goal was to maintain a well updated system capable of responding to users' needs such as data collection, data quality checks, data analysis and use by relevant MoH levels (facility/community to central) and external partners as well.

It was during the implementation of the DHIS2 that Kenya adopted devolution, which necessitated the redefinition of the structure of the health service delivery in the country. Newly established sub-national units needed to gather information for their own planning and transmission of requisite data to the national level. Changes in governance affected many of the implementation activities of the DHIS2. Health workers that were initially within the DHIS2 core team at the central level moved to various sub national units. This reduced the central control and supervisory role. Due to the high number of counties (47), most county health information officers did not receive adequate training in connection with their new roles, leading to poor use of the system. All these, coupled with the counties' loose connections to the national level, had a big effect on the newly launched DHIS2.

Summary of Chapter Three

This chapter has highlighted the background information about Kenya health system and the entire governance structure. The chapter has also documented a complicated government structure that emerged following the devolution of health services as per the new constitution (Kenyalaw.org, 2010).This massive restructuring affected all aspects of the country's health system, including the implementation of a web based information system, the DHIS2. To investigate these effects, the next chapter gives an elaborate methodology. The chapter will cover all aspects of methodology including the study designs, data collection modalities, data analysis and ethical considerations. The background information from chapter three will play a critical role in understanding the methods section. It will make it easy to understand the type of organizations visited during the study.

4 Chapter Four: Methodology

The objective of this thesis is to understand the institutional incentives involved in the devolution of health systems and how these shape the effectiveness of HIS in terms of data quality and information use. This chapter summarizes the research methods used in the thesis. Section 4.1 gives the study design and clarifies my epistemological and methodological positions. In section 4.2, I describe my role in the research process while section 4.3 provides information on the study population, which includes groups of people and organizations that participated in the research at various levels. Section 4.4 gives the data collections methods. The study adopted five processes of data collection; analysis of DHIS2 database, performance review meetings, key informant interviews, DQAs and participant observation. In section 4.5, I provide details of my data analysis methods, which utilizes both quantitative and qualitative analytic approaches.

4.1 Study Design and Epistemological Position

This thesis utilizes a longitudinal case study design, which according to Cornford and others (2005), is suitable for gathering detailed and specific information on events in their natural settings (Cornford & Smithson, 2005). In a case study, the researchers devote themselves to the specific situation, and the reward is a richness of data, obtained by multiple means (ibid). This exploration often needs to have a certain time span, as a snapshot of a situation, cannot capture the process of change. Yin (2003) further posits that a case study method is best suited to answer questions of "why and how"(Yin, 2013). The case study design enriched my research by providing empirical data to complement my implementation experience (Miles, Huberman, & Saldana, 2014). The longitudinal nature of the design allowed me to follow developmental trends across the various stages of the project. By tracking events and people, observed changes are more accurate. One drawback of longitudinal study designs is that they take a lot of time and are expensive.

Research (whether quantitative or qualitative) is based on some underlying philosophical assumptions about what constitutes valid research and which research methods are appropriate (Myers, 1997). In order to conduct research, it is important to know what these assumptions are. The most pertinent ones are those that relate to the underlying epistemology, which guides the research. Epistemology refers to the assumptions about knowledge and how it can be obtained (Klein & Myers, 1999; Myers, 1997). Orlikowski and Baroudi (1991) suggest three categories, based on the underlying research epistemology: positivist, interpretive and critical (Orlikowski & Baroudi, 1991). Interpretive studies generally attempt to understand the study phenomena through the meanings that people assign to them (Walsham, 1993), suggesting that reality is acquired through social constructions such as customs, norms, artefacts and other social constructs (Klein & Myers, 1999; Walsham, 1993). Interpretivism is thus an epistemological position concerned with approaches to the understanding of reality and asserting that all such knowledge is necessarily a social construction and thus subjective. I adopted an interpretive epistemological position, which I found to be suitable for gaining an in-depth understanding of the interactions surrounding the devolution of health systems and their effects on the implementation of HIS in Kenya.

4.2 My Own Role in the Research Process

As a medical doctor employed by the Kenyan MoH, my task was to oversee the implementation of an effective HIS, capable of producing high quality data fit for use in evidence-based decision-making. During the research process, I went to the field with some knowledge and concepts such as how to use the DHIS2 software, user participation, socio-technical complexity and network of actions. Considering the rapid development of DHIS2, an updated understanding of the system was required, so I took up the role of linking the MoH to the developers of DHIS2 at the UiO. Like in many research studies, two different roles namely, that of an outside observer and of an involved researcher exist (Walsham, 1995). From an interpretivist perspective, I classified myself as an involved researcher since I was part of the MoH team for the entire period of study. To clarify my dual role as a researcher and an employee, I received a study leave from the MoH enabling me to join the UiO, but retained my role as the leader of the DHIS2 implementation team, a position I held since 2010. The merits of this position were that I got an inside view, and was not barred from confidential or sensitive issues. On the other hand, as an involved researcher, I ran the risk of appearing as someone with a direct personal stake in various views and activities.

For this study, I actively participated in selecting the study sites, arranging for international support and giving my opinions in the study as one of the MoH employees. One of our research interventions included data use and database cleaning workshops. As this required health professionals with skills in analysing indicators and making reports, I provided capacity building to the data managers in data analysis and presentation of the information in charts, tables and maps in preparation for the meetings. I also attended planning meetings at regional and national levels in both capacities as a researcher and an employee, contributing to debates regarding the implications of the data for public health.

During the study period, the UiO played a key role. The university coordinates the development of DHIS2 as a tool that supports the building of national HISs to improve information for action (UiO, 2014). The DHIS2 is a database tool for collection, management, analysis, and presentation of aggregate statistical data, tailored to integrated health information management activities (Dhis2.org, 2017). Through training, education (PhD programs- including my own) and research, the UiO focusses significantly on information use. In this study, the UiO through the Health Information System Program (HISP UiO) gave technical support to the country for customisation of data entry tools, training on server management and cleaning of the HIS database. At the same time, the university exposed me to implementation of similar projects in South Sudan, Somalia, Burundi, Eritrea and the East African Community. These international missions richly improved my work on the Kenyan project. My global networks were very fruitful since I also got support from the global team especially in areas of server management.

4.3 Study Site and Study Population

We conducted the research in administrative units that were responsible for managing HIS at both national and selected county governments. At the national level, the mandate for managing HIS falls in four different units: the HIS, the e-Health, the Monitoring and Evaluation (M&E), and the Research and Development. In addition, the MoH has a separate unit in charge of ICT

which assists HIS in IT related processes although the staff are part of the ICT Authority in the Ministry of Communication and Technology (Icta.go.ke., 2017). The ICT Authority works directly with the ICT unit in the MoH to draft governance manuals that establish security, mobility, and web technology standards, while the e-Health unit oversees the enterprise architecture of electronic health records and releases guidelines for the development of EMR systems (M.O.H, 2011). Officers from these HIS units together with senior directors of medical services formed the study population at the national level MoH.

Besides working with national MoH teams supporting HIS during the research, I also worked with a local Non-Governmental Organization (NGO), called Afyinfo, whose responsibility was to support the MoH in HIS work. Afyainfo received bilateral funding from United States Agency for International Development (USAID) and provided technical support in database management of HIS. Since the hosting of DHIS2 required a secure environment with specialized ICT experts, the country saved money through external cloud computing (at Digital Ocean). Apart from other aspects of HIS, Afyinfo specifically worked together with the experts in the HIS units at the national MoH to coordinate all the activities of the day-to-day running of the servers hosting the country's DHIS2 database. Members of Afyinfo formed an important study population for my study.

At the sub-national level, each county has a HIS unit with a designated County Health Records and Information Officer (CHRIO) as the team leader. This team is responsible for data flow from health facilities up to the national level. They coordinate the distribution of data collection tools and computerisation of data. They also support other hospital information systems e.g. EMRs, IDSR and vital statistics. All other departments at the county e.g. EPI, have a monitoring and evaluation officer who works closely with the HIS team. At the county level, the county directors, health records and information officers (HRIOs), monitoring and evaluation officers in various programs constituted my study population.

4.4 Key Methods Adopted by the Study team for Data Collection

I used different qualitative and quantitative data collection techniques/methods including interviews, observations, discussions and document analysis for gathering data from empirical sources. Data came from five sets of processes: (a) In-depth analysis of the DHIS2 database (b) Performance review meetings (c) key informant interviews (d) Data quality assessments and (e) participant notes from the implementation of the DHIS2. Although I provided detailed data collection methods in the specific research papers forming the basis of this thesis, I use this section to highlight the key methods adopted by the study.

Performance Review Meetings

Every year, MoH has a planning cycle during which health managers at various health levels (e.g. national, county) make plans for implementation in the budget year. In these plans, the health authorities set targets for the year. Once the counties approve these plans and fund them, they organize joint quarterly meetings to review their performance as per the targets. I organized such performance review meetings for Busia, Homa Bay, Machakos, Nairobi, Kisumu, Siaya and Uasin Gishu counties during 2015 and 2016. As an employee of MoH at the national level,

I coordinated these meetings, which not only provided vital data for my study but also provided important information for both national and county governments. I used convenience-sampling technique to select these counties. Convenience sampling is a statistical method of drawing representative data by selecting units because of their availability or ease of access (BusinessDictionary.com, 2018). In this study, the main criterion for the convenience sampling was geographical proximity of selected units to each other. Since the focus of the study was in the western region of Kenya, so I selected counties close to each other in the former Western Province of Kenya through the convenience sampling. In addition, I added Nairobi, being a city with unique environment and another county close to Nairobi (Machakos) to the list. The advantages of this type of sampling was to facilitate quick data gathering. The disadvantages are the risks that the sample might not represent the population as a whole (BusinessDictionary.com, 2018).

I invited the following groups of people to the meetings, MoH directors at county, Hospital in charges, data managers and development partners. In addition, participants from all the health program areas with emphasis on HIV/AIDS, MNCH, TB, malaria and reproductive health attended. These joint meetings progressively reduced the need for multiple and expensive disease specific performance review meetings. The bulk of data for these meetings came from the HIS, providing a good opportunity to assess the quality of data from HIS. The meetings facilitated intense sharing of information. Figure 10 shows a picture taken during one of the meetings,

Figure 10: Picture of Participants Attending One of the Performance Review Meetings

To prepare for these meetings, I supported the counties to carry out a host of preparatory activities e.g. data mining for performance report compilation, verifying data accuracy, and establishing the status of timeliness and completeness of their regular reports. The national MoH, with support from the development partners, particularly Afyainfo, supported these field visits financially. To get these data, research teams comprising research assistants, county data managers and national MoH staff visited selected health facilities for data collection. In each of the participating counties, the research team, in consultation with sub county managers selected health facility sites using convenience-sampling methodology with bias towards health facility type (County Referral Hospital/Sub-County Hospital, Health Centre (High Volume), Dispensary) and geographical proximity. Each county team reviewed and identified gaps relating to relevant data collection tools, personnel and IT infrastructure. To get accuracy of data, the team conducted data quality assessments at health facilities. They presented these findings during performance meetings that lasted five days at the county headquarters. For this study, each county participated in two successive quarterly review meetings during the years 2015 and 2016. During the meetings, I picked all the presentations from the counties and summarized them. From these presentations, I conducted interviews with the data managers and director to get more in depth understanding of the situation in the county. I collected data through notes accruing from discussions in the presentations. For all the presentations, I summarized the achievements, challenges recommendations and way forward from all the presentations and analysed them. Figure 11 shows a sample of data retrieved from the presentations for one Sub County.

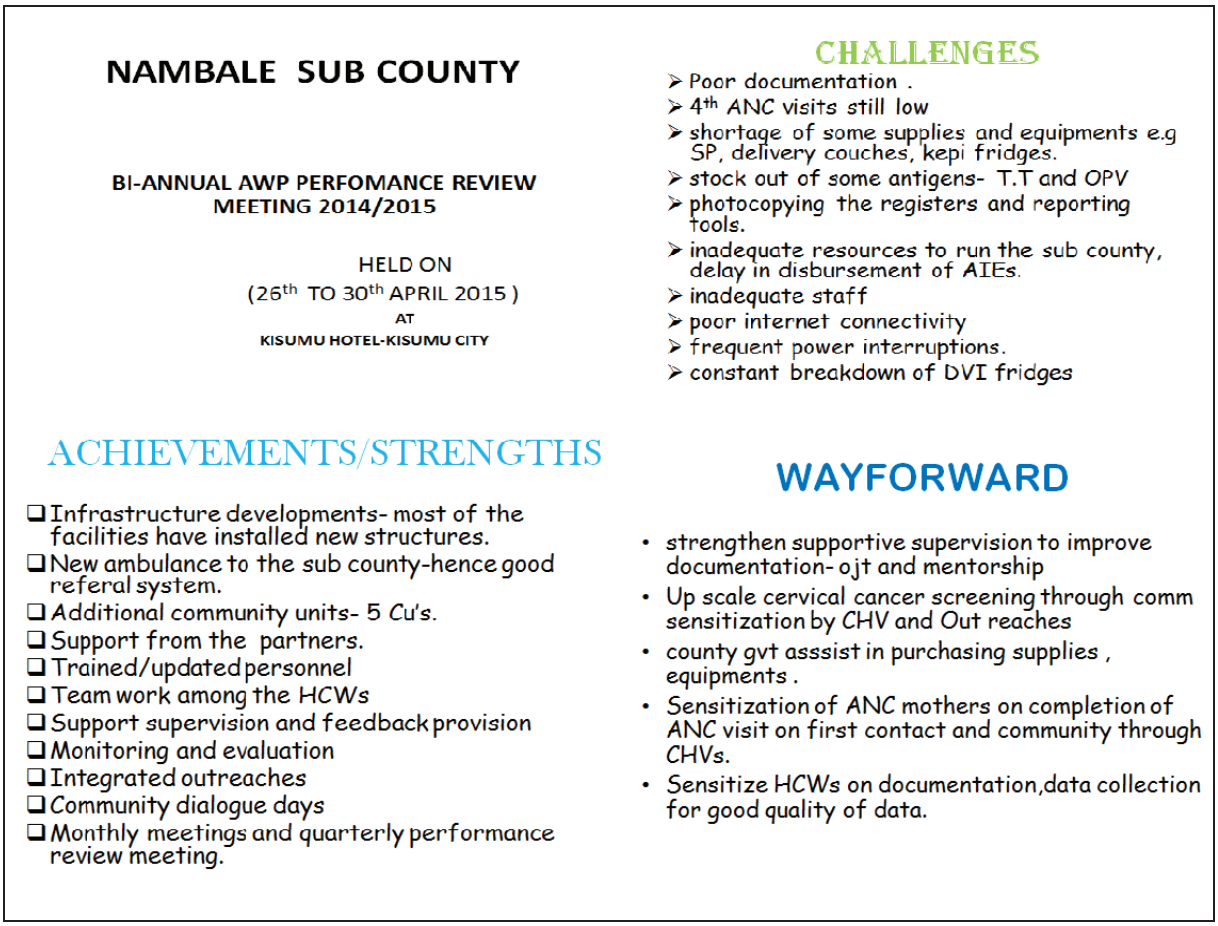

Figure 11: Summary of slides from presentations

Key Informant Interviews

I conducted key informant interviews during the field visits and at performance review meetings. Interviews offer researchers the chance to explore topics in depth and to gain appreciation of the context within which the interview was conducted (Cornford & Smithson, 2005). There are essentially three types of interviews, structured, semi structured and unstructured. Unstructured interviews, which provide the possibility of getting more information from the participants (Christensen, Johnson, Turner, & Christensen, 2011), have the most relaxed rules of the three. In this type, the interaction between the participant and the researcher is more like a conversation than an interview and researchers need only a checklist of topics for the interview. In this study, I interviewed key informants to understand what they believed to be key challenges and advantages of devolution, the availability of ICT infrastructure and identification of any special data needs. My targeted audience for the interviews were:

a. Heads and staff of HIS Units at the national, County, the sub county and health facility levels, who were actively involved in the running of their HIS

b. People who did not have the in-depth background on HIS but needed to have a general overview of its components because they were members of Multi-Disciplinary Committees tasked with overseeing the development of the HIS in their country- political wing of government at the county level

c. Managers and staff of vertical programmes whose responsibilities included any component of the information system of their respective programmes

All the interviews adopted the unstructured approach. To avoid missing some aspects of the study, I prepared a small guideline on relevant topics, although I had the discretion on how deep to engage an informant. A copy of the interview guide is in appendix I.

In total, I interviewed 55 participants as shown in table 5.

Table 5: Summary of Participants Interviewed During Meetings

Type of informants interviewed	No
Senior government officers	12
Health records and information officers	26
Bilateral donor agencies	10
IT officers	7
Total	55

Data Quality Assessments (DQA)

To assess the quality of data in the selected counties, I supported the selected counties Busia, Homa Bay, Machakos, Nairobi, Kisumu, Siaya and Uasin Gishu) to conduct a series of DQAs from March 2015 to August 2016 with the main objective of establishing the accuracy/reliability of the data in the national reporting system (the DHIS2). In simple terms, I

wanted to measure how much data are lost during transmission from source documents to the electronic database. To do this I used a modified version of the Routine Data Quality Assessment (RDQA) tool developed by MEASURE Evaluation (WHO, 2011). To help me in data collection, I constituted a team comprising representatives of the local health administrative office, senior data managers from the county, the officer in charge of each of the health facilities visited and the research assistants. Team composition included officers with mixed skills including public health (to support in the disease area and indicators), Program officers (e.g., health records and information officers) and relevant regional administrators. My role was the team leader.

To understand the process of DQA, it is important to give a preview of data flow in health facilities. Apart from delivering services, health staff at the health facilities are responsible for documentation and compilation of health data. Health workers at health facilities (hospitals, Primary Health Care Centres, community units) record data in paper registers (Antenatal Care, Delivery, Outpatient Department for Adults and Children, and Expanded Programme of Immunization) as they deliver their services. The staff involved in the data processing at health facilities are typically busy nurses with limited HIS skills. At the facility level, there are up to 13 registers depending on the services offered (Immunization, family planning, antenatal care, deliveries etc.). The registers are quite detailed, showing all the patient personal identities (name, age sex), address (village of residence), the diagnosis and treatment given. Data from these registers are then summarised using pre-defined summary forms. On a regular basis (weekly, monthly and quarterly), these summary forms are then transported by road to the Sub-county health records offices (formally district), where they are transformed into the electronic formats through entry into the DHIS2. Designated officers at the sub county level scrutinise the data received from health facilities for completeness and correctness before entering them in the system. Thereafter the data become available to all authorized persons at county, national and other stakeholders. This flow of data is prone to some challenges. Performing data quality checks helps discover some of these challenges, with the view of improving data use for decision-making.

To check the accuracy during DQA, we compared data representing immunization, reproductive health and outpatient services in paper formats with the same data in the electronic format (in DHIS2). Specifically, we verified data from the following: a) The number of children under one year who had received all the recommended vaccines (fully immunized), b) The number of pregnant women who had delivered in health facilities and c) The number of children under five years who had been treated for malaria in the outpatient department. In each of the participating counties, the audit team in consultation with sub county managers selected health facility sites using convenience-sampling methodology with bias towards health facility type (County Referral Hospital/Sub-County Hospital, Health Centre (High Volume), Dispensary) and geographical proximity. A limitation of the convenience sampling methodology was the inability to use the results for inferences or generalizations about all the sites, or a group of sites, or the wider region.

The audit team verified (recounted) data for the selected indicators from source documents (paper registers) at health facilities and compared them with data at intermediate level of

aggregation (sub county) and the DHIS2 (the highest level to which data are reported). Figure 12 shows a photo of an Officer Inspecting Records during DQA in a health facility in Uasin Gishu County.

Figure 12: Photo of an Officer Inspecting Records during DQA in a health facility

The team entered the data in the RDQA tool that was configured in a way that once data were entered; the accuracy was automatically calculated. The team presented these preliminary results to the health facility in charge before moving to a new facility. Table 6 shows a sample of data entry during the DQA.

Table 6: Data Entry in the RDQA Tool

	Recount results from source documents, compare the verified numbers to the site reported numbers and explain discrepancies (if any).	
4	Recount the number of people, cases or events during the reporting period by reviewing the *source document*s. **[A]**	**5**
5	Enter the number of people, cases or events reported by the site during the reporting period from the site *summary report*. **[B]**	**10**
6	**Calculate the ratio of recounted to reported numbers. [A/B]**	**50 %**
7	What are the reasons for the discrepancy (if any) observed (i.e., data entry errors, arithmetic errors, missing source documents, other)?	

Source: Courtesy of the Measure Evaluation

Field visits provided me with first-hand information on data flow and a chance to document devolution in action. While at the health facilities, I reviewed all the documents involved in the management of HIS. These included various registers, summary tools, and annual reports. Apart

from the review of paper formats of the reporting tools, I also evaluated the reports as they appeared for the facility in the online system, DHIS2. This assisted me in checking the correctness of the names of the health facilities and the consistency in reporting. I evaluated data completeness by inspecting the summary reporting tools for any unfilled slots. I checked for the timeliness of the reports from the DHIS2 by using the reports module that estimated the reporting rates based on the reports received on time. I recorded these findings using participant's notes, predesigned forms and pictures

Exploratory review of DHIS2 Database

I conducted an exploratory analysis of the entire DHIS2 database between 2015 and 2017. The main aim of this review was to find out if the metadata of the DHIS2 database was well structured and come up an executable plan of action. Taking the leadership, I coordinated the exercise with support from officers at the MoH headquarters, development partners and technical assistants from the UiO. The assessment focused on the following components of the metadata of the DHIS2 database: data elements and their associated category combinations (category option, categories and options for tracker), indicators, user module and validation rules. I also checked on the various data outputs such as charts, tables and maps. In all these, I evaluated their naming conventions, the associated datasets and data collection frequencies and their groupings. I also checked the data for the following

a. Data outside the data collection range (aggregate & tracker)
b. Values, which were not matching the data Element types (e.g. decimal values in Integer type)
c. Identifying consistency issues e.g. Spikes in values and percentages, which were above 100%.
d. Data quality checks (using various DQA tools in DHIS2) and population data

In addition, I reviewed all messages in the Kenyan DHIS2 from 2011 to 2014. I downloaded all the messages for the period under review and performed analysis based on the following criteria: sender, topic of message and the date of the message. Other aspects assessed included interoperability in order to understand the relationships between the DHIS2 and other systems. I assessed all these components in details.

4.5 Data Analysis

This study applied mixed method analysis, utilizing both quantitative and qualitative methods in addressing some of the emergent issues (Myers & Avison, 2002; Yin, 2013). This was because it was not possible to use only one approach. This has been supported by Kaplan (1988) who argues that no single approach of data analysis is adequate to provide the richness required in information system research (Kaplan & Duchon, 1988). I used quantitative analysis to get results regarding data quality attributes like accuracy, completeness and reporting rates. This approach was particularly relevant during the analysis of DQAs. I used qualitative analysis for data derived from meetings, participant observations and key informant interviews to understand the observed phenomena. This section describes my overall data analysis for the study.

Quantitative Analysis

In this study, quantitative data came from the health facility visits and the review of the online DHIS2 database. According to Babbie (2015), it is essential that quantitative research asks questions that can be measured and answered numerically, such as: What percentage of data were transferred correctly from registers into the computer (Babbie, 2015)? Analysis of such data involves techniques by which researchers convert data into numerical forms and subject them to statistical analyses. The numerical representation and manipulation of observations helps in describing and explaining the phenomena that those observations reflect (Babbie, 2015). Common outputs of quantitative analysis include percentages, frequencies and means.

In doing the quantitative analysis, I referred to my theoretical perspective, which seeks to demonstrate how devolution provides institutional incentives that shape the effectiveness of HIS in terms of data quality and data use. Quantitative analysis was particularly rich in measuring the HIS outcomes of data quality e.g. the accuracy timeliness and completeness. Figure 13 shows the areas for qualitative and quantitative analysis on the theoretical framework.

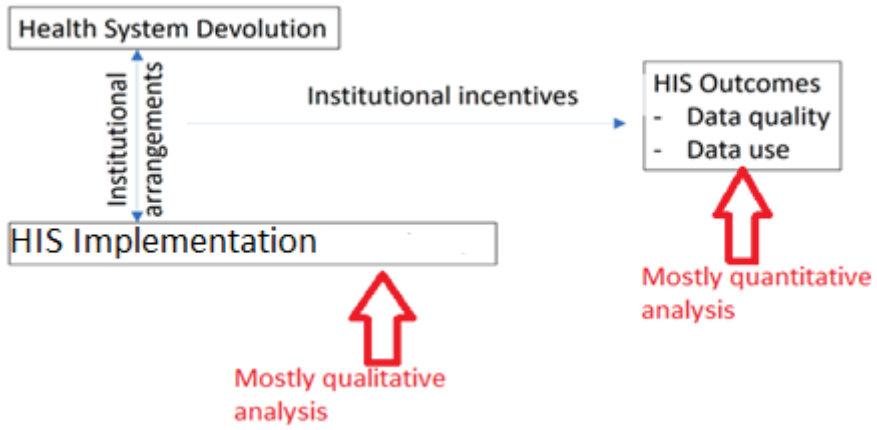

Figure 13: Theoretical Perspective Showing Areas for Qualitative and Quantitative Analysis

I used quantitative analysis during DQA (discrepancies in reporting between source data documents and DHIS2), the analysis of the DHIS2 database, to provide completeness rates for reports, reporting rates and comparisons between reporting rates. To determine the accuracy of reported figures in the national DHIS2 database, I reviewed the primary data sources for the same health facility and time. The aim of this data audit was to show how much data were lost in the process of transfer from primary sources and determine if the loses affected specific data elements than others. After documenting the data for specific elements from the registers, I retrieved the same from summary reporting forms (from registers, officers summarize the data into summary reporting forms and sent to sub county offices for computerisation into DHIS2). These data were entered in a table and ratios calculated by dividing the data in secondary data source by the data from the primary source. For this study, I called these calculated ratios, verification ratios. I obtained verification ratios, for the transfer of data between registers and summary forms and from summary forms to DHIS2. I compared these verification ratios across health facilities and indicators. To do this, I computerised these quantitative data analytic outputs (counts, percentages and ratios), using Microsoft Excel and later exported to Epinfo 7

software for further analysis to compile a list of health facilities and indicators with the highest data quality problems. I presented the results in graphs and tables. During the study, we conducted two successive data quality audits, so I used the comparison of data quality between the visits to determine any improvements in reporting practices. I published some of the findings in paper IV (Reporting Practices and Data Quality in Health Information Systems in Developing Countries: An Exploratory Case Study in Kenya. Table 7 is an example of data from one health facility for a specific month.

Table 7: Documentation of Data Quality Audits

		Verified numbers in			Verification Ratios	
Data element	Register	Register (A)	summary forms (B)	DHIS (C)	B/A (%)	C/B (%)
Deliveries	Maternity	294	294	294	100 %	100 %
Malaria	OPD	183	77	77	42 %	100 %
Fully immunized child	EPI	66	67	67	102 %	100 %

I used l quantitative analysis to assess the messages in the DHIS2 database. I downloaded all the messages for the period under review and then classified them according to the following criteria: sender, topic of message and the date of the message. At the time of study, messages originated from various groups of people including the system developers and users. To get an understanding of the type of messages, I classified the senders of the messages in four main categories: National DHIS2 core team, University of Oslo team and other users. All these senders had different functions, for example, the national DHIS2 core team and the University of Oslo team were the administrators of the system while other users had functions ranging from data entry to data viewers. One of the tasks of the review was to compare the frequency of messages from each category against time. The next step was to group the messages according to the message content or the topic of discussion. For instance, I classified a message that appeared to carry an instruction from one group of users to another as 'communication'. Communication messages typically originated from a higher administrative office directed employees to perform particular tasks, for example data entry. I classified other messages as 'general', since most of such messages discussed other issues not related to the system or just passing general information to specific users as seen in the following message from a user on 2013-10-10: "I think I forgot my cell phone in your car". We also had some messages questioning the 'quality of data' and others requesting for 'new features' in the system. All the messages were analysed along these classifications and presented in graphs and tables. Table 8 shows a sample of messages downloaded from DHIS showing classification according to the sender, message type and date. I published the findings in paper II (The Use of Social Learning Systems in Implementing a Web-Based Routine Health Information System in Kenya) of this thesis.

Table 8: Messages Downloaded From DHIS2 and Classified By Message Type, Sender and Date

Sender	User Role	Message	Classification	Date
Ayub Manya	HIS team	Kenya celebrates a new beginning in Health Sector Information Systems-Launch of DHIS	Communication	21.02.2012
Daniel Kongai	Program	Greetings	general	10.10.2013
Lars Helge Øverland	Oslo Team	Great Job	General	19.03.2012
Samuel Cheburet	HIS team	Appreciation to DHIS facilitators	General	15.05.2013
Waweru Samuel	District	request for powers to access reports for all facilities in nyandarua county	New Requests	01.05.2013
Ayub Manya	HIS team	Reporting rate being less than 100% and all reports are in the system.	Quality	19.06.2012
John Ollongo	District	Discrepancy between standard report and pivot summary - immunization	Quality	22.06.2012
Shinichi Suzuki	HIS team	Erroneous number of reporting facilities	Quality	12.09.2011
Beatrice Wamwayi	District	DHIS training	Training	20.06.2012
Jeremiah Mumo	HIS team	DHIS training	Training	20.02.2012
Irene J Chelagat	District	Correction: Putting in coordinates for Health Facilities	Use	22.02.2012

Qualitative Analysis

Qualitative Data Analysis (QDA) is the range of processes and procedures whereby we move from the qualitative data that have been collected into some form of explanation, understanding or interpretation of the people and situations we are investigating (Myers & Avison, 2002). Qualitative analysis helps to contextualize and support our interpretation of the quantitative interviews and observation. In this study, data for qualitative analysis came from participant notes during fieldwork, deliberation from meetings and key informant interviews. I took an Interpretivist epistemological philosophy with the idea of examining the meaningful and symbolic content of texts and observations made (Orlikowski & Baroudi, 1991).

In performing my analysis, I considered my theoretical perspective. Content thematic analysis techniques were employed in analysing qualitative data. In the first step, extensive notes taken during interviews, FGD and observations were reviewed by the assessment team to identify demonstrable elements in line with the objectives of the assessment through a manifest content analysis. In the next step, we conducted an interpretive reading of the demonstrable elements through a latent content analysis to derive themes.

We used qualitative analysis for data derived from meetings, participant observations and key informant interviews to understand the observed phenomena. Content thematic analysis techniques were employed in analyzing qualitative data. In the first step, extensive notes taken during interviews, FGD and observations were reviewed by the assessment team to identify demonstrable elements in line with the objectives of the assessment through a manifest content analysis. In the next step, we conducted an interpretive reading of the demonstrable elements through a latent content analysis to derive themes. Although I used the computer to summarize,

I did not use a specific qualitative data analysis software like Nvivo. Looking at the raw data, I found some recurring themes in relation to my theoretical perspective. Human resources issues, either inadequate in number or inadequate in capacity building, were among the recurrent themes. Data collecting tools and ICT infrastructures also featured.

I summarized key findings from the managers' presentations from meetings and analysed for particular trends. Figure 14 shows the common trends.

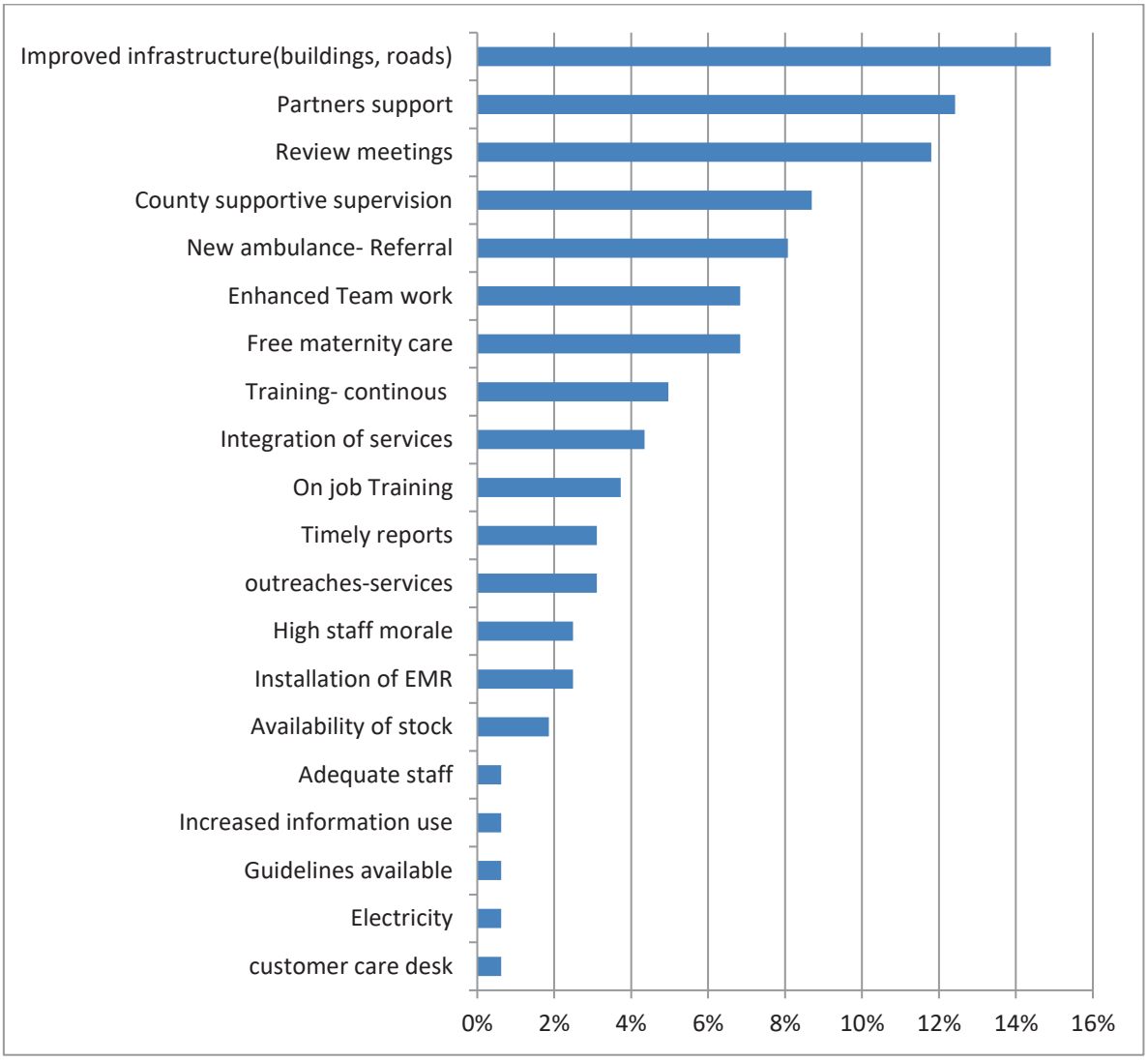

Figure 14: Emerging Trends Arising From Analysis of Presentations during Meetings

I triangulated the quantitative and qualitative data to address the assessment objectives. Preliminary results were discussed with stakeholders in a workshop, which served to seek their views on emerging issues and collect more information to enrich the findings.

I evaluated the institutional arrangements created by devolution. From literature, geographical scope is one of the most important institutional arrangements of devolution. The devolved units elect their leaders and so the leaders are answerable to the electorate (Madon et al., 2010). The other institutional arrangements allowed by the constitution include political autonomy where the national and sub-national governments communicate mainly through policies without direct supervision (Kenyalaw.org, 2010). Devolution of authority creates the ability for the devolved units to make decisions. During my analysis, I considered how these institutional arrangements interacted with HIS implementation. Health information system, which is part of a larger national or sub-national organization unit, is composed of people, procedures, data, hardware and software (Silver et al., 1995). For instance, I checked how the geographical autonomy affected the people, process and technology in HIS. I evaluated the participants involved in these interactions, what their stakes and resources were, and how they were linked to one another and to the HIS outcomes in question. For this study, these stakes constituted institutional incentives. Specifically, I attempted to identify the types of actions that actors took, the type of information available to them, how the actions led to the outcomes, and how rewards or punishments were meted out, in light of the actions taken or outcomes achieved. I then used the findings to predict the actions and aggregated outcomes that are most likely, given the structure of the incentives. This allowed me to predict the incentives or disincentives favouring the actions. After the first analysis, I presented the themes in the next meeting with the county management teams to get a more in-depth understanding of the observation. If these empirical settings, including meetings and consultative discussions with key informants verified the assumptions presented to them, I then adopted the explanations for the observations. In figure 12, I show my process of analysis in which I was looking for the institutional incentives that emerge following the interactions between the devolved health systems (devolved decision making, election of leaders and geographical autonomy) and HIS (People, process, technology) and how these incentives shape the HIS outcomes (data quality and use). Health information systems outcomes eventually have an influence on other organizations like national MoH, county governments and implementing partners. The main objective is to identify the incentives (a, b and c). Figure 15 shows the interactions between devolved Health systems and HIS implementation, and how these influence the effectiveness of HIS in terms of data quality and information use for informed decisions.

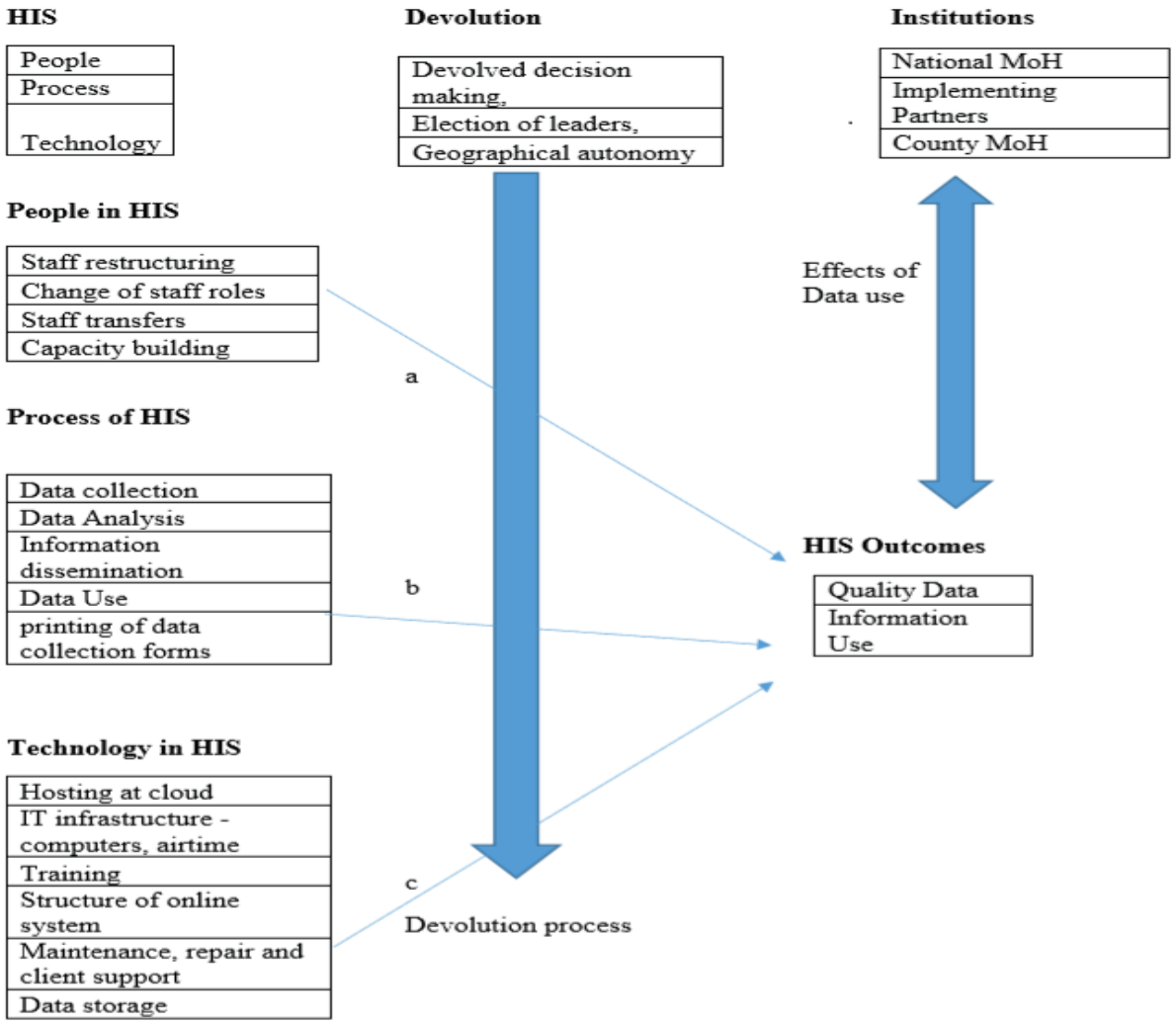

Figure 15: Interactions between Devolution and HIS Effectiveness

4.6 Ethical considerations

This was a unique study, which involved observation of regular work at the MoH, while at the same time learning from it in a structured manner with specific research questions. While in principle the study was part of the implementation of a national health information system, I used the participant notes and experience from the implementation of the project to form a major part of this thesis. In so doing, I encountered an important ethical consideration, which has been highlighted by Walsham (2006), who posits that, there exists a gap between the expressed purpose of the research and the broader agenda of the field researcher (Walsham, 2006). To address this ethical consideration, I presented my research protocol to Kakamega County for approval and a copy of the approval letter is in annex II. Besides the approval letter, I kept data obtained from the research confidential, without sharing with unauthorised persons. Furthermore, the study did not introduce any new invasive procedures nor did it expose the participants to any unethical practices. I obtained data from regular planned meetings and routine DQA to come up with the reports that were also useful in the implementation of the county health systems. Wherever I used interviews to gather data, I obtained verbal consent from the participants and their participation was voluntary. Even when external support for instance from the university of Oslo was provided, the technical assistants maintained all the ethical considerations.

During the study, I maintained the confidentiality as promised, and I did not use any identifies e.g. names in any of my publications or in this thesis, thus maintaining the trust bestowed on me as an involved researcher. For the publications that arose from the work, I received the required consent from the government and I shared the papers with the relevant organs of the ministry. As the principal researcher, I had two major roles, an external researcher and an employee of the MoH. These different roles gave me access to sensitive internal organizational data. Due to the sensitive nature of some of the issues, like corruption, I have not included them in my thesis, probably losing some of the richness of the findings.

Summary of Chapter Four

This chapter has elaborated the various methods used in data collection and analysis. The chapter has clearly shown the selected study design in answering the research question. It has also indicated the epistemological philosophy taken by the principal research and the role of the principal researcher in the study. In this chapter, I have shown the study site, study population and data collection methods. Following data collection, the chapter shows how the data were analysed using both quantitative and qualitative analytical approaches. Finally, the chapter discusses the ethical considerations in the study. This chapter therefore prepares the next chapter, which now shows the results arising from the data collection and analysis.

5 Chapter Five: Findings

In this chapter, I give a summary of the papers that form the basis of my thesis. I published five papers either in peer reviewed journals or presented in conferences. In all these papers, I was the first and corresponding author. During the preparation of the papers, I took leadership in data collection analysis and drafting of the manuscripts. I received substantial support from my co-authors at all levels of the preparation of the papers. In this chapter, I will discuss the following aspects of each paper: Purpose and background, Research approach, study findings, theoretical implications, practical implications and contributions to the theoretical framework. In section 5.2, I provide a summary of findings in terms of the institutional arrangements, incentives and their effects on HIS outcomes.

5.1 List of published papers

I. Manya, A., Braa, J., Øverland, L. H., Titlestad, O. H., Mumo, J., & Nzioka, C. (2012). *National roll out of District Health Information Software (DHIS 2) in Kenya, 2011– Central server and Cloud based infrastructure.* Paper presented at the IST-Africa 2012 Conference Proceedings, Dar es Salaam, Tanzania. .

II. Manya, A., & Nielsen, P. (2015). *The Use of Social Learning Systems in Implementing a Web-Based Routine Health Information System in Kenya.* Paper presented at the Proceedings of the 13th International Conference on Social Implications of Computers in Developing Countries, Jetwing Blue, Sri Lanka.

III. Manya, A., Nielsen, P., & Pundo, R. (2016). *Cloud Computing as a Catalyst for Integrated Health Information Systems in Developing Countries.* Paper presented at the 7th Scandinavian Conference on Information Systems, SCIS 2016 Ljungskile, Sweden, August 7–10, 2016, Proceeding.

IV. Manya, A., & Nielsen, P. (2016). Reporting Practices and Data Quality in Health Information Systems in Developing Countries: An Exploratory Case Study in Kenya. *Journal of Health Informatics in Developing Countries, 10*(1).

V. Manya Ayub, Sundeep Sahay, Braa Jørn, Shisia Belina. (2018). *Understanding the Effects of Decentralization on Health Information Systems in Developing Countries: A case of Devolution in Kenya.* Paper presented at the In IST-Africa 2018 Conference Gaborone, Botswana, Proceedings.

Summary of Paper 1: National rollout of District Health Information Software (DHIS 2) in Kenya, 2011–Central server and Cloud based infrastructure.

Purpose and background: This was the foundation paper for this thesis. It outlines a success story of the implementation of a new health information software (DHIS2) in Kenya, which was installed on a central server using cloud-computing infrastructure. The DHIS2 is a database tool for collection, management, validation, analysis, and presentation of aggregate statistical data, tailored to integrated health information management activities (Dhis2.org, 2017). It serves as a facility based data repository or data warehouse capable of addressing both regional

and national needs. Notable attributes of DHIS2 include data entry at health facility level, pre-defined analysis tools, user-defined dashboards (to give a quick overview of the latest data) and Geographical Information System (GIS) interface. The purpose of the paper was to show how the new information system was adopted, rolled out and its effects on the overall implementation of HIS in the country.

Prior to the change of the reporting system, Kenya was using File Transfer Protocol (FTP) to transfer excel based data from the districts to the national level. FTP is a standard network protocol used to transfer computer files from one host to another over the Internet (Rani et al., 2014). District data managers summarized data from health facilities using standardised excel files, and transferred them to a server located at the MoH headquarters. These district-aggregated numbers did not preserve the health facility "identity" of the data, making it impossible to perform analysis of comparative performance across health facilities. By focussing on transferring data to the national level, the health managers performed minimal analysis of data at the point of collection, thus making data use at point of collection difficult. FTP also lacked automatic quality assurance measures (such as range limiters) to avoid common clerical errors. In general, service-based data were incomplete, inaccurate and subject to delays and hence the quest for adoption of a more robust system (Luoma et al., 2010).

Research approach: The initial research approach was action research, which allows one to introduce changes to the complex social processes of an organization and observe the effects of these changes (Baskerville, 1999). In this case, the MoH, with technical assistance from the system developers based at the University of Oslo (UiO) introduced a new software and customised it to suit Kenyan needs. During the customisation period, the entire development team from UiO stayed in Kenya for the participatory action research. MoH would propose a feature to be included in the system and observe how it worked. However, for the purpose of publication of this paper, we reported it as a case study. Data came from participant observation during the implementation period, key informant interviews, desk reviews and analysis of computer systems. The interviews were unstructured, giving more room for discussions on the new system. The paper benefited from both qualitative and quantitative analysis, to establish peoples' opinions on the system and to calculate the reporting rates to populate league tables.

Findings: The paper demonstrated how the rapid development of mobile telephone networks and Internet provided a platform for improving the HIS in Kenya. The adoption of DHIS2 allowed districts and provinces to analyse their own data and even compete in terms of reporting rates through league tables. This was the first attempt of decentralizing HIS, with the help of advanced technology. Technology facilitated quick access of data, increased reporting rates and allowed easy data analysis thereby improving data quality and use. The paper points out some challenges faced by some of the users concerning the use of IT. Nearly all data managers raised the issue of internet connectivity costs and lack of trained personnel in IT. While the paper shows the important role played by advanced technology in the implementation of HIS, it points out the need to invest in significant human capacity on databases, data management and system support.

Theoretical Implication: This paper supports the institutional theory in which organizational fields are agents of change. For this study the organizational fields were professionals in information systems, users of the system and the developers of the software, who imposed coercive and normative influences (DiMaggio & Powell, 1991; W. R. Scott, 1991) to the MoH to institutionalize the use of DHIS2. Confronted with these isomorphic pressures and the availability of appropriate technology including fibre optic cables for internet, the country witnessed a successful adoption of DHIS2.

Practical Implications: The study shows that the customisation of the new software used participatory approach utilizing a dedicated national DHIS2 core team comprising different skills/backgrounds (Public health, Health Records and Information officers (HRIOs), Epidemiologists, Information and Communication Technology (ICT) experts, data managers and a project manager). The practical implication of this approach is that the country had an in-house team that could trouble shoot and maintain the system once the external technical assistance left. The study further revealed that the software had the capacity to link with other databases such as Human Resource management systems (iHRIS) and patient management systems through Standards of exchange, making it possible to integrate the previously fragmented information systems. The system also had data quality checks, effectively availing high quality data for decision making.

Contribution to Theoretical Framework: As opposed to the previous information system (FTP) which was highly centralized, the design of DHIS2 allowed manipulation of health facility and district data, thereby addressing both lower and national data needs. This was the first attempt to perform decentralization through technological approaches, i.e. by adoption of software that put emphasis on district data entry, analysis and use. After the rollout, users had instant access to their own data, from "anywhere" and at "any time". This greatly improved the sense of "ownership" to the data and the system, becoming institutional incentives for maintaining an effective HIS. Furthermore, users were happy that their data could not be affected by local computer viruses because the data were "up there", always available, "on the Internet". Applying my theoretical framework, rapid availability and ownership of data supported by advanced technology became institutional incentives that supported the production of high quality data for use by decision makers. In this case, technology plays a major role as an enabler of both data quality and information use.

Summary of Paper II: The Use of Social Learning Systems in Implementing a Web-Based Routine Health Information System in Kenya

Purpose and background: This paper addresses training, which was the most expensive activity during the implementation of a web based HIS in Kenya. The initial training for the rollout of the system adopted a cascade approach where a small number of people was trained (trainers of trainees), who eventually trained others through residential workshops. Training sessions comprised a combination of theoretical lectures and hands-on practice on relevant topics including data entry, data quality, data analysis and data presentation options (graphs, charts and maps). To reinforce the seminar type of training, the trainers followed the participants to their areas of work to offer on job training and mentorship. The advantage of this approach was

that users got individualized attention within their home working environments. With this approach, it was possible to involve more members of the district management team and address local issues related to computers (both software and hardware).

After the initial training and roll out of the DHIS2 countrywide, there was a disruption of this type of training approach for two main reasons. First, there was a change of the main implementing partner (donor) who was supporting the MoH in running the activities of the HIS and the new donor needed more time to settle and hence could not continue with the training through seminars as had been earlier planned. Second, there was implementation of a new constitution. Due to this, a new social learning through the development of a community of practice emerged. The purpose of this paper is to illustrate how social learning through a community of practice supported the implementation of a large-scale information system in a developing country.

Research approach: This was a case study design. The main source of data was the Kenyan national HIS. We conducted an exploratory analysis of all messages in the messaging module in the DHIS2 from 2011 to 2014. After downloading the messages, we classified them according to following criteria: the characteristics of the person who sent the message, the topic of the message and the date it was send. The category of those who sent the messages (senders) was further sub divided into three main categories: National DHIS2 core team, University of Oslo team and other users. The national and the Oslo teams were the system administrators while the rest of the users had different user roles in the system. The next step in the analysis was the classification of the messages according to the message content or the topic of discussion. We classified messages, which were requesting information on how to use specific functionalities in the system as "use". We also had some message questioning the quality of data and others requesting for new features in the system. All the messages were analysed along these classifications and presented in graphs and tables.

Findings: This paper highlights innovative ways of training people during an implementation of an information system. Due to rapid growth of the system, more people required training, outstripping the possibility of face-to-face training. This called for other forms of learning, including using telephone calls, short messages (SMS) and sending messages through the inbuilt messaging module in DHIS2. The introduction of messaging module in the DHIS2 provided an opportunity for the interaction of a group of knowledgeable people on the software, sharing their knowledge with others. Members of this community would post questions on the system using the messaging functionality and receive answers from colleagues with varying knowledge and experience through the same forum. An Analysis of the messages revealed that the leading topic addressed was how to use the new system, followed by data quality. Collectively, the people who shared knowledge using messages in the DHIS2 formed a community of practice, which proved very useful in the continuous education in support of the software. The internet and cloud-computing infrastructure facilitated the sharing of messages comparable to the social media. The paper shows that social learning, using a community of practice approach can augment the traditional forms of learning in implementing an information system.

Theoretical Implication: This paper contributes to the theory of community of practice. The messaging functionality in the DHIS2 met all the three characteristics of a community of practice (domain, community and practice). The key factors that made our communities effective and durable were the freedom of expression and a willingness to learn from peers.

Practical Implications: The community of practice played a big role in improving the teaching of DHIS2 through enabling members to integrate diverse disciplinary perspectives and exchange of ideas. The fact that the Kenyan DHIS2 implementation continued with minimal classroom type of training, we conclude that suitably designed and resourced, social learning systems can support the implementation of big information systems.

Contribution to Theoretical Framework: The interaction between people with knowledge and those with less knowledge through technology, created an opportunity to learn from each other with the aim of improving the effectiveness of the system. The people with knowledge were motivated to share their knowledge with others and the appreciation of their contribution became an institutional incentive to continue sharing.

Summary of Paper III: Cloud Computing as a Catalyst for Integrated Health Information Systems in Developing Countries.

Purpose and background: This paper shows the role of advanced technology, particularly cloud computing in strengthening HIS in developing countries. Based on a case study of the innovative use of cloud computing for the national HIS in Kenya, the paper shows that cloud computing can enable the integration and harmonization of fragmented HIS and provide real-time information to health managers for evidence based decision-making. However, like any modern technology, cloud computing is no silver bullet; it presents entirely new challenges and obstacles, particularly regarding coping with limited technical expertise, bandwidth, and IT resources. At the same time, cloud computing also suffers from lack of institutional support and legitimacy due to lack of proper policies and regulations. In general, governmental agencies are uncomfortable with storing data on public clouds.

Research approach: The main study methodology for this paper was case study, because it was well suited to answer the research question: 'How can innovative ICT applications like Cloud Computing support the implementation of integrated health information systems in the context of developing countries?' The unit of analysis was the county. We obtained data for the paper through key informant interviews. The stakeholders interviewed included health information officers, health facility managers, senior ministry of health managers at the national level, and the chief executive officers of development collaborators (donors). We used qualitative analysis to come up with write up.

Findings: Cost Effectiveness: Hosting a national and robust system such as DHIS2 requires a secure environment with specialized ICT experts. In Kenya, the ICT staffs do not form part of the skill mix at the MoH; making it very hard to implement some of the complex ICT procedures such as server management. On a monthly basis, the cost of renting international cloud computing services were less than 500 US dollars at the time of study, far less than what the country would use to construct and hire specialized staff to operate and maintain local

infrastructure. This cost effectiveness was an institutional incentive to retain the same services even after devolution. In maintaining a central server for DHIS2 for the whole country, it was possible for stakeholders at all levels of the government to access the data online, avoiding the bureaucracy of seeking permission from the devolved government units. In essence, the use of advanced technology became a centralizing factor in a devolved health system.

Another key finding was the integration of previously fragmented systems. At the start of implementation of DHIS2, only seven data sets were available. The scalability attribute of cloud computing arrangement prompted several donors in Kenya to start integrating their previously parallel systems with DHIS2. This reduced the fragmentation of the previous poorly performing information systems. Having data in one place increased the use of the system, effectively improving data quality, being in agreement with Braa and others (2012) who argue that the use of data improves data quality (Braa et al., 2012).

Technology presented some challenges especially the lack of an appropriate legal framework for hosting sensitive health data on the cloud. However, clients were assured that the commercial cloud providers took care of physical security in terms of controlled access, surveillance systems and onsite security. Other disincentives of advanced technology included the internet connectively, which was not uniformly good across the country, making it hard to access the data on the cloud. This overdependence on internet had on many occasions, delayed important meetings due to lack of data since the internet was not sufficient to download data from the central server. The advice to the users of the system was to make data backups, in order to avoid delays due to connectivity.

Theoretical Implication: The paper further reinforces the institutional theory that explains how organizations change to accommodate new technology. All the isomorphic pressures, coercive, normative and mimetic were at play. While the national government and the professionals provided coercive and normative pressure respectively, mimetic pressures were exerted by other counties, which adopted a central server as opposed to building their own information systems.

Practical Implications: Devolution led to many changes including human resources, but with advanced technology, the flow of data remained the same. Just like before devolution, data generation began at health facilities with summaries sent to sub county units for entry into the system. Access to the data was by authorised users. The use of technology therefore supported both the national and county government to access data without more investment in infrastructure. However, lack of supportive supervision from the national level had practical problems. The fact that management of technology was done by the central government brought some tensions since counties were just on the receiving end and could not even make changes to the system.

Contribution to Theoretical Framework: The main contribution to the theoretical framework is the role of technology. It shows that technology played a big role in the devolution by being a centralizing factor in the devolved health system. By providing ease of data analysis and cost effective access, technology provides institutional incentives towards the effectiveness of HIS.

Summary of Paper IV**:** Manya, Ayub, and Petter Nielsen, "Reporting Practices and Data Quality in Health Information Systems in Developing Countries: An Exploratory Case Study in Kenya." Journal of Health Informatics in Developing Countries 10.1 (2016).

Purpose and background: This paper addresses data quality, which is one of the common challenges facing health information systems in developing countries. The main objective of study was to determine the quality of data in terms of accuracy, timeliness and completeness and establish possible reasons for the observed data quality status. The paper pointed out that while there was evidence of poor data quality in HIS, not all data were of poor quality. The purpose was to explore the incentives for the data of excellent quality, and leverage upon this to improve the information systems.

Research approach: This was a case study design. To assess data quality in terms of accuracy, timelines and completeness, we conducted an exploratory assessment of data in both paper and electronic formats. Data collection involved DQA, key informant interviews and focus group discussions during quarterly review meetings at regional levels. During health facility visits, data from the source documents at health facilities (registers, tally sheets and summary forms) were compared with the data in the DHIS2 for the same period. We inspected the registers to establish the status of completeness in filling them. Health facility data managers were interviewed through unstructured interviews to determine any challenges relating to data collection materials and support from the MoH. We explored data in the DHIS2 with the aim of comparing the accuracy, timeliness and completeness based on field data. We analyzed the data using both qualitative and quantitative methods.

Findings: The study revealed that the completeness rate for the monthly reports was 86.9 percent while the timeliness of the reports was 78.7 percent. In terms of accuracy of the reports, the study showed that while there was a significant amount of low accuracy in many reports evaluated, there was a surprisingly high accuracy of reports coming from the maternity units of all health facilities visited. Further analysis revealed that the accuracy of data emanating from maternity units was attributed to the financial incentives provided by the government to health facilities as part of the country's free maternity care project in which mothers deliver free of charge in health facilities. The study further revealed that the accuracy of the transfer of data from summary reporting forms to DHIS2 was more accurate than the accuracy of the transfer of data from registers to summary reporting forms.

Theoretical Implication: The paper adds to the institutional theory, specifically to the concept of institutional incentives. It shows that institutional incentives such as the financial reimbursements in the maternity units can change the actions of the people working in these units, leading to improvements in data collections. Similarly, verbal acknowledgements of high reporting and completeness rates provide incentives to maintain the observed high rates.

Practical Implications: Involving all stakeholders is important in achieving tasks. Each stakeholder needs to understand the task ahead. This paper shows that people involved in maternity cases were aware that data on deliveries were required for cash reimbursements and so they became more careful. In addition, once the cash was received, the staff working in maternity wards got feedback through improvement of their working space, staff teas, and

procurement of work related equipment. The practical implications are that when data are used, the quality of the data also improves.

Contribution to Theoretical Framework: The main incentive in this case was financial incentive, which went for budgetary allocation at the county level, but a significant amount was directly ploughed back to the maternity wards to improve the general working environment like staff tea and provision of vital equipment like gloves. The number of deliveries then became important to everyone in the health facility, the county and at the national level. For all levels, the reimbursements acted as incentives to improve data quality. Since reimbursement depended on the number of deliveries reported in the DHIS2, this was a classic case of data use. In conclusion, the institutional incentives in terms of financial reimbursements positively improved data quality and use of data.

Summary of Paper V: Understanding the Effects of Decentralization on Health Information Systems in Developing Countries: A case of Devolution in Kenya.

Purpose and background: Devolution of government functions is becoming widespread in developing countries. While there is a lot of literature on the effects of devolution on health systems in general (Collins, 2001; Jeppsson & Okuonzi, 2000), there is a limited number of publications concerning its effects on HIS. The broad objective of this study was to understand how devolution of health systems affected the implementation of HIS. The working assumption was that by giving more power to lower administrative units, the demand for health data for planning and implementation of programs would significantly go up, positively enhancing the quality of data and the culture of information use by the devolved units.

Research approach: Although this was a case study, some empirical data came from action research. We obtained data from extensive desk reviews, DHIS2 database analysis, participant observations from action research, presentations in quarterly review meetings and key informant interviews conducted in eight administrative counties. Data analysis utilised both qualitative and quantitative approaches.

Findings: The study shows that devolution had both positive and negative effects on the effectiveness of HISs. On the positive side, elected leaders had developed a keen interest in data from their areas of jurisdiction, increasing information demand and data quality. Due to the need to analyse data by the lowest elective administrative unit, counties requested the addition of Ward administrative unit to the organizational unit hierarchy of the DHIS2. Some participants argued that it had become very difficult to document false data since the county government had a small area of jurisdiction and were likely to be aware of the event. All the health facilities visited had a health records office or store for data files, signifying the importance of data. During the unstructured interviews, participants were happy with the support afforded by county health managers through implementing partners. The partners were willing to support in photocopying some tools and providing training opportunities for the health records and information officers. Others were happy with the county governments' attempt to implement various electronic medical records (EMRs).

Despite the apparent increased focus on health information systems, majority of participants said that the county governments paid more attention to visible infrastructure developments like construction of roads, procurement of ambulances and construction of new hospital units than on addressing the needs of health information systems. Counties had not even printed new data collection tools. Devolution caused a lot of staff restructuring and movements. The relocated staff decried lack of training on the DHIS2. A key finding concerning the staff relocation was ethnicity. Officers were being posted to take up leadership in their home counties, causing some ethnic tensions. Devolution further weakened the national government's control on the overall governance of the health system, resulting in inadequate supportive supervision from the national level and reduced nationally organized trainings. Analysis of the database of the DHIS2 revealed that the metadata structure and overall organisation of the database had become disorganised. The counties had no role in maintaining the database and the national level did not even have the power or numbers to visit the counties to get inputs in organization of the database. Asked about their opinion on this, most participants were not happy about the situation. They stated that since the national government controlled the database they often saw changes in the system without consultation or orientation.

Theoretical Implication: The paper contributes to the institutional theory and specifically the concept of institutional incentives. The need for re-election for the local leaders created the need to get data about the population they served. The data demand by elected leaders formed an important institutional incentive to change the people working in information systems to produce data for use for planning. Excited by possibilities of promotion to head newly formed units, personnel were willing to take up new positions. The paper is in keeping with the institutional incentive concept which shows that actions done by agents are motivated by some rewards (Ostrom et al., 1993).

Practical Implications: Devolution has many effects on HIS including lack of training of staff, outdated reporting tools , replacement of hard working officers with incompetent ones from the right ethic group and an overall increase in data demand. There is need for both governments to address these issues to achieve a smooth implementation of HIS. This will require proper coordination and collaboration between the national and county governments.

Contribution to Theoretical Framework: devolution created social arrangements, which provided incentives to agents in health systems to act in a way that shaped the outcomes of HIS. For example, the geographical autonomy institutional arrangement brought by devolution gave rise to many incentives. First, it was reported that staff were being requested to work in their home counties, and so the prospects of taking up leadership in their own county of birth became an incentive for the person to relocate. Second, the quest for re-election of the local leader created high data demand, effectively leading to improved reporting. Advanced technology had an interesting effect on my theoretical perspective, by allowing the database to be controlled by the national level, advanced technology become a centralizing phenomenon in a devolved arrangement. The incentive in this case was the ability for county governments to have access to data without putting up new infrastructures.

5.2 Summary of results in the context of the research questions

From the foregoing, I have put down some summary point in the context of the research question. Table 9 shows this summary.

Table 9: Summary of Results in the Context of the Research Questions

No	**Papers**	RQ1: What institutional arrangements arise from the interactions between devolved health systems and health information systems implementation in the context of advanced information technology?	RQ2: How do the institutional arrangements generated by the devolution of health systems create institutional incentives that shape the effectiveness of health information systems in terms of data quality and information use?
I	National rollout of District Health Information Software (DHIS 2) in Kenya, 2011– Central server and Cloud based infrastructure	This is the first attempt to perform decentralization through adoption of a software that puts emphasis to district data entry, analysis and use. The use of technology became a decentralizing phenomenon in a centralized system.	Users of HIS had instant access to their own data from "anywhere" and at "any time". This greatly improved the sense of "ownership" to the data and the system, becoming institutional incentives for maintaining an effective HIS. Technology also allowed data sharing, thereby improving data quality and use.
II	The Use of Social Learning Systems in Implementing a Web-Based Routine Health Information System in Kenya	Technology facilitated community of practice learning through the messaging functionality in the DHIS2.	The people with knowledge were motivated to share their knowledge with others and the appreciation of their contribution became an institutional incentive to continue sharing.
III	Cloud Computing as a Catalyst for Integrated Health Information Systems in Developing Countries	Adoption of advanced technology	Technology allowed both governments to access data, becoming a centralizing factor in the devolved health system. By providing ease of data analysis and cost effective access, technology provided institutional incentives towards the effectiveness of HIS.
IV	Reporting Practices and Data Quality in Health Information Systems in Developing Countries: An Exploratory Case Study in Kenya	Decentralized decision making	The main incentive in this case was financial incentive, provided in maternity units. Since reimbursement depended on the number of deliveries reported in the DHIS2, this was a classic case of data quality and use.
V	Understanding the Effects of Decentralization on Health Information Systems in Developing Countries: A case of Devolution in Kenya.	Geographical autonomy	The prospects of taking up leadership in new counties provided incentives for staff movement from national level to counties. The quest for re-election of the local leaders created high data demand, effectively leading to improved reporting.

Summary of Chapter five

This chapter has provided a summary of results based on the publications. In the next chapter, I will make discussions based on these results.

6 Chapter Six: Discussions and Implications

In this chapter, I discuss the effects of devolution of health systems in the context of developing countries. I use institutional theory to understand how the devolution of health systems shapes the implementation of web based HISs, using empirical data from in Kenya. In theory, the central ministry of health leaders were to exert coercive pressures on counties to adopt the new health information system. Additionally, the presence of a strong professional network composed of health records and information officers would exert their normative pressures to support the implementation, particularly given their concerns about expected benefits from these systems. Finally, mimetic forces resulting from the successful implementation of such systems in other countries would influence the country to adoption. However, the study findings reveal that even though the country rapidly adopted the DHIS2 as the main reporting system through the coercive, mimetic, and normative isomorphic pressures, there were a number of dichotomies or contractions observed. These dichotomies were by-products of the interactions between the devolution of health systems and the adoption of advanced technology HIS using the DHIS2 platform. From a dialectical perspective, the accumulation of these contradictions both within and between institutions provides the seeds of institutional change.

In this section, I will discuss the changes that I observed during the devolution of health systems. These observations include the dynamics between advanced technology and devolution of health systems, movement of staff, the dual role of devolution as driver for data demand and a constraint to data use and the role of development partners in the institutionalisation of an effective HIS. I am not suggesting that devolution always produces these types of dichotomies. Instead, I suggest that as certain social relationships and actions become institutionalized over a long period, they are likely to produce one or a combination of these types of contradictions. In the end, these contradictions are the impetus that drives, enables, and constrains further institutional change. In all these discussions, I will attempt to flag out my theoretical motivation for this study, the role of institutional incentives.

6.1 Human Resources

The study shows that the devolution process had a significant impact on staff. There was almost a complete overhaul of staff. There were many dynamics involved in the staff movements. First, there were those who wanted to move from national to sub-national level while others resisted. To understand the dynamics or incentives involved in the movements of the public health officials, one must consider the generally low salaries they receive, their limited career advancement opportunities, their poor working conditions and types of work assignments. Some of the staff interviewed were worried about career progression, education opportunities and promotion opportunities either at the national or sub-national units. As a result, most staff working at the MoH headquarters preferred to remain in their stations. Besides the uncertainty of the working conditions in the newly created counties, the city based workers considered counties to be in the countryside, with little development and opportunities. Since most of them had established their families in the city, taking up posts at counties would require them to manage two households, one for the family living in the city and a minimal living arrangement for themselves in the counties. As a result, the officers would devote considerable time and

energy in arranging for traveling to the city. Given the low salaries and prohibitive costs of keeping two households, this created resistance of movement from the national level to counties. To accommodate the officers at the national level, the national government sub divided the administrative department of HIS into smaller units, including HIS unit, eHealth, Monitoring and evaluation and planning as reported in paper V. These units had similar duties, making it difficult to provide focussed support to the counties. Members of the DHIS2 core team that had previously coordinated the development of DHIS2 also moved to various sub units, effectively weakening the core team.

With the breakdown of a strong supportive team at the ministry of health and appointment of new county data managers, it became difficult to conduct face-to-face training sessions on various aspects of HIS including DHIS2. Paper II shows that motivated by the need to learn more about the DHIS2, a new form of learning emerged. People at county levels used the messaging functionality in DHIS2 to pass knowledge to each other effectively forming a community of practice. Officers learnt from each other through sending messages and getting answers from peers who had more knowledge in DHIS2. Ultimately, this social learning was very effective in training people on DHIS2 at a time when formal learning was difficult following the onset of devolution. My claim is that devolution of health systems effectively weakened the national government's control in the overall governance of HIS at both national and county governments. Some observers likened the situation to the metaphor from Chinua Achebe's book; "Things Fall Apart; the Centre Cannot Hold" (Chinua, 1958), literally meaning that the counties were lacking support from the national government which could not manage the oversight of all the 47 counties.

Despite the observed resistance for staff relocation from the city, there were those who were excited to move and take up new leadership roles in counties. Apart from academic and skills suitability for the new positions, social issues such as willingness to move and ethnicity were key factors for staff relocation. From participant notes, some staff moved due to favourable working conditions in different counties. This study shows that workers who went to work in counties of different ethnic compositions faced some hostilities. Paper V reports cases of replacement of hard working officers in favour of incompetent ones from the right tribe. The country also witnessed inequitable distribution of available health workforce due to health workers leaving certain counties in favour of others that had better working conditions. In the end, this led to staff shortages, loss of skilled workers to other counties and the lack of clarity in the due process for the transfer of health care workers in between counties. By the time of the study, the country had experienced several industrial actions by health workers in different counties as well as resignation of some health workers (Paper V). Considering that the political rationale behind devolution was to reduce ethnic tensions, this study argues that devolution can increase ethnic tensions instead of solving them. The same argument has been observed in literature (Collins, 2001). On staff movements, my claim is that adequate policies at both the national and county levels are required for smooth deployment.

6.2 Role of Technology

This study presents interesting results of the effects of advanced technology in the implementation of HIS in a devolved government dispensation. Health systems are highly institutionalized, in terms of regulatory oversight and professional roles. They are also operationally and technically complex. This complexity of health systems determine how advanced technology interacts with the devolution process. Previous studies have shown the impact of adoption of advanced technology on individuals and organisations, its impact on health IT has generated mixed results (Lee, Kozar, & Larsen, 2003). In this study, I argue that the effectiveness of the HIS is not only associated with organizational factors, specifically intuitional incentives but also with advanced IT. As computing capabilities become ubiquitously distributed throughout our everyday life experiences, users are enabled to store, mobilize, and interpret the types of information that were not readily available in the past, opening up a vast new vista of opportunities. Information Technology enables health information systems to process large volumes of data (Yoo, 2010), improving access to valuable information for health systems strengthening.

In this study, the use of cloud computing infrastructure was very pivotal. By having the DHIS2 hosted on a commercial cloud, the counties were happy with the arrangements since they did not have to pay for the hosting costs. The national level could easily get data from the system without the bureaucratic ways of asking data from the counties. The database was also management by the national government with support from bilateral partners. In this study, I observe a contradiction where the central government manages the database, going against the spirit of devolution. Therefore, the use of technology become a centralizing phenomenon in a decentralized structure. Asked about their opinion on this, some participants said that even though this saved them the need to establish parallel servers, they were not happy because often saw changes in the system without their consultation. Sometimes the system was down or completely shut down with minimal communication, suggesting that more involvement of database management at all levels was vital.

While technology was seen as a centralizing phenomenon in a devolved system, the opposite was observed during the centralized system. Paper I shows that the use of technology acts as a decentralizing phenomenon in a centralized government. In the paper, we observe how the adoption of DHIS2 and the use of cloud computing infrastructure supported collection of data at health facility level, enabling districts to view their data in a decentralized pattern. Indeed this was the first attempt of decentralization through technology. The study shows that the excellent features of the DHIS2 and availability of internet made it easier for parallel programs to integrate their data into the DHIS2. Similarly, emerging electronic medical records (EMRs) at hospitals were synchronized in DHIS2 though the process of interoperability. This showed that, a properly designed health information system could utilize technology to improve data collection, collation, analysis and dissemination, effectively providing high quality data for public health decision making. These two contrasting phenomena of technology, centralizing and decentralizing suggest an emergence of polycentric approach of government, afforded by advanced Information technology. In essence, there was no pure centralized or devolved system when it came to HIS since technology afforded polycentric approach.

The study shows that the use of technology posed some challenges. The challenges were both technical and managerial issues related to information technology. One major managerial issues was the management of the DHIS2 database. I observed that most of the people managing the servers did not have the requisite skills and knowledge for such huge task. There were periods when the system was slow or totally, down yet there was nobody to address the problem with the urgency it required. An analysis of the database of the web based health information system (DHIS2) revealed that the Meta data structure and overall organisation of the database had become disorganised as reported paper V. Apart from the server management the study shows that data mining from the DHIS2 was problematic due to minimal user training occasioned by the reduced organized trainings. Given the importance of information, it was surprising to find that serious obstacles to the use of data from health information systems were associated with difficulties in acquiring and analysis data from the online DHIS2.

Information acquisition problems derive both from the characteristic of information itself and from the application of modern technology. Training in IT utilizing regular continuous education through seminars, formal education through universities and online learning was encouraged at all levels. The challenges of training adequate staff to manage a countrywide health information system should not be under-estimated. It requires a lot of capital investments and yearly commitments to build systems. Widespread adoption of information technology applications requires behavioural adaptations on the part of large numbers of health workers. This calls for a nationwide commitment of all stakeholders to building an information infrastructure to support the health system.

6.3 Devolution a Driver for Data Demand and a constraint to data use

The previous centralized institutional arrangement for Kenya's health care system allowed decisions taken at MoH headquarters to be conveyed top-down through the provincial administration to district levels. With the adoption of devolution through constitutional change, there were changes in governance arrangements to involve sub national units as well as the involvement of stakeholders in decision-making. In the previous centralized structure, the country had eight provinces reporting to the national level but in the new structure, 47 counties were formed. These were semi-autonomous, communicating with national government through policies with little direct supportive supervision. In other words, the counties took leadership of their health services, requiring data to plan for their service delivery. While the need for data for planning was a good incentive to improve the management of HIS, this study shows that the elected leaders did not heavily rely on local data in the HIS for their decision-making processes. Paradoxically, even though there were institutional incentives towards increased data demand, the incentives to use alternative data for decision-making were greater. Just as observed by Damatew and others (2009) in a study in Ethiopia, this study showed that some managers used their tacit knowledge to make decisions (Damtew et al., 2009). They gained more visibility by the electorate by implementing projects that were easy to measure as well as promoting equipment intensive projects like building hospitals, buying sophisticated medical equipment, buying ambulances, constructing roads and even constructing governors' houses. They realized that the consequences of ignoring data from HIS were minimal. This resulted in less investments in HIS which explains the apparent lack of reporting tools, torn reporting tools and

less attention to the metadata of the HIS database. This highlights the finding that while devolution increased data demand from health systems, paradoxically the elected leaders relied on data from other sources for making decisions, negatively impacting on the information use from information systems.

6.4 The Role of Development Partners in the Implementation of DHIS2

A substantial number of HISs in developing countries are supported by grants and loans from an extensive list of donor organizations. These organizations, which are generally authorised to negotiate only with national governments of recipient countries, create additional institutional linkages that can have profound effects on the success of health information systems. The donor organizations, just like the elected leaders tend to favour implementing projects with indicators that are easy to measure, as well as equipment intensive projects. Hence, the incentives for donor and host government personnel are similar and tend to be reinforcing. For instance, personnel may get some benefits like allowances and funds further learning making them give more time to donor projects then the government ones. It is common to find officers continuously providing support to one donor, based on the incentives received. As a result, the types of projects that receive the most funding by external donors can be better explained by sets of incentives inside both donor and host government agents that are extremely difficult to overcome, rather than by conspiracy theories.

In this study, the implementation of the HIS received great support from DANIDA in the initial stages. Later as the USAID became the prominent supporter, it became difficult to coordinate the support through all the counties. It was during this time that the system was switched off due to non-payment of fees at the cloud computing services. The findings therefore show that over-reliance on bilateral donors can be problematic.

6.5 Understanding the Institutional Incentives in Devolution of Health Systems

The results from the study show that devolution of power and authority from national to sub-national units allows the sub-national units to take full charge of their health service delivery functions. Apart from the devolved decision-making, sub-national units also elect local leaders. In this study, I refer the devolved decision-making, election of local leaders, geographical autonomy and adoption of advanced technology as institutional arrangements. Findings show that these institutional arrangements, arising from devolution of health systems create institutional incentives, which affect the implementation of HIS. I will discuss the institutional incentives based on these institutional arrangements and how they shape the HIS outcomes in terms of data quality and information use. I use the HIS attributes of data quality and information use as proxies for effective HIS because some scholars argue that high data quality influences the use of HIS (Honest C Kimaro & Nhampossa, 2005; Honest C Kimaro & Sahay, 2007), suggesting that a successful HIS is associated with information use. I will draw upon the concept of institutional incentives described by Ostrome (1993) as positive or negative benefits that people obtain from their actions (Ostrom et al., 1993).I will discuss the findings of the study and their implications on the implementation of HIS in the context of developing countries.

A functional HIS is one of the key pillars of health systems (WHO, 2007, 2010). One important characteristic of devolution of health services is the concept the creation of a clear geographical area of operation for the sub national units (Madon et al., 2010). These units elect their leaders and so the leaders are answerable to the electorate. This study shows that the quest for re-election was a major institutional incentive at play regarding decisions taken by health managers. In order to generate plans and evaluate the progress of their area of jurisdiction, the managers demanded data from HIS. Quarterly review meetings were some of the avenues used to review data and assess performance of planned activities. To prepare for these meetings, data managers analysed data for presentations. The fact that data managers spent time on data analysis for presentation in meetings had an impact on data quality, since it was possible to pick up outlier data. During these meetings, the first slides in the presentation typically showed reporting rates of various reporting requirements. Those with the highest reporting rates were recognised and praised, while those with poor performance were encouraged to improve. The simple praises and fears of reprimand improved the reporting rates, accounting for the observed high rates of 78.7% (Paper IV).

One important observation regarding managing a smaller sub-national unit was that there was a possibility that the leaders were aware of some of the events being reported in the information systems e.g. outbreaks and deaths. Occasionally these leaders openly followed the statistics of their geographical areas. I called this phenomenon, "putting a face to statistics". For instance, during a discussion on cause of death of a certain patient, one of the managers who knew the deceased did not agree with the details presented in the report. Such interactions lead to the fear of repercussions arising from reports and can affect data quality. This may occur especially if there are some unpredictable repercussions under which the record may be used as part of the ongoing system of supervision and review. This is one circumstance where the geographical autonomy can became a disincentive in the implementation of a robust HIS.

Faced with a lot of demand for data from the county health management team and other stakeholders, the findings of this study revealed that the data manager at the county level had become very important, attending almost all the meetings. Some communities even coined a local name for the data person ("Ja data"). Further analysis revealed that the reason this position became important was that most other officers did not know how to extract data from the DHIS2. Being the only knowledgeable person, the data manager benefitted by attending meetings (associated with some allowances) and even trainings. While it was a good incentive to the person, it ended up being a disincentive to the larger community, because no work could continue in the data manager's absence.

The study found that when coordination from the national level was difficult, or not forthcoming, individuals at the county levels developed strong incentives to keep their jobs as easy as possible. Since employees find some task more fulfilling, they tend to perform activities of their interest like requesting money to conduct supportive supervision. Most ICT staff for instance, gain greater satisfaction from their involvement in the design of the health information system than from overseeing the maintenance of completed systems. Furthermore, bureaucratic rewards are more likely to go to those engaged in highly visible designs like computer programming than those with the harder to evaluate jobs of organizing effective system

maintenance regimes. This explains why the DHIS2 database was always in disarray. Because it is difficult to monitor how health information officers spend their time, few bureaucratic punishments can be administered to those who work on personal tasks rather maintenance.

An important finding is that involving both lower-level data managers and health facility workers can increase the quality of data available to decision makers. Their trust in the data will rest in part on their familiarity with system and their role in its creation and maintenance, often summarized in the term ownership. This was seen with the case of free maternity project in which pregnant mothers delivered their babies in health facilities free of charge, but the county received reimbursements from the national government for the deliveries. The money, though put in consolidated funds at the county, part of it was kept by the source health facilities to support the staff tea and other minor purchases like gloves. Considering that both the decision makers and the health workers at the health facility benefited from the reimbursements, the quality of data improved, as seen by the accuracy of transfer of data from maternity registers to DHIS2 during DQAs (in Paper IV). My claim is that these simple institutionalized financial arrangements shaped the cognition of managers, employees and stakeholders about HIS and influenced information use for decision-making. This reinforces the argument that the use of data improves data quality (Braa et al., 2012).

6.6 Understanding the Results from DHIS2 Database Analysis

As this was a longitudinal case study, the design allowed me to review the results of the assessment and carry out some corrective measures as part of the study. In this case, the assessment established that the database had shortfalls, which required fixing. The analysis showed that the perceived poor data quality was due to a disorganized metadata structure of the DHIS2 database due to few data quality control measures in place. At the time of analysis, the database had 80 datasets, which collected data on weekly, monthly and yearly basis. It also had more than sixty million records with more than twenty-three thousands authorised users to the system. Out of these users, 82% had not logged into the system for one year, meaning that the system was full of inactive users for various reasons. Most of the Meta data structure did not follow the laid down recommendations.

After deliberating on the findings with the MoH and other stakeholders, we took up the recommendations for database clean up and reconfiguration. The exercise of database cleaning was conducted through a five-day seminar that involved MoH staff, technical assistants from Afyainfo and university of Nairobi. During this mission, all those in the seminar participated actively in the clean-up exercise. The dual activities of action-intervention occurred within a mutually acceptable ethical framework. For instance, it was noted that some decisions for example to delete indicators required the involvement of the specific programs managers to assist in the identification of their current indicators. Since this was done together with the MoH technical officers and other stakeholders, the participants learnt new ways of working and also participated in the generation of knowledge in keeping with Greenwood's (1989) argument (Whyte, Greenwood, & Lazes, 1989). This approach of learning by doing was very effective since it was expected that the staff would be adequately trained once the technical assistance

ended. Having people with hands on the job provides the required experience to carry on with the system maintenance.

During the database-cleaning workshop, we checked and configured the system to improve performance. Specific work done during the clean-up included fixing the data elements, datasets, indicators, validation rules, data values and data outputs according to the right naming conventions, grouping and recommended formulae. The team decided to hide or backup the historical data elements containing data that were not of any immediate. We updated the list of the authorised users and their user roles (permissions in the system) even though we agreed that a clear policy for users' access was required to avoid the recurrences of the challenges experienced.

One important aspect of the database was the management of servers. Managing servers is a highly technical job requiring expertise in information technology. This level of specialized ICT staff is not the domain of the MoH (M.O.H, 2013a). Because the ICT staff do not form part of the skill mix at the ministry of health, it became very hard to implement some of the complex ICT procedures, like server management. The MoH outsourced the day-to-day management of the DHIS2 database to the University of Nairobi. During the data clean up seminar, participants, particularly from the University of Nairobi were trained on server management.

As noted, the DHIS2 system is a growing organism and therefore requires constant cleaning. A key lesson learnt from this exercise was that database cleaning should be carried out on a regular basis. Waiting for too long before reviewing the status of database predisposed more data to be in bad shape, negatively affecting its smooth running. Another key finding showed that it was very difficult to understand some reports and even know why some indicators were created. This was because there was no adequate library. It is therefore important that proper documentation be done for future reference. One of the challenges noted was that one of the staff that had highly benefited from this training moved to another organization. The ministry of health requires hiring their own personnel instead of depending on staff from other ministries or from other organizations. Table 10 shows the activities performed during the DHIS2 database assessment and cleaning

Table 10: Activities during the DHIS2 Database Assessment and Cleaning

Mission objective	**Mission dates**
To review and fix the DHIS2 meta data	13/03/2016 to 25/03/2016
To review and fix the DHIS2 meta data	14/07/2016 to 24/08/2016
Server Maintenance and Reconfiguration and training of personnel	September 2016

Summary of chapter six

Chapter six has given detailed discussions of the results of the study. It has shown how the various institutional incentives affected the implementation of a web based HIS in a devolved health system. The next chapter will evaluate these discussions and come up with tangible contributions to theory and practice.

7 Chapter Seven: Contributions and Conclusions

In this chapter, I describe the various contributions by my study. The first section will give the contributions while the last part will give the conclusions. The research contributes the information systems and implementation of HIS. On the theoretic aspects, the study contributes to institutional theory more so in the concept of institutional incentives.

This thesis has contributions to both practice and theory.

7.1 Contributions to Practice

Rapid Implementation of Devolution Countrywide: During the process of devolution, all counties, excited by the prospects to control local funding and employment, insisted on implementing devolution at the same time. They hurriedly formed their respective committees and set up county health management teams. None of the counties had experience and each one was groping in the dark without lessons learnt from others. My position is that at least one or two counties would have worked on pilot basis to provide lessons. My claim is that such drastic mechanisms should be tried elsewhere first before being implemented countrywide. The contribution to practice is that governments should implement such major restructuring processes through a phased out fashion, because the repercussions are huge in case of failure.

Weakened Control from the National Level: Previously, Kenya's health care system had a centralized institutional arrangement, with decisions taken at MOH headquarters from where they were conveyed top-down through the provincial medical officers to the district level. In the previous centralized structure, we had eight provinces reporting to the national level but in the new structure, we have 47 counties that are semi-autonomous, communicating with national government through policies with little direct supportive supervision. In other words, the counties are now fully in charge of their health services. My claim is that devolving powers to counties effectively weakened the national government's control in the overall governance of the health information system. This was evident in the analysis of the DHIS2 database, which showed that counties had inserted many data elements and users in the system but the national government could not manage to visit all the counties to correct the mistakes. Some observers likened the situation to the metaphor from Chinua Achebe's book; "Things Fall Apart; the Centre Cannot Hold" (Chinua, 1958), literally meaning that the counties were lacking support from the national government which could not manage the oversight of all the 47 counties.

Hybrid structure of management facilitated by Technology: The role of technology was very interesting. By having the health information system hosted on a commercial cloud, the counties were happy with the arrangements since they did not have to pay for the hosting costs. The national level could easily get data from the system without the bureaucratic ways of asking data from the counties. Therefore, the use of technology become a centralizing phenomenon in a decentralized structure. My claim is that a hybrid system of governance is appropriate for the effectiveness of health information systems.

Donor Dependency: Like any developing country, most of the funds to manage the health information system came from bilateral donors. For instance, bilateral donors supported the hosting of the database and printing of data collection tools. Sometimes the database required

more storage space, but neither the national nor the county governments could respond. There were times when there were no reporting tools, the DHIS2 was down or totally switched off due to non-payment of the server fees but the counties had no control over it. Therefore, my claim is that over dependence on donor funding for vital programs like information systems is not good.

Capacity to Handle Servers Leading to Poor Data Quality: Because the national ministry of health does not have sufficient staff mix to manage the servers hosting the DHIS2 database, the University of Nairobi has been contracted to manage them. Even with the support from the University of Nairobi, an analysis of the database revealed that Metadata structure and overall organization of the database had become messy and required cleaning. My claim is that adequate training in servers is required because poor configuration of the database can affect the data quality of the health information system.

Personnel: Devolution necessitated massive staff movement both from national level to county and from one county to another. There were mixed reactions towards health worker's movements. There were those who were excited to move and take up leadership in counties while others feared leaving the city to lower levels. Social issues like families, ethnicity were considered. For instance, if an officer who was settled in the city moved, then the family would remain in the former place, which translated to running two homes. To accommodate such people who did not want to leave the city, the national department of health information system was split into many small sub units (eHealth, M&E, HIS). The study shows that personnel issues were massive. These included lack of career opportunities, education opportunities and promotion of health workers. By the time of the study, the country had experienced several industrial actions by health workers in different counties as well as resignation of some health workers. The country had also witnessed inequitable distribution of available health workforce due to health workers leaving certain counties in favour of others that have better working conditions. My claim is that adequate incentives at both the national and county levels are required for smooth personnel deployment.

Ethnicity: A key rationale of devolution was to reduce ethnic tensions in the country. Therefore, during the migration of health workers, ethnicity was considered. Workers went to their home counties and those who did not go to their homes found some hostilities. Some were being asked to leave. In the end, this led to staff shortages, loss of skilled workers to other counties and the lack of clarity in the due process for the transfer of health care workers in between counties. My claim is that if not well handled devolution could cause more tensions that are ethnic.

Data Demand at lower level: The demand for data for planning at the county level was very high. This was evidenced by the request to add a new organization unit representing the lowest organization unit called the ward in the health information system DHIS2. The elected leaders at the Ward level, referred to as the member of county Assembly were keen to get data for their area of jurisdiction, so they wanted data analysed by the wards. Occasionally these leaders openly followed the statistics of their geographical areas. At the county level, they required data to make and monitor annual work plans. My claim is that by devolving decision making to the

lowest level, the demand for data for planning and evaluation of progress of health care increased.

Alternative way of learning through a community of practice: the study showed that with the breakdown of a strong supportive team at the ministry of health and appointment of new county data managers, it became difficult to conduct face-to-face training sessions. Motivated by the need to learn more about the DHIS2, a new form of learning emerged. People at county levels used the messaging functionality in DHIS2 to pass knowledge to each other effectively forming a community of practice. This community of learning was very effective in training people on DHIS2 at a time when formal learning was difficult following the onset of devolution. My claim is that a community of practice can be an effective alternative way of training.

Integrated health information systems: The study shows that the excellent features of the DHIS2 and availability of internet made it easier for parallel programs to become integrated into the DHIS2. Similarly, emerging electronic medical records (EMRs) at hospitals were synchronized in DHIS2 though the process of interoperability. My claim is that the use of advanced technology can lead to integration of previously fragmented health information systems significantly improving data quality and use of the information for decision-making.

7.2 Contribution to Theory

The fact that most of the counties visited had similar study findings suggested that there were some social or institutional forces at play. We argue that these institutional arrangements provided some incentives to the participants, bringing up the concept of institutional incentives. For instance, during the free maternity project, which used data from the health information system to determine reimbursement, we noted that the data were very accurate. Both the county managers and the health facility staff benefited from the money from the deliveries. At the health facilities, the money was used to improve basic infrastructure in the maternity unit and buy tea for the staff. All these formed incentives that supported accurate data. This is a classical case supporting the concept of institutional incentives. This study therefore contributes to the theory of institutions and particularly the concept of institutional incentives. Another concept that emerges is the unbounded rationality. Given the counties were forced to make decisions with less data due to poorly developed health information systems, the mangers opted to use other sources of information for planning especially in the first year.

Growing Importance of the Data Manager at the County: From the studies, we see that the data manager at the county level has become very important, attending almost all the meetings. Some communities even coined a local name for the data person ("Ja data"). Further analysis reveals that the reason this position becomes important is that most other authorities do not know how to mine data from the health information systems. Being the only knowledgeable person, the data manager benefits by attending meetings (associated with some allowances) and even trainings. While it is a good incentive to the person, it ends up being a disincentive to the larger community. My claim is that the high data demand required in devolved units create a strong data manager who is not willing to share knowledge, something that can be counterproductive especially when absent.

High Reporting Rates: Counties regularly hold data review meetings in which data from the DHIS2 and hospitals are presented and discussed. During these meetings, the reporting rates from counties is considered important. Managers with high rates are congratulated verbally and encouraged. The verbal appreciation drives them to maintain high reporting rates. At the same time, participants from hospitals that had reported high numbers of mothers who had died in the hospital during delivery are asked to explain the circumstances of the deaths. The fear of repercussions may lead to revealing only fewer deaths. My claim is that intuitional incentives, either positive or negative can affect data quality. This contributes to theory.

Theory of Institutions: The study shows that the formation of the county health information systems was in keeping with the three mechanisms of institutional isomorphic change; coercive, mimetic and normative isomorphism. In this study, the coercive isomorphic pressures were exerted by the constitution, which formulated the formation of counties. Employees that were migrating from other counties and the national level reinforced mimetic processes. The professions who have developed norms during education and seminars exerted normative Pressures. This study therefore contributes to the general institutional theory.

7.3 Limitation of the Study

The study was biased toward the implementation of the DHIS2, which is only a part of HIS. A focus on the other systems like EMRs, would have added more analytical power

- While addressing data quality, the assumption was that whatever was recorded in the registers by the clinicians was correct. There is evidence that mis-diagnosis can occur leading to mislabelling of wrong cases. There is need to start addressing data quality attributed to clinicians.

- The study heavily relied on the funding from Afyainfo, with support from USAID, who paid for the meetings and travel to health facilities and so only eight out of 47 counties were involved in the program, probably not representative for the whole country

- After the successful roll out of DHIS2, there was a change of donor, from DANIDA to USAID. The project had kicked off as action research where the ministry together with UiO planned and implemented activities. At one time, the entire DHIS2 laboratory from UiO was based in Kenya, working together with MoH to implement the action research under DANIDA support. With USAID funding, it was difficult to frequently access the TA from UiO. This changed my research methodology from action research to case studies

- The study took longer than expected because sometimes going to the field depended on the availability of the MoH staff who always had competing schedules with support from the many implementing collaborators in the counties. The structure of the country did not allow centralized planning and each county had different schedules at the same time. Getting time for them to have joint quarterly review meetings was always difficult.

7.4 Responses to the Research Questions

This study had two major research questions: RQ1: What institutional arrangements arise from the interactions between devolved health systems and health information systems implementation in the context of advanced information technology? and RQ2: How do the institutional arrangements generated by the devolution of health systems create institutional incentives that shape the effectiveness of health information systems in terms of data quality and information use? From the results, I identified four key intuitional arrangements that affect HIS: Devolved decision-making, geographical autonomy of the devolved units, election of local leaders and the adoption of advanced technology. Table 11 shows the summary of institutional arrangements, incentives and their effects on the effectiveness of health information system in terms of data quality and information use.

Table 11: Summary of Institutional Arrangements, Incentives and Their Effect on HIS

Institutional arrangements	**Organisational incentives**	**Effects on data Quality**	**Effects on data use**
Devolved decision making	Financial incentives from the national free maternity project was utilized by both county management team and health facilities to improve working conditions-staff teas, gloves etc.	All levels were keen on the number of women delivering in maternities. This led to accurate data transfer from paper tools to the electronic information system, the DHIS2, as seen during DQAs	Data for free maternity reimbursement came from DHIS2 enhancing information use.
	The need for counties to have data from the lowest administrative units to support them in answering questions in their local assemblies and follow up while in the field, was a great incentive for the leaders to demand data from HIS	Elected leaders keenly followed any adverse reports in their area of jurisdiction. It was difficult to document false data since the local leaders may have known about the incident (putting faces on statistics), improving data quality	There was increased data demand for planning purpose, effectively increasing information use for informed decisions.
			A new organization unit, the administrative Ward was added in the DHIS2. This improved information flow from lowest level, encouraging information use
	To gain financial support in implementation of projects, the devolved units decided to collaborate with local implementing partners in health.	Development partners provided support in photocopying tools, training, review meetings, improving data quality	Increased data use especially for meetings-analysis and presentation in meetings. The partners had access to data for their programmatic reporting from the HIS
Election of leaders	The quest for re-election became a major organizational incentive for the subnational units to concentrate on visible projects which could easily be seen by the electorate e.g. construction of roads, buying ambulances, construction of hospitals, forgetting to support HIS adequately	There was minimal investments in HIS leading to lack of trainings, outdated and torn reporting paper tools, which adversely affected data quality. High dependency on donor funding for small things like photocopying	Reduced use of data from HIS as seen when Initial data for planning came from surveys, Service Availability assessment (SARA).

Institutional arrangements	Organisational incentives	Effects on data Quality	Effects on data use
Geographical autonomy	Organizational incentives to conduct professional staff restructuring based on competence and geographical distribution	Presence of highly qualified personnel at the county level supporting data analysis and improvement of data quality	Improved data analysis and presentation. Results show that the data manager was always busy responding to data needs in the county, suggesting the importance of data
	staff incentivised by the need to take up leadership roles in newly created units	Improved morale affecting data quality positively	Improved data analysis and presentation
	To retain as many national workers as possible in the MoH headquarters-National HIS was restructured and divided into smaller units eHealth, HIS, M&E	Previous DHIS2 core divided. It was difficult to coordinate HIS from many units. Lower levels not sure who to call for help, leading to poor quality	Poor supervision affecting data use
	Incentivised by the need to acquire data for their own planning and evaluation of programs	Data review meetings regularly held which included DQA improving data quality	Increased data demand data use especially for planning, analysis and presentation in meeting
Adoption of advanced technology, including central server using cloud computing	Districts, regions and national levels had instant **access** to their own data from "anywhere" and at "any time " greatly improving " **ownership**" of the system and data	The ability to review own data online and the ability for others also to view the same data created room for high quality data	Increased data use as evidenced by data analysis in forms of charts, tables, league tables and maps
	The need to have data in one integrated system led to putting many standalone programs in DHIS2	Easy to access data across different units and systems which improves data quality	Triangulation of data increased data analysis and use information
	Financial incentives in terms of saving costs by having the database to be handled at the national level using cloud computing technology	All levels able to see data and can communicate in case of quality issues	Information available improving data use
		National level not supervising lower units and not receiving inputs and hence problems in the metadata (one county had added Ward unit unilaterally affecting the whole system)	Messy metadata led to poor quality, reducing the use of data
		Donor dependency-System was once switched of for non-payment once during the study	Counties were worried of constant problems in DHIS2 and started losing faith affecting data use

7.5 Conclusions

This thesis utilized institutional theory to evaluate the effects of devolution of health systems on the implementation of HIS in the context of developing countries. At the beginning of the study, the evidence that over centralization of government authority has contributed to the difficulties of getting high quality data for informed decisions was convincing. However, from this study, I argue that over centralization was a rather general diagnosis and the prescription of devolution as an all-purpose solution lacked specificity and grounding in empirical and theoretical analysis. While the devolution of health systems was supposed to be smooth in the presence of coercive, mimetic, and normative isomorphic pressures, this study observes various dichotomies or contradictions. These dichotomies were by-products of the process of institutionalization of the new constitution and the adoption of advanced technology in the implementation of HIS. Arguably, the effectiveness of HIS was not shaped by devolution per se, but by a raft of institutional arrangements and incentives arising from the interactions of devolution health system and HIS implementation. To use one example from the study, a major institutional arrangement afforded by devolution of health systems is the election of local leaders. These leaders tend to require information regarding their geographical area, although they do not provide funds to support the generation of data. Each of these elected officials weighs the observable benefits of specific projects in the community more heavily than the costs. As a result, they concentrate more on building hospitals, constructing roads, buying ambulances, and constructing governors′ houses instead of supporting data management activities. This brings up an interesting contradiction of increased data demand but reduced information use for informed decisions. The use of advanced technology allowed both national and county governments to access data. In this case, advanced technology acted both as a centralizing, phenomenon in devolved environment. From a dialectical perspective, the accumulation of these contradictions both within and between institutions provided the seeds of institutional change.

In conclusion, institutional incentives played a big role in the effectiveness of health information systems in terms of data quality and information use. Due to the use of technology, pure centralization and devolution was not observed but more of a polycentric approach. Therefore, appropriate institutional incentives and a polycentric approach of government systems have the potential to shape the effectiveness′ HIS.

7.6 Further Research

I wish to suggest more research on the impact of the performance based incentives on the effectiveness of health information systems. Bearing in mind that this study concentrated on the aggregate data from the DHIS2, I suggest that more studies should be done to evaluate the various electronic medical records. Lastly, there is a lot of literature on the data collection, collation and transmission from the health facilities, but very little attention is paid to the clinicians who generate this data. I suggest more studies to check the validity of the data recorded since data quality problems arise from the point of generation.

Annex I: Guideline for Unstructured Interviews

Please comment on any observed changes in data quality since the onset of devolution.	Accuracy
	Completeness
	Adequacy
	Timeliness
Compare and contrast the following components of DHIS since devolution	Data processing
	Data analysis
	Data dissemination
	Supply and logistics
	Staff development
	Coordination, cooperation and communication within and between different units in the ministry of Health, as well as with related agencies outside of the ministry
Comment on the following common Problems in HISs since devolution	Duplication of forms
	Too many records books/forms being filled out at this level
	Lack of constant supply of forms
	Reports not submitted on time
	Inadequate training of health workers on how to fill out forms
	High degree of inaccuracies in data collected
	Lack of technical expertise of staff to properly analyse the data collected
	Lack of utilization of data being collected
	Low level/no dissemination of and feedback about data collected
Comment on the following aspects of data management	Data processing facilities (calculators, computers, etc.)
	Staff with computer skills
	Storage facilities for raw data at lower administrative levels.
	Data retrieval issues; inability to generate any information because of computer breakdown.
	Availability of personnel with the proper background/level of technical expertise to run a computerized system; in particular, the software skills of the staff at the lowest level
	Availability of technical support in case of hardware breakdown
Sustainability-Sustaining interest among stakeholders for HMIS	Generation of resources to support the different activities for system enhancement.
	Coordinating the activities of the different donor agencies so as to minimize the proliferation of data collection forms and the duplication of efforts
	Ensuring the continued existence of a body/committee to oversee the HMIS after the roll out

Annex II: Letter of Authorisation for Research

REPUBLIC OF KENYA

Telegrams: "PROVMED", KAKAMEGA
Telephone: 056 31125
Fax: 056 31125
E-mail: pdmswestern@gmail.com
When replying please quote

KAKAMEGA COUNTY
P O BOX 2309
KAKAMEGA
G.P.O. 50100

16TH January 2015

Ref : CGK/MOH/CIR/VOL1/ 4/179

COUNTY GOVERNMENT OF KAKAMEGA
OFFICE OF COUNTY DIRECTOR OF HEALTH

To
Dr. Ayub Manya
P. O. Box 1441-50100
KAKAMEGA.

Dear Sir,

REF: PERMISSION TO CARRY OUT DATA QUALITY INTERVENTION STUDY IN KAKAMEGA COUNTY.

Refference is made to your letter dated 13th January, 2015. We are glad that you chose to conduct your study here.

You have been granted permission to carry out your research work in the County and we hope it will help us improve quality of data as a county.

Thank you

Dr. David Oluoch,
For Ag. Chief Officer of Health,
Director of Health Services,
KAKAMEGA COUNTY

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National Roll out of District Health Information Software (DHIS 2) in Kenya, 2011 – Central Server and Cloud based Infrastructure

Ayub MANYA[1], Jørn BRAA[2], Lars ØVERLAND[2], Ola TITLESTAD[2], Jeremiah MUMO[1], Charles NZIOKA[1]
[1]Minstry of Public Health and Sanitation, P. O. Box 30016, Nairobi, Kenya
Tel: +254202121250, Email: ayubmanya@yahoo.com
[2]*Department of Informatics, University of Oslo, Olav Aukrustsvei 2b*
0785 Oslo, Norway, Tel+4790568342

Abstract: Recent years have seen an increasing focus on the strengthening of Health Information Systems (HIS) in countries. On the ground, however, HIS development in Africa has proved difficult due to; 1) poor and unevenly developed infrastructure, 2) fragmented health programs and donor initiatives and 3) poor capacity. In this paper, we present the case study of Kenya, where a web based system for data management was developed using the free and open source DHIS2 platform and rolled out countrywide during 2011. This case study shows that with the improvement of Information and Communication Technology (ICT) infrastructure, it is possible to deploy web based systems countrywide in Africa using central server and "cloud" based infrastructure. Further, by demonstrating success, rapid deployment and increasing data reporting rates, additional health programs and donor initiatives are now joining forces, and thereby helping integrating the previously fragmented HIS. The lessons regarding capacity development is that the instant access to own data, from "anywhere" and at "any time", has greatly improved the sense of "ownership" to the data and the system and thereby enabling important learning-by-doing processes significantly complementing the formal training and support activities. Users across Kenya are now able to access the system online through modems over the mobile Internet and web enabled mobile telephones. The new HTML 5 web standard is adding to this positive technology development through increased memory in the browsers, which makes it possible to capture data "offline" and thereby better handling fluctuations in connectivity and poor Internet.

Keywords: Cloud based infrastructure, File Transfer protocol, DHIS2, Customization, Datamart

1. Introduction

Governments around the world are increasingly using Information and Communication Technologies (ICTs) to modernize their public management systems and their external relationships with citizens, businesses and other organizations. Expectations of the introduction, management and use of ICTs in the public sector, also called 'e-government' [1], are high: policy makers anticipate that e-government applications, such as the Internet, geographic information systems, will not only enhance cost efficiency and effectiveness in the public sector, but also bring about transformational change in public service provision, administration and engagement with the general public [2]. A classic problem of public administration is the Health Information System (HIS). HIS development in Africa has

proved difficult due to; 1) poor and unevenly developed infrastructure, 2) fragmented health programs and donor initiatives and 3) poor capacity in management of health information among the workforce [3].

Recent years have seen an increasing focus on the strengthening of national Health Information Systems in Kenya. In its strategic plan, the Health Information System has a vision of being a centre of excellence for quality health and health-related data and information for use by all. Its mission is to provide timely, reliable and accessible quality health service information for evidence-based decision making in order to maximize utilization of scarce resources in the health sector [6]. To achieve this, a robust and functional Health Information System is required. The urgency of having a functional HIS had been lent extra impetus by the introduction of annual operational plans which required measurement of performance across a range of service-based indicators. The recent acceleration of disease control initiatives (notably HIV, TB and Malaria) provided additional demand for timely measurement of results achieved.

In an attempt to improve the health information system in Kenya, several reviews were conducted over the past ten years. At the time of the last review, HIS was using File Transfer Protocol (FTP) to transfer excel based data to national level from the districts. The national level received data aggregated at the district level. The aggregated numbers did not preserve the health facility "identity" of the data, making it impossible to perform analysis of comparative performance across health facilities. There was minimal analysis at the point of collection, thus making data use at point of collection difficult. FTP also lacked automatic quality assurance measures (such as range limiters) to avoid common clerical errors. In general the reviews of HIS noted that service-based data was incomplete, inaccurate and subject to delays. It was noted that despite the fact that a great deal of data continued to be captured at the health facility level in service registers, tally sheets, quarterly and annual returns [4], there was weak capacity in the use of information for decision-making and limited downward feedback to reporting facilities and districts.

Upon reviewing the available options, the District Health Information Software (DHIS2), a web based solution, was adopted. Notable attributes of DHIS2 included data entry at health facility level, pre-defined analysis tools, user-defined dashboards (to give a quick overview of the latest data) and Geographical Information System (GIS) interface. In selecting a web based software, it had been noted that all districts in the country had been uploading data to a central server through the File Transfer Protocol (FTP), meaning that Internet was available at all district headquarters. This was also in keeping with the Kenya Health Policy Framework envisioning Vision 2030 activities [5] which had singled out improvement of data management using appropriate Information and communication technology (ICT), including the internet and an integrated data warehouse approach that rationalised and harmonised different sub-systems and databases. Installation of DHIS2 on a central server was therefore the preferred choice for Kenya. The main advantage with a central server was that changes made at any point of the system were immediately available to all users across the country.

This paper outlines a success story of the implementation of new health information software based on a central server and "cloud" based infrastructure in Kenya. The paper shows how the rapid development of mobile telephone networks and Internet has provided a platform for improving the health information system in Kenya. It also points out challenges and learning points in the uptake of ICT in public health sector.

2. Objectives for the deployment of DHIS

The following were the main objectives for the adoption and deployment of the District Health Information Software countrywide:

1. Establish a central database, with health facility level reporting.

2. Define standard health facility, district, and national report outputs.
3. Link service delivery and other health system input databases.
4. Scale up ICT infrastructure countrywide to support the new software.
5. Build staff capacity to support system.
6. Achieve critical stakeholders' support.

3. Methodology

3.1 Setting up of a Central Server and Customisation of the DHIS

A national DHIS core team comprising different skills/backgrounds (Public health, Health Records and Information officers (HRIOs), Epidemiologists, Information and Communication Technology (ICT) experts, data managers and a project manager) was formed in the initial stages of the project. One member of the team was appointed as the team leader. The purpose of the team was to coordinate the implementation of the DHIS project by driving the database design process and customization. Technical assistants from Oslo University were hired through a competitive process to support the implementation.

The first task of the DHIS core team was to set up a server for the database. The advantage of using one central server in the country was because it was easier to provide technical support to only one central server installation. If standalone (offline /online) installations in each district, health facility, had been chosen, then one needed to provide technical support to all the hundreds of installations, when new versions needed to be synchronized or when something went wrong. Due to poor Internet connectivity and inadequate capacity of the servers at the Ministry of Health headquarters, a central server using cloud computing was set up. The goal of cloud computing was to provide easy and scalable access to well managed computer servers and other ICT services.

The team then embarked on the process of customization. This involved desk reviews and key informant interviews. The initial activity of customization was setting up of the organizational hierarchy in the DHIS. In doing this, the team paid attention to the new constitution that had created counties as new geographical administrative units (replacing provinces). As a first step, the DHIS2 was set up to include the same routine reports from the facilities as the current FTP Excel system in order to replace this system. Other initial activities of system customization included defining: data elements, data sets, validation rules and setting up the dashboard. Population data by district was included and indicators and evaluation rules defined. Geographical Information System (GIS) for mapping and graphical tools for reporting as well as standard reports were then developed.

3.2 Pilot of the DHIS

After the initial customization, DHIS was tested in three selected districts; Machakos, Nyamira and Kisumu East. Results from these testing sites informed the improvement of the system before it was taken to a larger region (province) on pilot basis. The Coast province was selected for the pilot. The activities of the pilot project included: stakeholders' meetings, training of health workers, supportive supervision and procurement of ICT infrastructure. A one-week residential training of selected health workers from coast province was conducted. Members of the DHIS core team and the technical assistants from Oslo University facilitated the training. The training covered the general aspects of DHIS, data entry, data quality and generation of reports.

Immediately after the training, the facilitators visited all the districts in the province. The primary objective was to review the availability of the technical infrastructure, Internet connectivity, install the software in the districts and solve any local problems. During this follow up visit, other members of the District Health Management Team (DHMT) who had

not been at the residential training were introduced to the new software. A similar supportive supervisory visit was conducted six weeks later to review the progress of the project and address any emerging issues. A consultative review meeting followed this.

A two-day review meeting was held in the coast province to review the results of the pilot project. This meeting was graced by the attendance of the Director of Public Health and Sanitation, the head of the Department of Planning and Co-ordination, the head of the Division of Health Information System, senior officers from the Ministry of Health headquarters and coast province. During the meeting members discussed frankly all the good and bad attributes of the DHIS. At the end of the meeting, it was declared that DHIS was to be rolled out to the rest of the country.

3.3 Roll out of DHIS Countrywide

The national roll out of DHIS had a series of objectives that were planned and executed. This was by far the largest and most resource-demanding objective of the project. The time lines of the roll out were organised around the logistics of scaling up to the whole country in a staged manner. The components of the roll out included:

3.3.1 Training of Trainers (ToTs)

The rollout process started with a one week Training of Trainers (ToTs). The criteria for selection of the ToTs included regional balance and those with experience with web based programs. These ToTs formed a pool of trainers during the rollout. They supported implementation of DHIS 2 in their own provinces and offered support to neighbouring provinces.

3.3.2 Training of District Personnel in Readiness of National Roll Out of DHIS

A national training schedule was prepared for roll out. The training was conducted province by province. Those who were trained included the district health records information officers, hospital health records information officers and the district health management team members. The main objective of the training was to equip district and provincial healthcare managers with knowledge, attitudes and skills needed to effectively manage health information using DHIS2. Topics covered during the training included; introduction to the DHIS project, getting started on the DHIS, reporting /analysis tools in DHIS (Standard reports, data sets, report tables, completeness, static reports) and how to use DHIS for data reviews, analysis and planning. Two weeks after the training, the districts were visited by the trainers to support the implementation of DHIS.

3.3.3 Import data from other systems

Interoperability between the DHIS 2 and other systems, such as Human Resource management systems (iHRIS) and patient management systems was enabled by the new World Health Organization (WHO) Statistical Data and Metadata Exchange for Health Domain (SDMX-HD) standard for exchange of Meta data and statistical data. Data on human resources from the Capacity Plus iHRIS system was exported to SDMX-HD format and imported into the DHIS2. All data sets in the FTP for 2008-2010 were imported in DHIS. This process was done by the technical assistants.

3.3.4 Pilot the use of mobile phones for DHIS 2 data collection.

The use of mobile phones to collect and report data on Health Sector Services Fund (HSSF) and Integrated Disease Surveillance and Response (IDSR) data sets were investigated and included in the DHIS.

4. Technology Description

DHIS 2 is a modular web-based software package developed with free and open source Java frameworks. This means that the application runs on any web server that supports Java Servlets [7] and can be accessed via a web browser over the Internet. DHIS2 can therefore be deployed on a national online server as well as in an intranet offline setting.

The DHIS 2 is a database tool for collection, management, validation, analysis, and presentation of aggregate statistical data, tailored to integrated health information management activities. It is designed to serve as a facility based country data repository - or data warehouse - and to address both local and national needs. It is a generic tool rather than a pre-configured database application, meaning that the Kenyan DHIS2 is being designed and developed according to user needs and requirements as they are being defined and developed in Kenya. DHIS2 is based on an open "meta-data model " (e.g. data elements and data sets, types of facilities and the hierarchy of the health system, indicators, evaluation rules) and a flexible user interface that allows the HIS team to design the contents of the system and to add new data sets and modules without the need for programming.

5. Developments

5.1 Semi-online DHIS2 design and implementation in Kenya.

Nearly all data managers raised the issue of internet connectivity costs. This was addressed by the provision of modems and airtime. A further step was the development of an offline data entry capability. The implementation of the new HTML 5 standard, allowed the offline data entry, thus improving the robustness of Internet connectivity in rural parts of Kenya. Users capture data offline by using the memory in the browser and "flush" the data (i.e. transfer to the server) when online. The following message was posted by a user at the DHIS2 messaging system after the new feature of offline data capture had been included:

2011-09-13

"Hi, this is wow! I have realized that I can now work with a lot of ease without any interruptions from network fluctuations since some of us are in the interiors where we have lots of challenges with the network. This is so good, a big Thank you....."

Figure1 below shows the Semi-online DHIS2 design and implementation in Kenya.

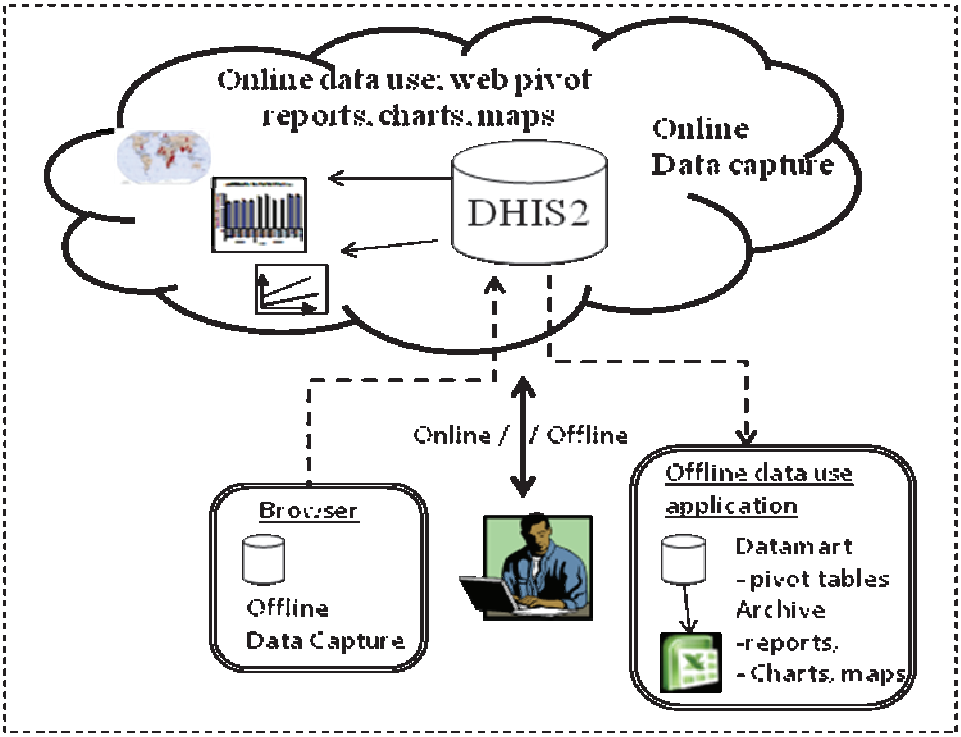


Figure 1: Semi-online DHIS2 design and implementation in Kenya

5.2 Development of data mart and pivot tables

The ability to analyse and use data from the system "offline" was an important development. This was done by introducing a small application used to download data from DHIS2 on the central server and storing the data in a datamart (database for processed data) on the users' computer. The datamart was then used to populate a predesigned Excel pivot table. In this way users were enabled to analyse and access their own data offline on their own computer. As the Excel pivot tables are not easy to update, or "refresh", online regardless of bandwidth, the offline local datamart was an important development.

5.3 Development of new reporting forms

While the first step was to incorporate currents forms in FTP, a second step, was to develop new forms to address new needs such as the Health Sector Service Funds (HSSF) data sets. Note that due to the modular design of the DHIS2 – and the online (one) server implementation – additional data sets and requirements may be included and added in a continuous process without affecting the stability and the running of the system.

6. Results

All customization of the system was performed by the Kenyan team under the supervision of the consultants. The Kenyan team demonstrated great knowledge of information systems and the team members were quick learners. The customization process went smoothly demonstrating the importance of knowledge transfer and capacity building. During the period March – September 2011, the system was successfully rolled out to all 8 provinces and districts in Kenya. The roll out process was also supported by the technical assistants.

6.1 Actual Use of the New System

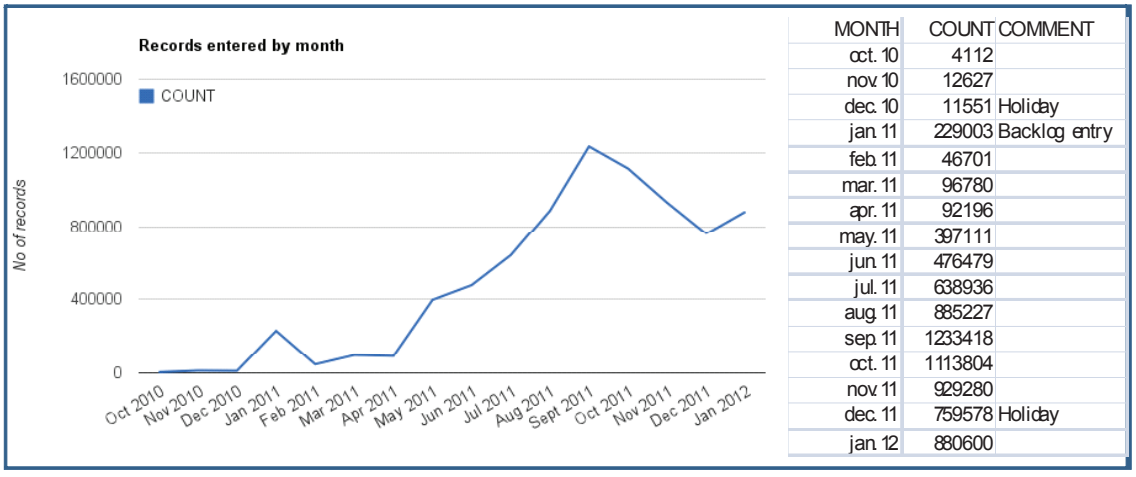
Following the successful roll out of DHIS, users across Kenya are able to login and access or enter data using modems or Local Area Networks (LANs). For example, on the 7th of February 2012, 361 unique users from all over Kenya had logged on to the system. In general the country has an active core group of 500-600 users; translating to 40-50% of all registered users (1351). We take this to indicate that the officers in charge of data entry and data management at all levels of the country are now using the system routinely. Table 1 below shows statistics of total registered users and their usage of the system.

UNIQUE USERS LOGGED IN BY FEB 8 2012	No of users
7th. Feb., 2012	361
Last 7 days(from 7th Feb., 2012)	503
Last 30 days(from 7th Feb., 2012)	676
Total Users registered in the system	1351

Table 1: Statistics of total registered users and their usage of the system.

6.2 Data Entry

In terms of data entry, it was noted that there was a rapid rise in volumes of data entered in the system across the year 2011. The rapid increase was due to the roll out and retrograde data entry. The peak in January 2011 was due backlog data entry, while the drop in December could have been due to Christmas holidays. Figure 2 below shows data values that were entered in the system per month.



MONTH	COUNT	COMMENT
oct. 10	4112	
nov. 10	12627	
dec. 10	11551	Holiday
jan. 11	229003	Backlog entry
feb. 11	46701	
mar. 11	96780	
apr. 11	92196	
may. 11	397111	
jun. 11	476479	
jul. 11	638936	
aug. 11	885227	
sep. 11	1233418	
oct. 11	1113804	
nov. 11	929280	
dec. 11	759578	Holiday
jan. 12	880600	

Figure 2: Statistics of records (data values) entered in the system per month

6.3 Acceptance of the New System

The statistics tell us that the system is being used. Generally, due to the good attributes of the software, data managers and data entry staff readily welcomed it. They are describing it as being "user friendly" and very easy to use. The standard reports and the data visualizer are very popular tools for making graphs and reports.

Users in districts and health facilities also stated that they had easier access to their own data, as well as data from the rest of the country from DHIS than before. The argument is that they can now access their data regardless of power-cuts (when they used their laptop), viruses or computer problems, because the data was "up there", always available, "in the

Internet". Furthermore, they really appreciated the dynamic updates of data from around the country and the messaging system in the DHIS, used for communication between users and the system support team to report bugs and to get help when having problems. "Just like Facebook" as one user said.

6.4 Comparing Provinces in Terms of Reporting Rates

A good indication of increasing acceptance of the system is that the provinces now are competing to be best in terms of reporting completeness. The so called league table shown in figure 3 is very popular as it compares the performance between provinces. Coast and Nyanza provinces maintained the top of the league throughout.

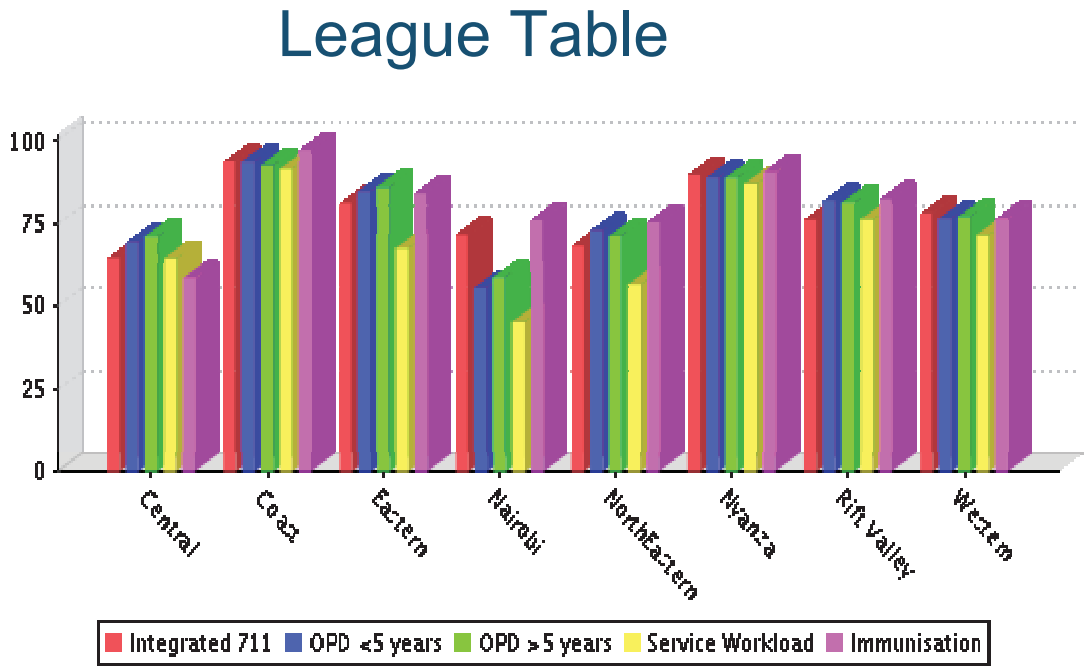


Figure 3: Reporting completeness all provinces, December 2011

7. Business Benefits

7.1 Data Use for Decision Making

DHIS provided simple analysis encouraging data use for decision-making. With inbuilt validation process, data managers are able to pick errors thus helping in improving data quality. DHIS has further:

- Improved the dissemination of public health information and facilitated public discourse and dialogue around major public health threats
- Strengthened ability to monitor the incidence of public health threats and timely response
- Improved the efficiency of administrative systems in health care facilities.

7.2 Capacity development

After deployment of the system, the users were able to get instant access to their own data, from "anywhere" and at "any time". This greatly improved the sense of "ownership" to the data and the system and thereby enabled important learning-by-doing processes, significantly complementing the formal training and support. The national team participated in the system customisation and roll out, giving them lots of experience and knowledge.

7.3 Support from stakeholders

The rapid and successful roll out of DHIS received lots of support from stakeholders. Further, by demonstrating increasing data reporting rates, additional health programs and donor initiatives have started joining forces to start reporting through a unified system (DHIS) thereby integrating the previously fragmented Health Information System.

8. Conclusion

The norm when implementing country HIS in Africa has been to capture the data in stand-alone databases and transmit to the next level through email attachments, electronically (by FTP as was in Kenya) or physically on a memory sticks. Significant human capacity on databases, data management and system support is needed in order to manage a national HIS based on numerous standalone database applications with fragile flows of data between them. Problems of data reporting, completeness and the maintenance of numerous standalone applications across the country make it very complicated.

Kenya made a bold move to adopt a web based system for data management. This was due to the improvement of the Internet using the mobile telephone networks in Kenya. The ability to implement DHIS2 online on one central server made it significantly "easier" to roll out the system countrywide, as compared with the alternative of having to support and maintain separate installations in all districts, hospitals and health facilities around the country. This rapid rollout and high number of users has been made possible by the central server solution used and the good connectivity available nearly all over Kenya. During the rollout process, suggested improvements, new reports and bugs reported, could all be handled as soon as possible and made available to everybody "online" through the central server.

Building a web-based data warehouse on a central server, as is the norm in industrialized countries, and even using a cloud infrastructure, is much simpler technically and in terms of human capacity and needed support structures, for hardware, software and database management.

Based on the rapid increase in mobile coverage in Africa (cables being laid in both East and West African Coasts); internet connectivity is going to improve, making it easier to deploy web based databases in Africa. Cloud based infrastructure using a central server with universal access, would therefore be appropriate for Africa. It is however important that capacity building, relevant infrastructure and staffing levels be evaluated for the system to work well since significant human capacity on databases, data management and system support is needed.

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THE USE OF SOCIAL LEARNING SYSTEMS IN IMPLEMENTING A WEB-BASED ROUTINE HEALTH INFORMATION SYSTEM IN KENYA

Ayub Manya and Petter Nielsen, University of Oslo, Norway

Abstract: Many countries have adopted the state of the art Information and Communications Technology (ICT) in their health information systems. Kenya adopted the use of District Health Information System (DHIS2), a web based system to manage aggregate routine health information data in 2010. The software was installed on a central server using cloud based infrastructure. National roll out of the system required lots of training. This was initially done through the workshops (face to face) and on-job training. Due to logistical and financial constraints, it was not possible to maintain this approach of training throughout the project implementation. The introduction of messaging functionality in the system enabled social learning through a community of practice. Members of this community posted questions on the system and received answers from colleagues with varying knowledge and experience through the same forum. We document how the messaging functionality, imbedded in the software evolved into social learning through communities of practice, effectively supporting the implementation of the project. This paper shows that when well-managed, communities of practice can augment traditional learning methods in the implementation of complex systems.

Keywords: boundaries, communities of practice, Health information system, social learning systems

1. INTRODUCTION

Globally, there is increase in demand for better data to facilitate evidence based decision making in health departments. The World Health Organization's framework of action (2007) emphasizes the importance of reliable health information systems as part of the six pillars for strengthening health systems (WHO, 2007). Data from these systems are essential in identifying gaps for interventions to reduce mortality, improve quality of care, determine the extent of coverage and track progress of various interventions (AbouZahr & Boerma, 2005). In order to improve her health information system, Kenya adopted the use District Health Information Software (DHIS2) as a tool for data management, replacing the excel-based File Transfer Protocol (FTP) in 2010 (Manya, *et al*., 2012).

Like the implementation of any new system, user training was a key component of the DHIS2 project. The initial training approaches involved workshops and on-job training sessions. Due to the rapid evolution of the system, and considering the involvement of large numbers of stakeholders, other forms of learning including social learning through communities of practice (Wenger, 2004) emerged. This paper evaluates the contribution of social learning in the implementation of DHIS2. It shows that when well-managed, communities of practice can augment traditional learning methods in the implementation of complex systems. This section will focus on the background of the Kenyan health information system, the evolution of the messaging functionality into social learning and the theoretical aspects of communities of practice.

1.1. Background and Overview of the Kenyan Health Information System

In Kenya, the activities of health information systems are imbedded in the Strategic Plan for Health Information Systems (Ministry of Health, 2009). The strategic plan envisions the administrative department of Health Information System as "a centre of excellence for quality health and health related data and information for use by all" (HIS Strategic Plan 2009-2014, p.10). One of the strategic objectives in the plan is strengthening the use and application of Information and Communication Technology (ICT) in data management (HIS Strategic Plan 2009-2014, p.12). Functions of the health information systems are also guided by the health information system policy (Ministry of Health, 2010).

A major improvement of the Kenyan health information system was the adoption of the District Health Information Software (DHIS2) in 2010 (Manya, *et al.*, 2012). A number of factors influenced the change of the health information system. Various reviews of the health information system had shown that the country was not doing well in routine health information systems and needed improvements (Ministry of Health, 2008). The DHIS2 was chosen for several reasons: first, the software was free and open source, eliminating the issues of proprietary software and their challenges. Second, it was designed to allow data collection and use at the facility and district levels, encouraging data-use for decision making at the lowest level. Third, the DHIS2 supported a full Web-API which gave access to all of the functions of the software through a web interface allowing data entry or reporting interfaces on mobile devices and desktops. Furthermore, the software had a strong support from a worldwide network of users and developers (Dhis2.org).

During the early stages of the DHIS2 project implementation, the Ministry of Health formed a national DHIS2 core team comprising public health specialists, health records and information officers, Information and Technology (IT) specialists and general administrators to oversee the overall implementation of the project. At the same time, the Government, through development partners, hired consultants from the University of Oslo, Norway, to provide technical assistance during the process of customization, training, piloting and countrywide roll out. The consultants from the University of Oslo were selected because these were the main developers of the software. Besides training the Kenyan DHIS2 core team on key aspects of DHIS2 the consultants also participated in the stakeholders' meetings, providing the necessary answers to questions raised about the software. After extensive stakeholder consultations, the Kenyan DHIS was installed on a central server using cloud computing.

A key component of the national roll out the DHIS2 was user training. This utilized a Trainer of Trainees (ToT) approach, through residential workshops. A team of ToTs were first trained and later facilitated to cascade the training to the lower levels. Training sessions comprised a combination of theoretical lectures and hands-on practice on relevant topics including data entry, data quality, data analysis and data presentation options (graphs, charts and maps). Participants were kept to a manageable number depending on the facilities and number of trainers available. Another training approach was on-job training. This involved visits to districts with the aim of offering coaching and mentorship services. The advantage of this approach was that users got individualized attention within their home working environments. With this approach, it was possible to involve more members of the district management team and address local issues related to computers (both software and hardware). Common computer problems solved during such visits included; installation of the software, provision of power back up systems, installation of mobile telephone modems and updates on computer antiviruses. Despite the logistical challenges in terms of organizing workshop venues, trainers, participants, equipment and hardware, all the targeted stakeholders were trained during the countrywide roll out of DHIS2 (Manya, *et al*., 2012).

As a growing organism the DHIS2 needed to be maintained and constantly extended. In addition to new reporting tools being added, new versions of the system continued being released

requiring more learning. An important challenge that required massive training was the devolution of health services to counties. In August 2010, Kenya adopted a new constitution that had far reaching provisions for democratization including the devolution of Government to 47 counties. As a governance tool, devolution was based on the principle of subsidiarity, which assigned specific functions hitherto conducted by the central level to lower levels (Nyanjom, 2010).While a number of clauses in the new constitution were implemented in 2010, devolution of the health system commenced after the general elections of March 2013. The change of the governance therefore required more training. At the same time, there was a change of funding agency in 2012 from one donor to the other, causing disruptions in planned activities. Due to financial constraints and big numbers of people that required training, it was very difficult to continue with organized training sessions as before. This called for other forms of learning, including using telephone calls, short messages (sms) and sending messages through the DHIS2. Collectively, these formed a community of practice, which proved very useful in the continuous education in support of the software.

1.2. Evolution of Messaging Functionality into Communities of Practice

After the initial roll out, the national DHIS2 core team continued handling users' questions by phone and emails. On realizing that this was taking a lot of time, and bearing in mind that some of the questions were similar, the idea of having a messaging functionality in DHIS2 was suggested and implemented in 2011. At the time of its development, the main function of the messaging functionality was to pass messages from the national DHIS2 core team and system developers from the University of Oslo to the rest of the users, notifying them of any new functionality in the software. Users would read the messages using their personal DHIS2 accounts and act as advised. Further developments in the messaging functionality allowed users to send out feedback messages to all users in DHIS2 including the national DHIS2 core team and the system developers. In the initial stages, the feedback messages were seen and acted upon by the national team and the system developers from the University of Oslo. With time, other users of the system began solving problems raised by their colleagues without waiting for responses from either the national team or the developers, thus creating a community of users with knowledge on DHIS2. This effectively reduced the burden on the national team and created a new learning process through a community of practice. Figure 1 below shows a print screen of an example of a massage in the DHIS2.

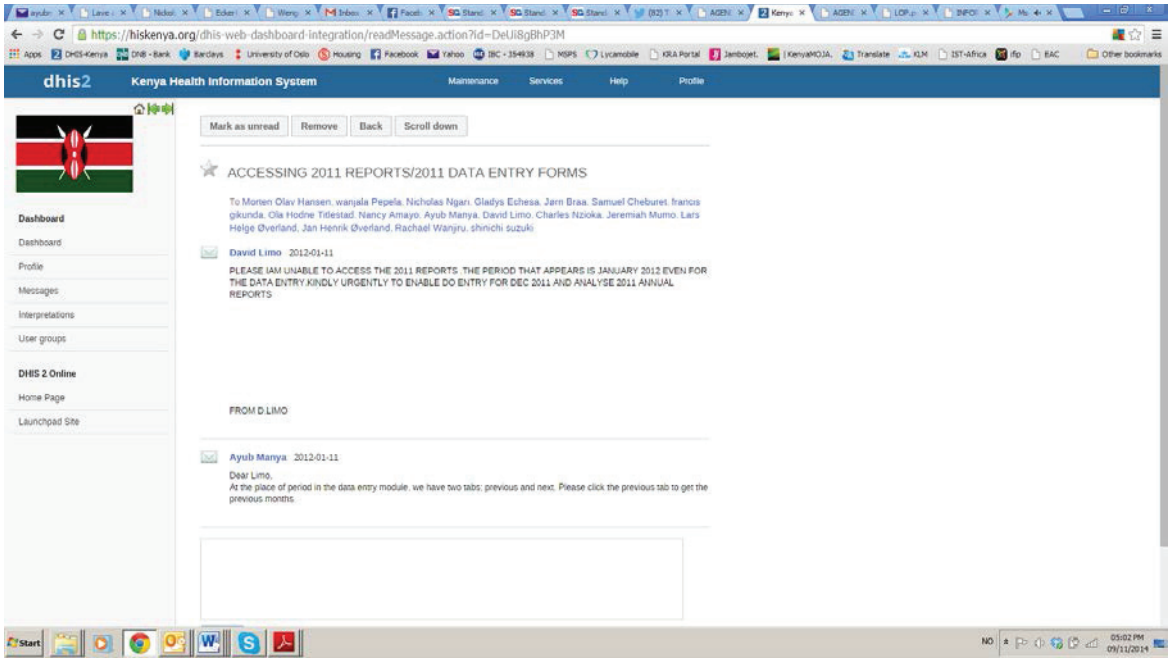

Figure 1: An Example of a Message in the DHIS2

1.3. Theoretical Background of Community of Practice

The idea that learning involves a deepening process of participation in a community of practice has gained significant ground in recent years. Etienne Wenger (2004) describes Communities of practice as groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly (Wenger, 2004). This aspect of learning is quite different from the classroom type that we are accustomed to. Wenger (1998) posits that most people assume that learning "has a beginning and an end; that it is best separated from the rest of our activities; and that it is the result of teaching" (Wenger, 1998, p. 3). It has however been proposed that learning is social and comes largely from our experience of participating in daily life. Jean Lave and Etienne Wenger (2013) came up with a learning model that proposed that learning involved a process of engagement in a community of practice (Lava & Wenger, 2013; Lave & Wenger, 1991).

The basic argument made by Jean Lave and Etienne Wenger was that communities of practice are everywhere and that people are involved in a number of them - whether at work, school, home, or in civic and leisure interests. They propose that in some communities of practice groups, some members assume core membership while others remain more at margins. According to these authors, a community of practice involves much more than the technical knowledge or skill associated with undertaking some task. Members are involved in a set of relationships over time (Lave and Wenger 1991: 98) and communities develop around things that matter to people (Wenger, 1998). The fact that they are organizing around some particular area of knowledge and activity gives members a sense of joint enterprise and identity. For a community of practice to function it needs to generate and appropriate a shared repertoire of ideas, commitments and memories. It also needs to develop various resources such as tools, documents, routines, vocabulary and symbols that in some way carry the accumulated knowledge of the community. In other words, it involves practice; ways of doing and approaching things that are shared to some significant extent among members.

2. METHODOLOGY

The objective of this study was to determine if the messaging functionality in the DHIS2 contributed to social learning through a community of practice. An exploratory analysis of all messages in the Kenyan DHIS2 from 2011 to 2014 was done. The analysis was done using the community of practice theoretical lens. We analyzed the messages by exploring knowledge sharing in Lave and Wenger's (1991) theory of communities of practice (Lave & Wenger, 1991) and investigating how messaging may translate into social learning. The features of communities of practice that were evaluated were: a) the domain (an identity defined by a shared domain of interest), b) the community (members engaging in joint activities and discussions, helping each other and sharing information) and c) the practice (having a shared practice) (Wenger, 2004).

Messages were downloaded and classified according to following criteria: sender, topic of message and the date the message was sent. The category of those who sent the messages (senders) was further sub divided into three main categories: National DHIS2 core team, University of Oslo team and other users. The national and the Oslo teams were basically the system administrators while the rest of the users had different user roles in the system. Analysis was then done along these classifications.

The next step in the analysis was the classification of the messages according to the message content or the topic of discussion. For instance messages that appeared to pass information from one group of users to another were classified as communication. Communication messages were typically sent from a higher administrative office and were meant to direct employees to perform a particular task, for example data entry. The messages were normally replied with short acknowledgments such as "yes". The following message classified as communication was sent by a DHIS2 core team member on 2012-01-11: *"New release of DHIS2 2.4 offline data entry:*

Dear all, we do encourage districts to use offline data entry. This will greatly reduce a lot of airtime during data entry." We also had some messages classified as general; most of these were messages discussing other issues not related to the system or just passing general message to specific users as seen in the following message from a user on 2013-10-10: "I think I forgot my cellphone in your car. It must have fallen under the seat. Please help me get it."

We classified messages which were requesting information on how to use specific functionalities in the system as "use". We also had some message questioning the quality of data and others requesting for new features in the system. All the messages were analyzed along these classifications and presented in graphs and tables.

2. RESULTS

A total of 1267 messages were evaluated. This section gives the results of frequency of messages by time, analysis of messages according to the main user categories

3.1. Trend of messages over time

All the messages were tabulated according to the date they were sent. The results show that the peak of the messages was reached in 2012. Thereafter there was an observed downward trend with yearly peaks as shown in figure 2 below.

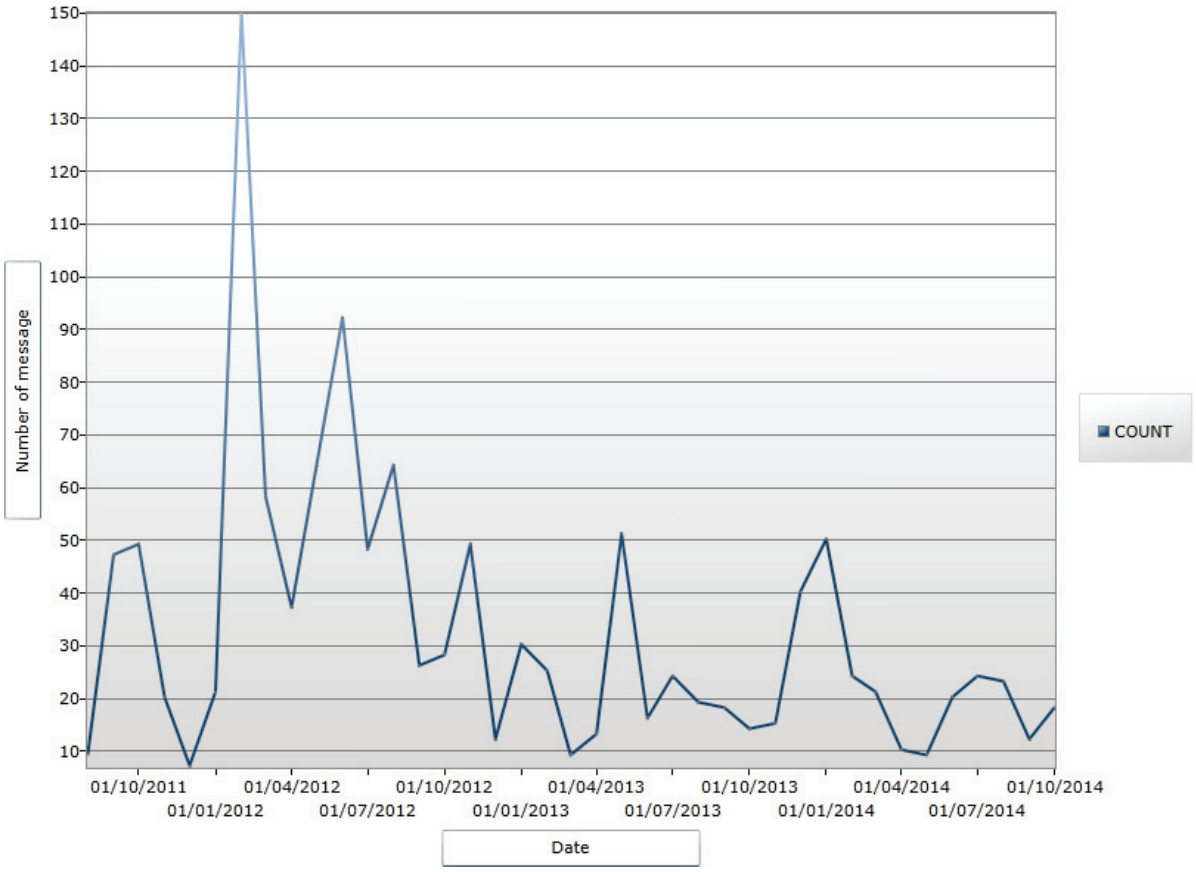

Figure 2: Line Graph Showing the Frequency of Message from 2011 To 2014

3.2 Analysis of Messages according to the Main User Categories

The messages were analyzed according to the main user categories of the DHIS2 core team, Oslo university team and all the other users. The graph shows that initially most messages emanated from the DHIS2 core team and the Oslo team. By the year 2012, the other users had started responding to questions in the system. As the number of messages from the other users started rising, contributions from the DHIS team and the Oslo team started going down. From

2013 most of the contributions were from other groups. By 2014, the contribution from the Oslo team was totally out, as shown in figure 3 below.

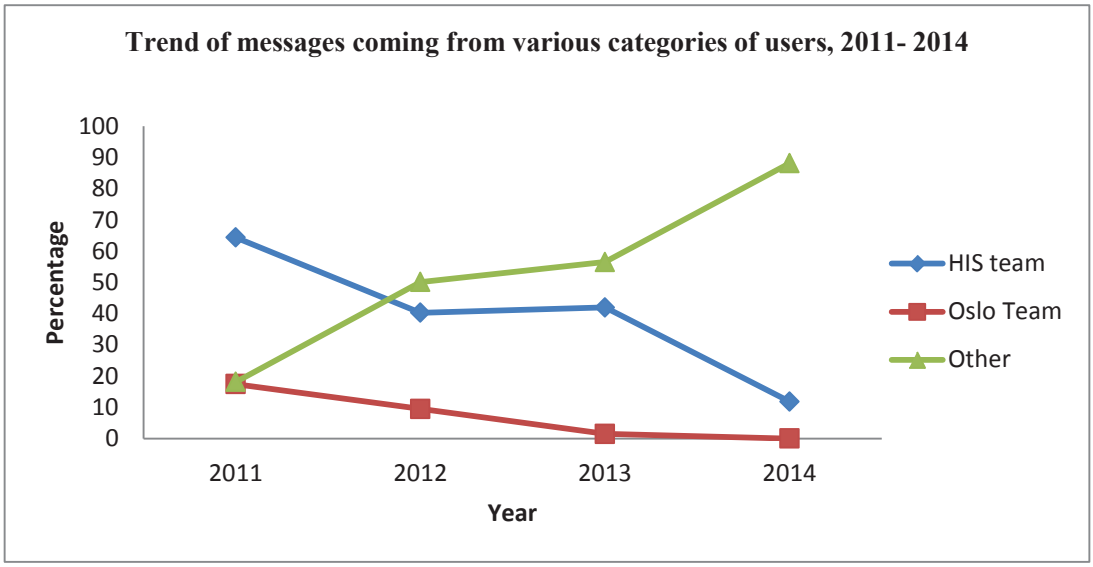

Figure 3: Trend of Messages Coming from Various categories of Users, 2011-2014

3.3. Analysis of type of messages compared to the sending group

Further analysis showed that new functionalities in the system were mostly requested by other users apart from the HIS team and the Oslo team. The same group (Other) also raised most of the data quality and general issues. HIS team handled most of the messages on communication shown in table 1 below.

Message Type	**HIS team**	**Oslo Team**	**Other**	Total
Use	46.0%	7.6%	46.4%	100.0%
Communication	52.1%	12.7%	35.2%	100.0%
Quality	31.7%	2.4%	65.9%	100.0%
New requests	5.3%	5.3%	89.5%	100.0%
General	29.7%	9.0%	61.3%	100.0%

Table 1: Proportion of Message Types Disaggregated By User Groups

3.4. Analysis by the type of Messages being sent

The leading topic in messages being sent was on the use of the system while the least topic was the one demanding new features in the system. It has also been noticed that apart from primarily solving use related issues, some messages were purely general, thus using the system as a communication tool. The quality of data in the system was also a concern of the community of practice group as seen by the proportion of messages concerning data quality. This is shown in figure 4 below.

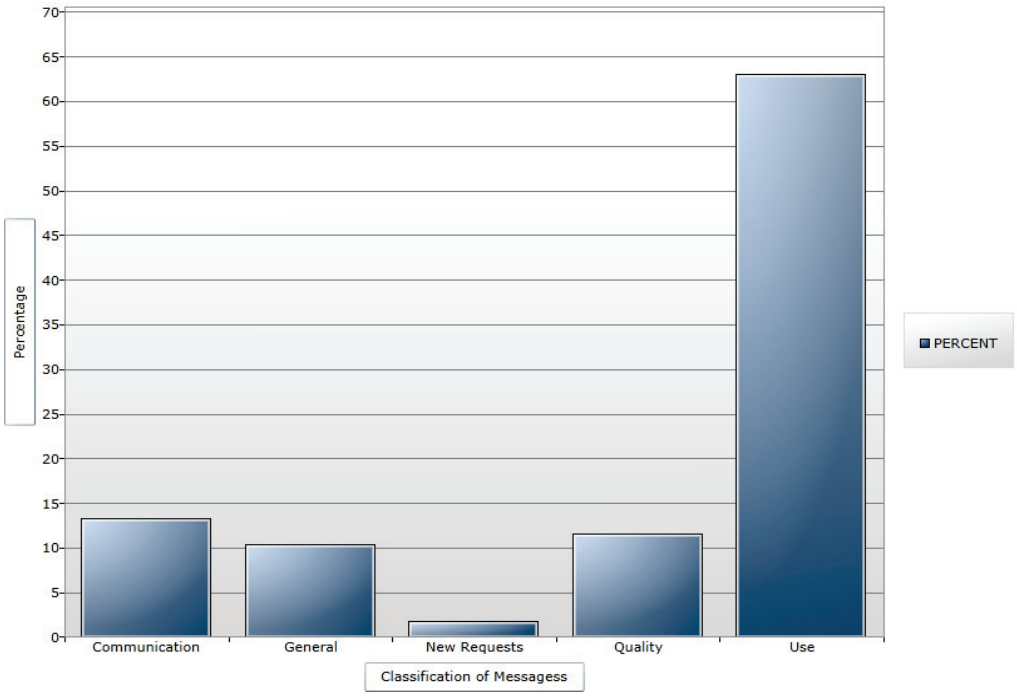

Figure 4: Proportion of Messages Based on the Communication Topic

4. DISCUSSION

The initial function of the messaging functionality in the DHIS2 was for passing messages from the DHIS managers at the national level to end users in provinces and districts. With time, the end users also started writing feedback messages to higher levels and also among themselves, effectively reducing the need for the national team members to respond to every issue. The first team whose contribution reduced drastically was the Oslo team. While it could be attributed to the fact that the local team had mastered the art of handling the DHIS2, the reduction could also mean that the Oslo team was busy implementing the DHIS2 in other countries.

Assuming that the national DHIS2 core team and the Oslo team were the experts of DHIS2, we argue that the other users formed the community of practice that supported the social learning in DHIS2. Further analysis showed that there was a sharp reduction of the national and Oslo team in 2013, coinciding with the devolution of health services in Kenya. However this did not affect the other users, whose activities continued to rise despite the fact that there was that no formal training during this transition state. The main boundary object for those participating in the social learning was the possession of user rights to the system. The user rights ranged from those with administrative rights to guests who only viewed data.

Careful analysis of the messages showed that the messages were very many in the beginning, with major reductions being seen in subsequent years. This could also be attributed to the fact that the team had mastered most of the issues or that there were no new versions of the DHIS2 being adopted by the country. Since most of the messages concentrated on the use of DHIS2, it can be argued that this team had a common focus. The results also show that the team had interest in the quality of data going by messages attributed to data quality. This further confirms that the team had a common interest of improving the health information system. Considering that the theme of the messages was largely aimed at supporting the software, it can be concluded that this team had a common practice, supporting the formation of a community of practice.

In conclusion, the messaging functionality met all the three characteristics of a community of service (domain, community and practice). The community of practice played a big role in improving the teaching of DHIS2 through enabling members to integrate diverse disciplinary perspectives and exchange of ideas. The key factors that made our communities effective and

durable were the freedom of expression and a willingness to learn from peers. The fact that the Kenyan DHIS2 implementation continued with minimal classroom type of training, we conclude that suitably designed and resourced, social learning systems can support the implementation of big information systems like the DHIS2.

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Cloud Computing as a Catalyst for Integrated Health Information Systems in Developing Countries

Ayub Manya
University of Oslo, Norway, ayubmanya@gmail.com

Petter Nielsen
University of Oslo, Norway, pnielsen@ifi.uio.no

Raphael Pundo
AfyaInfo Project, Kenya, raphael_pundo@afyainfo.org

Cloud Computing as a Catalyst for Integrated Health Information Systems in Developing Countries

Ayub Manya[1], Petter Nielsen[1], Raphael Pundo[2]

[1] University of Oslo, P.O. Box 1032 Blindern, 0315 Oslo, Norway
[2] AfyaInfo Project, Kenya
ayubmanya@gmail.com

Abstract. Cloud Computing is increasingly becoming important in the generation, storage and transmission of information worldwide. In this paper, we discuss the potential of Cloud Computing in terms of how it can strengthen health information systems in developing countries. Like any new technology, Cloud Computing is no silver bullet; it solves certain challenges while bringing new ones to the table. Based on a case study of the innovative use of Cloud Computing for the national health information system in Kenya, we discuss how Cloud Computing can enable the integration and harmonization of fragmented systems and provide real-time information to health managers for evidence based decision making. The key contribution of the paper is to provide an understanding of how Cloud Computing can enhance health management by acting as a catalyst for the integration of health information systems.

Keywords: Cloud Computing, Health Information Systems, Developing Countries, Integrated Health Information System

1. Introduction

The emergence of Cloud Computing has made a tremendous impact on the Information Technology (IT) industry over the past few years. Cloud Computing broadly refers to applications delivered as services over the Internet based on large data centres that provide them as services [1, 2]. The National Institute of Standards and Technology (NIST) defines Cloud Computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [3] p.2. The Cloud Computing architecture consists of three components: a) infrastructure as a service (delivering server storage and network technologies), b) platform as a service (an online environment for quick development of web application) and c) software as a service (for example, email in web browsers) [3]. It is usually up to the user to choose how many of these components to use. Cloud Computing can be classified as public (company selling cloud services to public), private (owned by single organization for their own work), community (owned by several organizations) or a hybrid (composition of two or more of the above) [3]. Since health care requires confidentiality and integrity of information stored,

enforcement of security and privacy is required, meaning that a private cloud is most suited.

Compared to investing and maintaining servers locally, Cloud Computing is attractive for organizations both in the private and the public sector. Running national online information systems calls for highly specialized Information Communication Technology (ICT) services that guarantee 99.9% access and availability to all the users. Robust redundancy and failover protocols must be in place to guarantee business continuity in times of system failure. Up-time is one of the most critical requirements for servers. This is to ensure that whatever hour of the day, if something goes down there will be someone to address it. Staffs need to be available 24/7 to ensure maximum amount of uptime. This level of specialized ICT services is not the domain of ministries of health [4] and so the adoption of commercial Cloud Computing becomes very attractive. Since resources in commercial Clouds are centralized, pooled and shared among many users, it is cost effective in terms of economies of scale[5]. Users only pay for their usage and they do not need to make risky investments in hardware when their future needs for capacity is uncertain. This approach is highly relevant in the public health sector in developing countries where financial resources for investments in hardware are scarce and the human capacity to maintain local servers is often lacking.

From the literature, the use of Cloud Computing in healthcare is identified to offer many benefits: storage of large amounts of data (it is scalable and elastic for increasing or decreasing), offering remote access (the data can be accessed from internet from anywhere) and allowing sharing between authorized units [6]. Other benefits include the ability to share information within the community that includes patients, regulators, providers and even insurance firms. Chang (2009) posits that the emerging Cloud Computing appears well-suited to meet the demands of a sustainable healthcare through the concept of shared infrastructure ecosystems [7].

Like any new technology, Cloud Computing is no silver bullet; it presents entirely new challenges and obstacles, particularly regarding coping with limited technical expertise, bandwidth, and IT resources [8]. At the same time, Cloud Computing also suffers from lack of institutional support and legitimacy due to lack of proper policies and regulations. In general, governmental agencies are uncomfortable with storing data on public clouds [9]. A similar finding was found in South Africa where a lack of well-coordinated regulatory framework for proper governance of eHealth standards implementation was found to be a key concern [10].

In this paper, we focus on a different, yet an important underappreciated problem facing health information systems in developing countries; fragmentation. The increasing international funding towards public health diseases like malaria, tuberculosis, immunization preventable diseases, Human Immunodeficiency Virus infection and Acquired Immune Deficiency Syndrome (HIV/AIDS), has given rise to multiple and parallel disease specific reporting systems. This happens because donors are only concerned with their disease specific reports, without adequately appreciating their relation to the larger health information system. The result is a fragmented health information system supported by different donor interests [11-13]. Fragmentation, though primarily well-intentioned, has the potential to give rise to unintended consequences like having different public health statistics for the same indicator (but from different parallel systems), leading to mistrust of national reports.

This paper explores the interaction between Cloud Computing and the implementation of reliable information systems that reduce fragmentation and foster integration of different parts of independent diseases programmes. It attempts to answer the following research question: How can innovative ICT applications like Cloud Computing support the implementation of integrated health information systems in the context of developing countries? To answer this question, we use a case study from Kenya, which is utilizing Cloud Computing for its national online health information system. The information system under the study carries aggregate service delivery data, mostly numbers and percentages, without personalized patient information. Based on the experiences from Kenya, we argue that Cloud Computing can be used as a catalyst to establish integrated national data warehouses, reducing fragmentation and availing data to Government officials, implementing partners and international health agencies "wherever they are." The key contribution of the paper is to provide an understanding of how Cloud Computing can enhance health management by acting as a catalyst for integration of health information systems.

2. Adoption of Cloud Computing in Implementation of the Kenyan Health Information System

The first organized health information system in Kenya was established back in 1972. The system has gradually grown, having started with pure paper and progressed to a hybrid paper-digital system. While computers were introduced in the 80s, the first networked computer system was introduced in the year 2008, with the introduction of File Transfer Protocol (FTP); a system that is used to transfer files over the Internet [14]. During the time of FTP, numerous data quality issues were exposed. For example, in one of the annual data review meetings, a senior district medical officer did not agree with data being presented at the national level. These discrepancies prompted heavily donor funded programs like Expanded Program of Immunization (EPI), Tuberculosis (TB) and Malaria to establish their parallel reporting systems. An evaluation carried out to improve health information system [15] suggested a better and more robust software, leading to the adoption of the District Health Information System (DHIS2)[16].

In 2010, the DHIS2 was adopted and implemented in Kenya [17, 18]. At the onset a decision was reached to install the new system in the FTP server at the data Centre at the Ministry of Health (MoH) headquarters. On evaluating the suitability of the government data centre, it was observed that the data centre was a just room that housed several racks of equipment for the ministry's Health Information System (HIS) together with the Integrated Finance Information system (IFMIS) of the Ministry of Finance. The room was dark, dusty, musty, and generally not a conducive environment for sensitive and delicate electronic equipment meant to host information of immense importance. At the same time, the Internet connection barely worked because of outdated network equipment. There were also no power backup systems.

Based on consultation with senior ministry officials, outsourcing of the server was considered a better option and therefore adopted. Still, this was meant as a temporary arrangement and the long term strategy was to build local servers and necessary

infrastructure at the MoH headquarters. The server and the system were hosted by the Cloud Computing provider Linode in London, with support from the University of Oslo. Initially, all the management of the server was done from Oslo. In this concrete setting, the greatest benefit of Cloud Computing was the immediate availability of data. Due to excellent network connections, the speed with which data were uploaded and downloaded was remarkable. Previously getting data from the central server hosting health information delivered at the MoH headquarters was difficult. The DHIS2, with excellent access through the cloud, was rapidly rolled out countrywide within one year. Another key benefit was that the cloud service provider adjusted quickly to the growth in the database and the data traffic. This elasticity of resources proved very useful, since the Kenyan database was growing at a rapid rate. By 2011, all health facilities were reporting their routine health indicators using the software hosted in the cloud [18].

Since adopting DHIS2, data management in the country's health information system is both paper and electronic based. Health workers at health facilities (Hospitals, Health Centres, and Dispensaries) record data in paper registers as they deliver their services. Data from these registers are then summarised and entered into pre-defined summary forms on a regular basis (weekly, monthly and quarterly). These are then transported by road to the sub-county health records offices (formally districts), where they are transformed into the electronic formats through entry into the DHIS2. Designated officers at the sub-county level are charged with the responsibility of scrutinising the data received from health facilities for completeness and correctness before entering them in the system. Once in the system, any person with access rights can view the outputs (charts, tables and maps). Figure 1 below shows the data flow of health information system in Kenya using DHIS2 and Cloud Computing. Figure 1: Flow of Data in Kenyan Health information using of DHIS2 and cloud computing

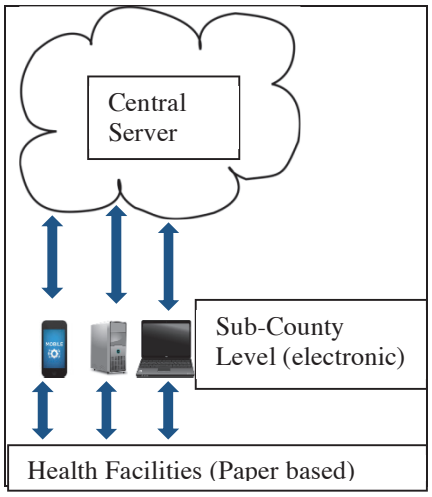

Figure 2: Data flow From Health facilities to Central server using cloud computing facilities

Since hosting of DHIS2 was initially thought to be a temporary fix, the government constructed a modern data Centre at the Ministry of Health headquarters in 2012. During the opening ceremony of the data Centre, the Permanent Secretary for the Ministry of Health said, "*This data center is unprecedented in the history of the Health Ministry and represents the biggest investment in IT to date; as technology improves, so does the quality of life, therefore the ministry is willing to embrace technological advancements that will help improve the health sector*" [19]. However, due to staff shortages and lack of a dedicated internet connectivity to the data Centre, Kenya continued to host the DHIS2 in the commercial public cloud, raising many issues with the government. For example, one senior MoH official was concerned with the lack of legal framework supporting hosting of health data out of the country. The official hinted to the possibility of confidentiality breaches with sensitive health data in the cloud. Even though it was only aggregated data without any personal identifiers, some senior ministry officials continued asking: "where is our data?" Based on these concerns, the ministry again tried hosting the software on the newly refurbished data center. But again, this was not possible due to the fact that in country facilities were slow. Eventually the ministry organized for the migration of the system to an in-country server at the Safaricom (mobile company) cloud in 2012. However, due to growth constraints and limitations of the ICT resources at the Safaricom cloud, the system was once again migrated to an offshore managed server - Digital Ocean in 2013. Digital Ocean is an American cloud infrastructure provider that provides virtual servers for software developers. The company is headquartered in New York City and possesses data centres worldwide [20].

All costs for hosting the database in the cloud are currently supported by the United States Agency for International Development (USAID) through a Kenyan Non-Governmental Organization (NGO). Besides hosting costs, four ICT officers at the NGO were trained in the administration and support of the DHIS2 database and software through the cloud computing technology. The hired ICT specialists work closely with selected government workers from the Ministry of Health, providing on-job training. The same NGO also collaborates with a local University on issues of software development, management and sustainability.

3. Methodology and Data Analysis

This paper is part of a larger study on the implementation of an online health information system in Kenya. The larger research utilizes Acton Research methodology, a qualitative research method in which the researcher is actively involved in solving a real-world problem by bringing about change in an organization, while at the same time contributing to development of knowledge and theory [21, 22]. It involves integrating theory with practice through an interactive process of problem diagnosis, action intervention, and reflective learning [23]. The action research in Kenya is part of the global Health Information System Program (HISP) research on

health information systems in developing countries and the development of the District Health Information Software (DHIS2). HISP is a global network of people, entities and organizations, who design, implement and sustain Health Information Systems. As a network, HISP was established by the Department of Informatics at the University of Oslo and supports local management of health information systems [24]. The principal researcher is part of this HISP team and some of the empirical data used in this paper are derived from his participant notes on lessons learnt in the Action Research.

The main study methodology for this paper is case study, because it is well suited to answer the research question[25]. The unit of analysis was the health information systems. Data were obtained by interviewing key stakeholders in the health sector. The stakeholders interviewed included health information officers, health facility managers, senior ministry of health managers at the national level, and the chief executive officer of a Non-Government Organization (NGO) project with the mandate for managing the country's health information system. Table 1 shows the number of key informants interviewed.

Table 1: Summary of Interviews

Type of informants	Number interviewed
Senior government officers	4
Health records and information officers	10
IT officers	2
Bilateral donor agencies	3

Analysis of the qualitative data was done by summarising the interviews, participant notes and proposing explanations. The principle researcher was part of the stakeholders working for the ministry of health and his opinions were also considered taking, an interpretivist position.

4. Findings

Cost Effectiveness: Hosting a national and robust system such as DHIS2 requires a secure environment with specialized ICT experts. In Kenya, the ICT staffs do not form part of the skill mix at the Ministry of Health; making it very hard to implement some of the complex ICT procedures such as server management. Kenya built a state of the art server but was not able to operationalize it partly due to staff shortages and other technical issues. This is a classic example where funds are invested in the information infrastructure, but does not translate into use. On a monthly basis, the cost of the rented services for the country are less than 500 US dollars, far less than what was used to construct and what would be required to hire specialized staff to operate and maintain local infrastructure. In Kenya, the cost of maintaining the cloud servers was provided by donors.

Support from the policy makers: Hosting of the software out of the country was discussed with the senior ministry of health official. Despite agreeing on a lack of an appropriate legal framework, they accepted the cloud option on the condition of maintaining high data security (in view of the confidentiality nature of health data). This was interpreted by other stakeholders as an assurance of security, ultimately allowing their data in the system. This further reinforced the integration of data from the disease based systems.

Improved internet connectivity in the country: Improved access to online systems through the availability of fibre optic cables and mobile internet makes it easy to get data from the cloud. With excellent connectivity, clients are able to download data for use wherever they are. However, the internet connectively is not uniformly good across the country, making it hard to access the data on the cloud. This overdependence on internet has once delayed important meetings due to lack of data since the internet was not sufficient to download data from the central server. However, the users of the system have been advised on the need to make data backups, in order to avoid delays due to connectivity. DHIS2 has been designed to allow data entry while offline, allowing those with low internet to work offline without interruption.

Due to accessibility afforded by the country's good internet connectivity and the efficiency of international clouds, it was very difficult to adopt local clouds which were slower, thereby reinforcing the continuous use of high efficiency international commercial clouds.

The use central server as a centralizing factor in a decentralized health sector: During the study period, Kenya adopted devolution as a form of government, effectively decentralizing the health sector. With most activities being decentralized, hosting the DHIS2 on a central server was a key factor to keep a national and centralized health information system. This has made it possible for stakeholders at all levels of the government to access the data online, avoiding the bureaucracy of seeking permission from the decentralized government units. This meant that the running of the health information system was not drastically affected by the political change of governance.

Addressing Security Concerns: Literature has identified privacy and security issues as the top concerns for Cloud Computing [26]. Negative institutional influences are related to the perceived lack of security of Cloud Computing. This is particularly so for patient based information which is highly sensitive and requires appropriate security. Of great concern is the possibility of unauthorized access to sensitive data and confidentiality breaches with the use of public clouds. The commercial cloud providers take care of physical security in terms of controlled access, surveillance systems and onsite security. Cloud providers also offer solutions using anti-virus, fire-walls and data encryption software to assure data security and privacy. The fact that Cloud Computing offers great security features, organizations felt comfortable hosting aggregated non personalized health data on the commercial cloud.

Integration of Previously Fragmented Systems: At the time of implementation, DHIS2 was a customization of seven datasets that were previously being used during the FTP days. Due to the scalability of the Cloud Computing arrangement, more data sets (such as those on HIV, malaria commodities, nutrition and many others) were added to accommodate other stakeholders (National AIDS control program, Malaria program, department of vaccines). This reduced the fragmentation of the previous poorly performing information system. As a reinforcing side-effect, this also prompted several donors in Kenya to start integrating their previously parallel systems with DHIS2. As a result, the number of datasets increased from the original seven in 2010 to 90 in June, 2016 [24]. The elasticity nature of the cloud afforded this integration of parallel systems since storage space was not an issue anymore. Further, accessibility, a key characteristics of Cloud Computing [27] made it very easy for many stakeholders to have confidence in the system. Managers were able to view their data wherever they had Internet access. This is a big step towards integration of parallels systems using DHIS2 as data warehouse. Beyond health information, this Cloud Computing arrangement also offered the opportunity for certain information systems to share information through established standards. Such systems included: Human Resources Information System (HRIS); which aims at bringing Human Resource Information for the tens of thousands of health workers and Electronic Medical Records (EMRs) that facilitate effective patient management especially in large hospitals. Additional information systems involved in data sharing include: disease outbreak monitoring through Integrated Disease Surveillance & Response (IDSR) and a number of projects using mobile technology for reporting.

5 Discussion

Over the past couple of years, we have witnessed diffusion and adoption of Cloud Computing in the health sector of developing countries. However, health and IT managers need to have clear ideas of what they wish to achieve by moving to the cloud. Whether it is reducing overhead costs, increasing internal IT efficiencies, or ensuring that data are kept secure and compliant, it is important to document the reason for the move.

A well-documented problem affecting health information systems in developing countries is fragmentation, which is typically brought about by independent health programs and donor dependencies [11, 28]. The emergence of Cloud Computing offers an opportunity to solve this problem by reducing the hurdles of integrate data from different and parallel health programs and systems. This case study shows that with cloud computing the number of data sets in the health information system in Kenya soared from seven to 90. This was due to the fact that Cloud Computing facilities are scalable according to the needs of the client and have excellent Internet connectivity. The development of a strong Internet backbone and utilization of fibre optics in developing countries like Kenya is reinforcing this.

Another factor driving cloud adoption is costs; the cloud has been proven time and again as a more cost-effective model than running an on-premises data centre [29]. This is further shown by the fact that countries can utilize the benefits of web based

systems with minimal initial infrastructural costs. Countries can simply pay for services before constructing their own private servers. It is also an assumption that countries can save money when they do not need to pay staff to manage local servers. In Kenya and other developing countries, the argument of staff must also be seen in relation to the availability of human capacity to operate and maintain servers locally and inside the ministries.

This study shows that Cloud Computing is promising, but not a silver bullet. Challenges included the failure of countries to come up with timely legal frameworks to support its uptake. Also as medical data is shrouded with secrecy and confidentiality, many health managers are concerned, particularly pertaining to the breach of patient confidentiality. While most companies have addressed this issue by careful encryption, and continuous monitoring of security compliance, it is always difficult to assure the customers 100% security. Despite the security concerns, some authors argue that most enterprise-centric cloud architectures have a stronger security than in-house servers [30]. The issue of costs for maintaining the Cloud Computing servers is an issue in developing countries, which most often than not depend on donors for such installations. External support is not always sustainable and so hosting costs are seen as one of the challenges of Cloud Computing. Further, addressing the lack of local capacity to run and maintain local servers is a short term solution that removes any incentive for buildings such capacity.

5.1 **Conclusion**

Following the interpretation of the findings and supported by arguments from existing literature review, we find that this study has several contributions to make to literature. The following are key contributions highlighted from the paper.

Cloud computing as a catalyst for integration of health information systems: we have seen that a strong "side effect" of Cloud Computing is facilitating integration. This aspect of Cloud Computing has not been addressed before in literature.

Donor Dependency: This paper shows that the success of Cloud Computing in developing countries is highly dependent on donors and the IT infrastructure especially the emergence of fibre optic internet connectivity. The dependency on donor may be a short term fix but risks related to dependency can be devastating due to unreliability of some donors.

Human Resource: Most developing countries lack human resource capacity for handling local servers. Even when local servers are present, they are situated in murky server rooms, not properly maintained.

Recommendation: In order to leverage on Cloud Computing, it is recommended that adequate and long-term planning should be done to avoid situations that might lead to

disruption of services, confidentiality breaches and support the development of human capacity to deal with servers also in developing countries.

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Reporting Practices and Data Quality in Health Information Systems in Developing Countries: An Exploratory Case Study in Kenya

Ayub Manya[1a1] and Petter Nielsen[1]

[1] University of Oslo

Abstract. Despite increased attention paid to health information systems and their key role for improving health systems in in Low and/or Middle income countries (LMICs), it is believed that data from majority of the health information systems contribute little to the decision-making processes due to poor data quality. We carried out an exploratory assessment of the health information system in Kenya with the main objective of determining the quality of data in terms of accuracy, timeliness and completeness. The study also considered the reasons for the observed data quality status. Data quality audits were carried out in selected health facilities. Data from the source documents at health facilities were compared to the data in the national health information systems for the same period. Key informant interviews were conducted and focus group discussions conducted during quarterly review meetings at regional levels. The study revealed that the completeness rate for the monthly reports was 86.9 percent while the timeliness of the reports was 78.7 percent. In terms of accuracy of the reports, the study showed that while there was a significant amount of low accuracy in many reports evaluated, there was a surprisingly high accuracy of reports coming from the maternity units of all health facilities visited. The accuracy of the number of deliveries could be associated with the financial incentives provided by the government to health facilities as part of the country's free maternity care project in which mothers deliver free of charge in health facilities. While most health information systems are plagued with poor data quality, a simple and practical incentive can improve accuracy, timeliness and completeness.

Keywords: health information systems, data quality assessments, incentives, data quality, accuracy of data, timeliness of data, completeness of data.

[a] Corresponding Author: Ayub Manya, ayubmanya@gmail.com

1. INTRODUCTION

In recent years we have seen an increasing focus on health information systems globally, with significant human and financial resources being invested at various levels to improve them (Arts, De Keizer, & Scheffer, 2002; Kihuba et al., 2014). Adoption of modern Information and Communication Technology (ICT) has greatly improved access to health information systems (Kimaro & Nhampossa, 2007). Access to timely and high quality data is very important for strengthening health systems (WHO, 2003, 2007). Such data are vital for facilitating long term planning, policy formulation and day-to-day resource allocation within the health sector (AbouZahr & Boerma, 2005). In order to run an efficient health information system, data are derived from several sources including census, surveys, service delivery reports, registration of births and deaths, (Ledikwe et al., 2014). Data from service delivery are gathered by health workers, particularly nurses, clinicians and laboratory staff, who document their service delivery work. Regularly, after the data are collected and entered in paper registers, the providers fill out summary forms and send them up to the next reporting level. Research has shown that data often get lost or become erroneous during these processes of data collection, collation and transfer; leading to mistrust in routine health information systems. It is argued that unless there are adequate mechanisms to provide high quality of data as well as for developing a culture for using data to inform decisions, health information systems have no value (Tara Nutley, 2006).

Despite the increased attention paid to health information systems in developing countries, some researchers argue that data from most of these systems contribute less to decision-making processes due to poor quality (Arts et al., 2002; Braa, Heywood, & Sahay, 2012; Kihuba et al., 2014; Sahay, 2001). When health managers are asked how many women delivered in health facilities or how many maternal deaths occurred at health facilities, they must answer them with facts, rather than beliefs and opinions. At the same time, data are too often used uncritically from health information systems without checking the data for any errors; often resulting in misleading interpretations, unwise decisions and increased costs (Chapman, 2005). Of the three challenges identified above (poor data quality, non-use of data and non-critical use of data), this paper focuses mainly on data quality.

Determining the quality of data is complex. This is because data quality encompasses multiple dimensions. Juran and Godfrey(1999) posit that data quality is determined by how fit the data are for specific uses (Juran & Godfrey, 1999). Other researchers view data quality as "the measure of the agreement between the data views presented by an information system and that same data in the real-world" (Orr, 1998) p.3. Other data quality dimensions include accuracy, completeness (having all relevant information recorded), timely data, consistency and relevance (Ballou & Pazer, 1985; Herzog, Scheuren, & Winkler, 2007; Ledikwe et al., 2014). This paper focuses on accuracy, completeness and timeliness. In order to assess data quality, there is a need to compare the data in question with the equivalents from the real-world in order to correct any deviations.

Even though most stakeholders keep raising the issue of poor data quality in health information systems, our starting point is that not all data are of equally poor quality. Thus, we should explore and learn from data of good quality, and leverage upon this to improve the information systems. This paper is an attempt to answer the following research questions: How can we leverage on high quality data and the related data collection and processing best practices to enhance health information systems? To answer this question, we evaluated the data in the Kenyan health

information system; with the main objective of determining the quality of data in terms of accuracy, timeliness and completeness. The study also considered the reasons for the observed data quality status.

The specific objectives included:

1. To determine the accuracy, timeliness and completeness of data for selected data items reported at selected health facilities, compared against what was reported for the same facilities in the national health information system for a particular period.
2. To establish possible reasons for observed differences in data quality and identify the good practices behind the high quality data that can be used for strengthening health information systems.

2. REVIEW OF COMMON DATA QUALITY PROBLEMS

There are many possible problems that undermine the quality of data in health information systems. Some of these problems relate to the set-up of the organization and the technical knowledge of those who work with the data. In a study conducted in Botswana, it was found that data quality was not only affected by the limited capacity to collect, analyse, and interpret but also by the lack of skills to ensure that data being collected are of good quality (Ledikwe et al., 2014). Data quality assessments conducted in Kenya in 2010 and 2014 consistently found many discrepancies between data in primary tools and those in the national system. The assessments outlined the following reasons for the discrepancies: failure to use registers as per instructions, failure for health workers to understand the indicators, the use of multiple tools to aggregate the data and lack of data collection tools (GOK, 2010b, 2014). Researchers have also observed that there is a relationship between data quality and use (Braa & Sahay, 2012; Orr, 1998). Braa (2012) further hypothesised that, "poor data quality will not be used, and because they are not used, the data will remain of poor quality" (Braa et al., 2012) p.379. It has also been observed that when data remain in the system for too long without use, they lose their quality (Orr, 1998). The practice of collecting large amounts of data that are not of immediate use is therefore not recommended since "it is clear that if an organization is not using data, then, over time, real-world changes will be ignored and the quality of the data in the system will decline" (Orr, 1998, p. 7).

2.1. Data Quality in Health information system of Kenya

In 2010, Kenya adopted the use of District Health information software(DHIS2), which is used countrywide (Karuri, Waiganjo, Orwa, & Manya, 2014; Manya et al., 2012). One critical program in Kenya that requires accurate data is the free maternal care project. Faced with the problems of women dying during delivery (maternal mortality ratio 362 deaths per 100,000 live births in 2014(Obonyo, 2010)), the government of Kenya decided to provide free maternity care, starting from 2013. In this program, pregnant women are allowed to deliver in any government or faith based health facility, free of charge. The accrued costs to health facilities are then reimbursed by the government according to agreed rates. The country's Health information system is used as a means of verification for these reimbursements.

Kenya adopted a decentralized system of governance (GOK, 2010a) through a constitutional change In 2010. The new constitution abolished the eight administrative provinces and instead created 47 counties (Kanyinga & Long, 2012; Nyanjom, 2011). The change was part of a negotiated agreement to stop ethnic based chaos that had erupted, following the disputed presidential election of 2007 (Kanyinga & Long, 2012). The main rationale of adopting devolution was to increase autonomy and political power to the lower levels and thereby diffuse ethnic and regional tensions (Sihanya, 2012). The counties were semi-autonomous or federated with powers to elect their own political leaders. Each administrative County was further subdivided into sub-counties, which in most cases became the parliamentary constituencies. Apart from powers to collect revenue in their area of jurisdiction, the counties were allocated formulae driven grants from the national government for recurrent and development activities, including paying workers' salaries. This was a new reality for the health sector, affecting most aspects of governance. Devolution has the potential to promote data demand and use for planning at the local levels. Local use of data represents a change to the practice that data are seen only as for onward transmission to higher levels and hence leads to better data acquisition, storage, and sharing.

Based on data from their paper registers, health facilities summarise data into predefined summary reporting forms and send to sub-counties (formerly districts), for entry into the electronic system (DHIS2). In terms of governance, the previously strong leadership at the Ministry of Health headquarters has been diluted. The county management has taken a central role in utilizing the data for implementation of various programmes. Authorized officers from the central government are able to access data for their reporting needs from DHIS2 since it is a web based system. Other functions formerly conducted by the central government like preparation and printing of paper reporting tools have been assigned to the county. Based on this concept of local data use, we argue that devolution has the potential to drastically enhance health systems.

3. METHODOLOGY

We conducted a longitudinal study in selected administrative counties between April 2015 and December 2015 using a case study methodology. The Assessment team comprised representatives of the local health administrative office and the research assistants. Team composition included officers with mixed skills including public health (to support in the disease area and indicators), program officers (e.g., health records and information officers) and relevant regional administrators. Quantitative data were collected from data collecting tools health unit and from the online database (DHIS2). Qualitative data were obtained through meetings, participant observations and key informant interviews to contextualize and support our interpretation of the quantitative. Field visits by the first author to health facilities further provided first-hand information on the processes of data management through participant observation. Findings from the field visits were presented during quarterly review meetings attended by stakeholders including senior Ministry of Health officials in the county and development partners. Discussions during the meetings provided a more in-depth understanding of data management. Thereafter the county came up with data quality improvement work plans to be implemented in the following three months.

3.1. Study Site

Following consultations with the authorities, four counties were selected for the study, based on geographical proximity (Busia, Kisumu, Siaya and Uasin Gishu). Similarly, the assessment team in consultation with sub county managers selected health facility sites using purposive sampling methodology with bias towards health facility type (County Referral Hospital/ County Hospital, Health Centre (high volume), Dispensary). Table 1 shows the targeted participants for the study.

Table 1: Target Study Participants at Each Selected Study Site

Level	Study Participants
County	County Director of Health, County Health records and information officers (CHRIOs), Directors of the county referral hospitals
Health facility	Facility manager, data clerks, nurses and clinicians in various departments

The focus was on the tools and procedures used related to health data on the county and the health facility level as summarised in table 2 below.

Table 2: Levels, tools and procedures

Level of health system	Tools	Procedures
County	DHIS2 Summary forms	Enter data from summary forms into DHIS2 Use data from facilities for local decision making
Facility	Paper registers Summary forms	Enter data in paper registers Summarise data from registers into summary forms Transfer summary forms to next level for computerization

3.2. Selection of Data Items for Verification

Three data items were selected for verification, representing data on vaccine preventable diseases (immunization), reproductive health and outpatient curative data. Specifically the following were chosen: a) Fully immunized children under one year of age b) Pregnant women who delivered in health facilities and c) The number of children under five years who were treated for malaria in the outpatient department. In coming up with the list, the following criteria were applied:

• Information needs in terms of data that have been seen to attract interest from the managers e.g. hospital deliveries in view of the free maternity program.

• Information gaps and issues e.g. misreporting, omissions, under reporting etc.

• The impact of interventions and the importance of selected data in service delivery

Availability of research resources also served to limit the number of items to be assessed. Table 3 below shows the tools from which the selected data were sourced.

Table 3: The Source of Data for the Selected Indicators

Name of indicator	Name of register	Name of summary reporting form
The number of children under one year who were fully immunized	Immunisation Register (MOH 510)	Immunization summary (MOH 710)
The number of pregnant women who delivered in health facilities	Maternity (MAT) Register (MOH 333)	MOH 711 Integrated RH, MCH, Social Work & Rehab Summary (MOH 711)
The number of children under five years who were treated for malaria in the outpatient department.	Outpatient Register: Under 5 years (MOH 204A)	Outpatient summary under 5years(MOH 705A)

3.3. Assessment of Data Accuracy: Data Quality Assessments

To assess data accuracy three main procedures were followed. First, paper registers at each health facility were evaluated in order to identify common problems related to data generation. Second, the study investigated the accuracy of transferring data from the registers to summary reporting forms. For this study the registers and summary reporting forms were considered to be source documents since they were the primary data entry documents. Accuracy of data transfer from the source documents to DHIS2 was then investigated using a tool customised from world Health Organization; the Routine Data Quality Assessment (DQA) tool (WHO, 2011). It was structured in a way that when the responses were keyed-in, data accuracy was automatically calculated. In this study, accuracy was presented as the ratio of transmitted data items compared to the data in the source document. However, the study team did not assess the accuracy of the clinical data as written by the clinicians.

3.4. Assessment of Completeness and Timeliness of Reports

Data completeness was investigated using two criteria. First, the paper tools i.e. registers and summary reporting forms were inspected to see if all parts were completely filled. The second method of assessing data completeness was done using the DHIS2. The DHIS2 has an inbuilt reporting rate functionality which provides the completeness and timeliness of reports based on the number of facilities expected to report. Timely reports were defined as those that were in the DHIS2 by 15th of the month and were presented as percentages. In addition, the team assessed the general aspects of the health information system in terms of personnel, availability of appropriate data collection and reporting forms/tools.

3.5. Process of Data Analysis

Data analysis was both quantitative and qualitative. Quantitative analysis was particularly applied during Data Quality Assessments while qualitative analysis was mainly for the views gained from quarterly review meetings and participant observation. Analysis for the qualitative data began by summarizing the notes from the meetings and the notes from the field.

Analysis for the Data Quality Assessments was done by comparing data from registers with data in duplicate copy of summary reporting forms and in the DHIS2. Verification Ratios for the indicators were calculated by dividing the recounted figures from the registers with the figures in the summary reporting forms. The same was calculated for the data in summary reporting forms compared to those in the DHIS2. These quantitative data (counts, percentages) were entered in a computer database using Microsoft Excel. Results were compared between indicators, showing which indicators had high data quality.

4. RESULTS

A total of 63 health facilities in 23 sub counties and 4 counties (Busia, Kisumu, Siaya and Uasin Gishu) were visited. Nearly all the facilities (95 percent) in the study were managed by Ministry of Health while only 3 were run by Faith Based Organizations (FBOs). Privately owned facilities were not represented. In terms of type of facilities, hospitals comprised 40 percent as shown in table 4 below.

Table 4: Type of Health Facilities Visited During the Study

Type of health facility visited	Number of facilities	% of facilities
Dispensary	19	30 %
Health Centre	19	30 %
Hospital	25	40 %
Total	63	100 %

4.1. Results on Completeness and Timeliness of Reports

Reviewing the paper registers, we noted that most of them were large with many columns which were not being filled. This was in particular the case if a certain service was not being offered in the facility. Due to many blank columns, some health workers decided to record other findings in the empty spaces, against the guidelines given. This lack of standardization meant that a different person would have problems understanding the data in the registers. And it made it difficult to count and summarize data unless the people who maintain the registers were available. Despite this, all the services that were conducted had data in the registers. Completeness of reports was also retrieved from DHIS2. This was calculated by the system as the proportion of facilities that actually sent their reports to the DHIS2 compared to the total facilities expected to report. The

online system (DHIS) revealed that the average completeness rate for the study group was 86.9 percent.

Timeliness of the reports was determined by the number of reports that were entered in the DHIS2 before the agreed deadline of 15th of day of the Month. On average 78.7 percent of the facilities evaluated submitted their reports on time as shown in figure 1.

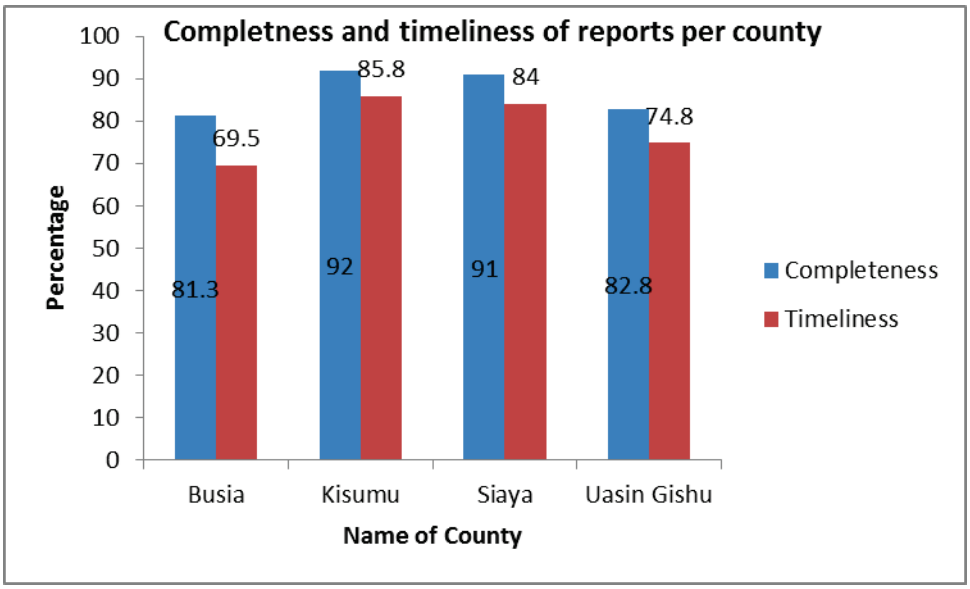

Figure 1: Completeness and Timeliness of Reporting for Selected Counties in 2015 – source: https://hiskenya.org

4.2. Accuracy of Reports

In an ideal situation where the parameters in the recorded data were found to be the same during the verification, the data accuracy value would be 100 percent. If the value of the verified data exceeded 100 percent there this was interpreted as over-reporting whereas less than 100 percent was interpreted as under-reporting.

Data verification for the different indicators revealed that there were discrepancies between the paper forms and DHIS2, albeit to varying degrees. There was over-reporting for children under five being treated for malaria (149 percent), and fully immunized children (119 percent). The number of deliveries was however nearly accurate (101 percent). This means that the data for maternal deliveries was the most accurate while that for a fully immunized child was the least accurate as shown in figure 2.

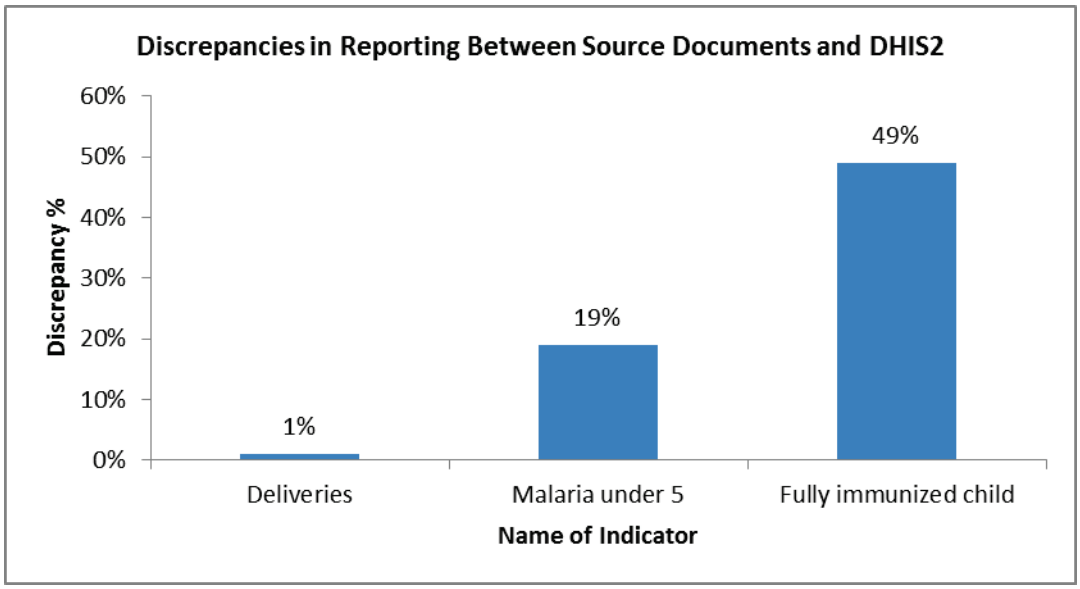

Figure 2: Discrepancies in Reporting between Source documents and the electronic database, DHIS2

4.3 Comparison of Accuracy of Data Transfer

The accuracy of transfer of was not equal. Defining 100 percent as the desired result for the compared elements figure 3 shows that transfer of data from summary tools to DHIS2 is more accurate than transfer of data from registers to summary tools.

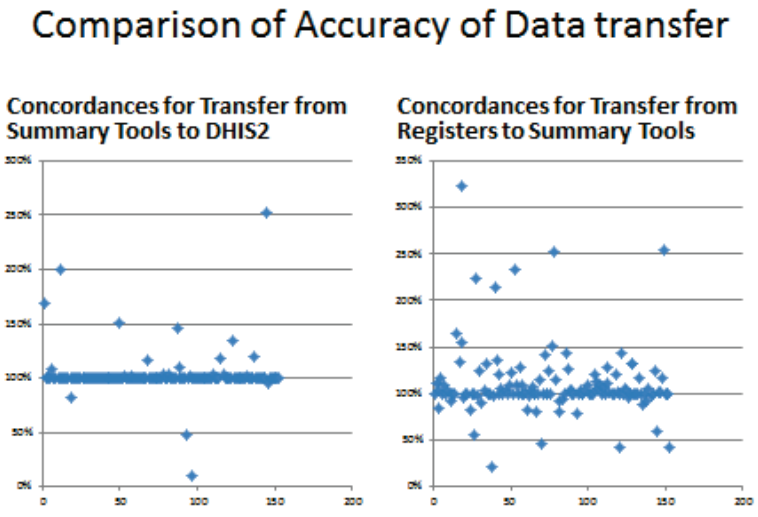

Figure 3: Comparison of Accuracy of Data Transfer between Register to Summary Tools and Summary Tools to DHIS2

5. DISCUSSION AND IMPLICATIONS

Health managers require reliable data for planning purposes. It has been shown that when data are of bad quality, their demand also drops, thereby affecting program effectiveness (Braa et al., 2012; Foreit, Moreland, & LaFond, 2006; Mavimbe, Braa, & Bjune, 2005).

The findings in this paper reflect common problems challenging health information systems. While this paper highlights poor data quality, it also shows a surprisingly high accuracy of reports coming from the maternity units of all health facilities visited. The accuracy of the numbers of deliveries was attributed to the free maternity care program. This program requires accurate data to enable reimbursement of the costs of deliveries by the national government. While most of the money is used for budgetary support to the facility, some of it is directly ploughed back to the maternity ward to improve the general working environment like staff tea and provision of vital equipment like gloves. The number of deliveries then becomes important to everyone in the health facility, the county and at the national level. For all levels, the reimbursements act as incentives to improve data quality. Due to this incentive, we expect health workers to establish their own ways of getting each day's work done and give accurate reports. It was also found that unlike in other departments, the maternity registers and summary reporting forms are managed by the same staffs who conduct the deliveries. This reduces the number of errors as would have likely happened if external clerks managed the data. These practices become intricately tied to other routinized activities, becoming part of the valued practices of the health facility. This is an example where incentives can give rise to better practices, something that should be leveraged upon to improve the health system.

From participant observation in the field, we found that counting fully immunized children from the registers and tally sheets were problematic. While data from all immunizations were recorded in registers, the records for fully immunized children were captured by tally sheets. Some health workers even forgot to tally and some tally sheets were torn. There was also confusion in counting malaria cases as some clinicians did not separate confirmed malaria and suspected malaria. So those collecting data just counted any malaria cases yet the indicator was for confirmed cases only. We further observed that the loss of quality when transferring data from registers to summary forms was more challenging compared to when transferring from the summary forms to the DHIS2. This could be due to the fact that the definitions of indicators are not clear and the way registers are maintained is not uniform. Counting from register may have peculiar problems especially since the people counting may not understand the work. In this case, the people who managed the registers were never trained while those doing data entry into the DHIS2 had undergone substantial training. Besides training, entering data from summary tools to the DHIS2 is similar to doing a copy typist work, with minimal typing errors as shown by the relatively good accuracy in this activity. Thus, the deployment of DHIS2 and related capacity building should be seen as supporting the improvement of data quality.

The decentralisation of Kenya had some effects on the observed data quality. For instance, reports were used at the county level for immediate planning. Data managers at this level were working with data not just for sending to another level but for local purposes. The findings in this paper also suggest that financial incentives may have positive effects on data quality. This should encourage more research on data quality related to mechanisms such as Results-Based Financing and their effects on data quality. Such studies should also be critical to the potential of adverse effects of incentives such as over-reporting.

The research design in this study, based on comparing different data sources and triangulation of qualitative and quantitative data, was very appropriate. This approach is useful to reveal and highlight the quite common lack of data quality in the health information systems in developing countries. But more importantly, it can also be used to identify data of relatively high quality and further to scrutinise its underlying practices. An understanding of these practices can be used to inform actions towards improving data quality across the health system.

6. CONCLUSION AND RECOMMENDATIONS:

This study shows that while most health information systems are plagued with poor data quality, a simple and practical incentive can influence data accuracy, timeliness and completeness. It is recommended that similar research should be done on large scale with the aim of scaling up the good practices.

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Understanding the Effects of Decentralization on Health Information Systems in Developing Countries: A Case of Devolution in Kenya

Ayub MANYA[1], Sundeep SAHAY[1], Jørn BRAA[1], Belina SHISIA[2]
[1]*University of Oslo, Address, Postal address: P. O. Box 1032 Blindern, 0315 Oslo*
Tel: +4745581544, Email: ayubmanya@gmail.com
[2]*Ministry of Health, Kenya*

Abstract: Devolution of government functions is becoming widespread in developing countries. However, its effects on health information systems are not well understood. To gain more understanding, a study was conducted in Kenya, a country that has recently adopted devolution and is implementing a new web-based health information system; the District Health Information System (DHIS2). The empirical data for this study were obtained from extensive desk reviews, participant observations and key informant interviews conducted in eight administrative counties. The study shows that devolution has both positive and negative effects on the effectiveness of health information systems. By giving more power to lower administrative levels, the demand for health data for planning and implementation of programs significantly goes up; positively enhancing the culture of information use by the devolved units. Furthermore, the elected local leaders have a keen interest in statistics from their area of jurisdiction, increasing information demand and data quality. Any large variations in data from health information systems would easily be detected by the stakeholders, due to the small size of devolved governments. On the negative side, devolution has weakened the national government's control on the overall governance of the health system, resulting in inadequate supportive supervision from the national level, reduced nationally organized trainings, increased tensions in management of the country's health information system database (DHIS2) and lack of requisite data reporting tools. The findings further show that the sub national units prefer to invest in visible infrastructural projects like roads, buying new ambulances, building hospitals instead of investing in health information systems. In conclusion, devolution has more positive effects on health information systems. However, to gain full benefits, it is recommended that proper coordination and collaboration between the national and county governments is required.

Keywords: Health Information Systems, Devolution, District Health Information System (DHIS2), Institutional theory, institutional incentives and Governance.

1. Introduction and Background

In the 1990s, many developing countries started implementing decentralized institutional arrangements. Decentralization is conceptually seen as the transfer of authority and power from higher to lower levels of government [1, 2]. The objectives of decentralization vary from country to country. The following are the typical reasons for decentralization: bringing authorities in more direct contact with citizens, improving the quality of public services and resolving ethnic tensions arising from unequal distribution of wealth in different regions of the same country [3, 4]. Decentralization has diverse effects on health systems, depending on how the health system fits in the broader governance structure. In

some cases, decentralization has met with major resistance and obstacles and has not been implemented and in countries where it has been implemented, it has caused major problems in the health systems [5, 6]. From literature we find that while Kenya, Tanzania and Papua New Guinea showed some success in the 1980s, the majority of decentralization processes have not brought any significant improvements in health status of the communities [7, 8]. In Uganda for instance, staff employed by the local authorities suffered delayed salaries while those whose salaries originated from the central government had prompt payment, causing major resistance and obstacles in the decentralization process [6]. While significant literature exists on the consequences of decentralization on health systems in general [1, 9], its effects on health information systems lacks specificity and grounding in empirical and theoretical analysis. This paper portrays the findings of a study conducted in Kenya, a country which adopted devolution in 2010 and is implementing a new web-based health information system; the District Health Information System (DHIS2).

Kenya adopted DHIS2 as the national reporting system in 2010 [10]. During its implementation, the country's Constitution changed; paving way for devolution of government functions to sub national levels [11]. The new Constitution changed provinces to counties. Instead of the previous eight provinces, 47 administrative counties were created based on Kenya's 1992 district framework [12, 13]. Unlike the provinces, the counties are semi-autonomous with powers to elect their own leaders (governors and members of county assemblies). Each administrative County is subdivided into sub counties, which in most cases also form the parliamentary constituencies. Sub counties are further subdivided into administrative units referred to as Wards.

While several clauses in the new Constitution started being implemented immediately after it was approved in 2010, devolution of health systems commenced after the general elections of March 2013 (G.O.K, 2013). This was a drastic change for the health system, affecting crucial departments such as procurement, human resources, finance and governance mechanisms. Among the key services that were devolved to counties include service delivery, preparation and printing of paper reporting tools and employment of workers. The national government was left with the following functions: 1) to formulate policy, 2) set service standards, 3) oversee quality assurance of services, 4) provide training and human resource development guidelines, 5) provide technical supervision, 6) manage the national referral health facilities, 7) respond to epidemics and other disasters and 8) monitor and evaluate health services. In terms of funding, both the national and county governments raise revenue from taxation, fines, sale of assets and collection of fees for services rendered. In addition, the counties receive formulae driven grants from the national government.

Due to the massive changes in governance brought about by devolution, we hypothesized that most components of health information systems (personnel, data collection, collation, transmission, analysis, dissemination and information use) would be affected. However, the magnitude and the nature of these effects were not clearly understood. This motivated this study, whose main objective was to understand the potential positive and negative effects of devolution on health information systems. The study was guided by one research question: *What are the Effects of Devolution on Health Information Systems in the context of Developing Countries?* Besides filling the literature gap on decentralization of health information systems, this paper can prepare relevant stakeholders to leverage the positive and manage the negative effects of devolution, effectively promoting health information systems as sources of high quality data for evidence based decision making.

A case study design was used. Data were obtained from extensive desk reviews, analysis of the database of the reporting system and key informant interviews in selected administrative counties. More data were obtained through participant observation by the

principal researcher, who works for the Kenyan Ministry of Health and was involved in the implementation process.

2. Objectives

The study of health information systems involves reviewing the personnel involved in the systems, technology, data and procedures. Any changes that may occur in any of these components (as may happen during devolution), may affect the effectiveness of the health information system. The main objective of this paper is to evaluate the effects of devolution on all the aspects of health information systems. Three specific objectives formed the basis of inquiry for this paper, which sought to understand how:

1. devolution of decision making and political autonomy from the central government to county government affects the health information system in terms of data collection, transmission, storage (including electronic database), data analysis and dissemination of information
2. devolution of budgeting and planning functions from the central government to county government influences the use of data from health information systems
3. devolution of personnel affects the effectiveness of health information systems in terms of data quality and data use.

3. Methodology

This study is part of a larger project aimed at improving Kenya's health information system through the deployment of a computerised health information system (DHIS2). This section looks at the methodology: study design, study population, evaluation of the electronic reporting system and data analysis.

3.1 Study Design: Case Study

A longitudinal case study was conducted in eight selected administrative counties. According to Cornford and Smithson (2005), a case study is an in-depth exploration of one situation [14]. This exploration often needs to have a certain time span since a snapshot of a situation cannot capture the process of change. In a case study, the researchers devote themselves to the specific situation, and the reward is a richness of data, obtained by multiple means. A Case study approach is considered the most appropriate method for conducting interpretivist research in the Information Systems field [15, 16]. Data from health facilities and key informant interviews were collected between April 2015 and December 2015. Participant observation and analysis of the health information system database continued up to August 2017.

3.2 Study Population and Selection of Study Participants

The study population comprised county health mangers from eight counties namely: Busia, Kisumu, Nairobi, Machakos, Homa Bay, Migori, Siaya and Uasin Gishu. Study participants were drawn from the Ministry of Health (MOH), county-level health records information officers (CHRIOs), program managers of various health programs, Monitoring and Evaluation (M&E) advisors from HIV/AIDS, Tuberculosis (TB), and Malaria programs. A team of two researchers, accompanied by senior data managers from the counties visited selected health facilities where they collected data regarding the status of the personnel, data reporting tools (registers and summary forms) and the electronic reporting system (DHIS2). These findings were presented in quarterly performance review meetings that were attended by the Ministry of Health and other implementing partners. While at health facilities and during performance meetings, key informants were selected and interviewed. This selection was based on purposive sampling, but in general, all county health directors, medical superintendents of county referral hospitals and health records and information

officers (HRIOs) were selected. Unstructured interviews were used to collect data since it was a more relaxed way of verifying some of the data that had been presented from the field visits. Since unstructured questions were like natural conversation patterns, participants were encouraged to speak more freely and without bias. This facilitated the researcher to discover richer, more in-depth information that may have not been originally considered in the discussion guides, adding useful and interesting responses to the research. A total of 35 key informants were interviewed as shown in table 1.

Table 1: Summary of Interview Participants

Type of informants interviewed	Number
Senior government officers	8
Health records and information officers	16
IT officers	5
Bilateral donor agencies	6
Total	35

3.3 Analysis of Electronic Reporting System, the DHIS2

The integrity of the metadata in the District Health Information System (DHIS2) at the server level was evaluated. The team reviewed system configurations, the data values, user accounts, user authorities, data output data analytics (Checked for data analytics failures and errors) and organizational units. The main aim of the assessment was to establish all the shortfalls within the DHIS2 that could be attributed to devolution.

3.4 Data Analysis

Data analysis was mainly qualitative, evaluating the views of participants of quarterly review meetings, unstructured questionnaires and participant observations. Analysis for the qualitative data began by summarizing the notes from the meetings and the notes from the field. The results were further evaluated through the institutional theory lens. Given that health information systems are key components of the health systems, attempts to understand the effects of devolution must be seen in the context of the entire health system and the government structure, hence the choice of institutional theoretical lens. Institutional theory has risen to prominence as a popular explanation for both individual and organizational action [17, 18]. This study uses the concept of institutional incentives to understand the effects of devolution on health informatization systems.

4. Technology

The DHIS2 is a database tool for collection, management, validation, analysis, and presentation of aggregate statistical data [19]. The Kenyan DHIS2 project utilizes servers provided by commercial hosting companies through cloud computing. Users connect to the server through the Internet provided by mobile connectivity or wireless technology (WiFi). These services are supported by implementing partners, coordinated by the national Ministry of Health. Similarly, the daily management of the database is coordinated by the national Ministry of Health through a U.S. Agency for International Development (USAID) supported project based at the University of Nairobi. This description of technology highlights a highly centralized structure, which may cause tensions in a decentralized government structure.

5. Developments

Kenya adopted District Health Information Software (DHIS2) in 2011, replacing the Excel-based File Transfer Protocol (FTP). Right from the onset, the DHIS2 was highly accepted

by many stakeholders. Apart from the DHIS2, other information systems that have been adopted in Kenya include: Human Resources Information System (HRIS); which aims at bringing Human Resource Information for health workers to the electronic age and Electronic Medical Records (EMRs) to facilitate effective patient management especially in large volume hospitals. In addition, other initiatives include; disease outbreak monitoring through Integrated Disease Surveillance & Response (IDSR) and several projects using mobile technology for reporting. While system design and strengthening activities have contributed to progress over several decades, stakeholders both within and outside the government agree that the country's health information system has potential to grow because of devolution.

6. Results

This section gives results of effects of devolution on the components of heath information systems; process, personnel, technology and financing.

6.1 Review of Process of Health Information Systems

The study showed that devolution did not drastically affect data flow. Just like in the old constitutional dispensation, routine data from health facilities are summarised and sent to sub counties (formerly districts) for entry into the electronic format using district health information system (DHIS2). The county management has taken a leading role in utilizing the data from health facilities for planning and monitoring programs implementation. The central government can access data from their system online for their reporting needs. The only change noticed was the apparent increase in sub county units which increased from 185 to 316 countrywide. Most of the newly created sub counties did not have qualified health information officers to handle the data and so other cadres like nurses gave a helping hand. Table 2 shows the changes that occurred

Table 2: Effects of Devolution on the Processes of Heath Information System

No	Process	Before Devolution	After Devolution
1	Data collection	Health workers at health facility collect service delivery data and make summaries for sending to next level	No changes noted
2	Data computerisation	District health information and records officers enter data in the DHIS2 online. A total of 185 districts	No change in procedure. However, the number of Sub counties increased from 185 to 316, leading to inadequate capacity of HIS staff in terms of quality (knowledge, skills) and quantity
3	Technical support of the process	DHIS2 core team of different skills established at national level including IT staff (from different ministry)	Weakened central team. Technical support on the database still being done through the national government.
4	Printing of data reporting tools	Organized at the national level	Printing tools devolved to counties but funds were not allocated for the process. Health facilities not having enough tools during the study period

Regarding the data collection tools, it was revealed that some health facilities did not have the recommended reporting tools. When probed for reasons for the observed lack of tools, participants responded that there was confusion as to who was supposed to print the tools following the devolution of health services. The county governments had not been provided with money to print the tools, yet the national government declined to make commitments towards the printing, leaving some health facilities without basic tools. A considerable number of health facilities had resorted to photocopying the tools as a stop gap

measure. From participant observation, some health facilities had worn out registers and tally sheets that required replacement. Figure1below shows a photo of torn tally sheets found in one health facility during the visits.

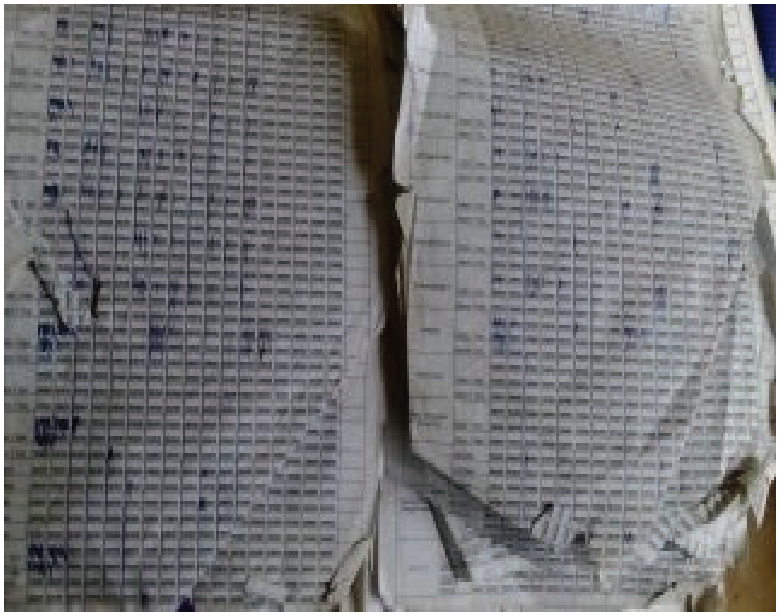

Figure 1:Photo of Some Torn Tally Sheets Found in Health Facilities

One of the issues we noted about the tools was lack of standardized way of recording. Some registers were too huge; containing disease conditions that were not applicable in the county, leading to many unfilled columns. Due to many blank columns, the health workers had decided to record relevant disease conditions in columns that had non-existent conditions. It was therefore difficult to understand the data unless the people who performed the modifications were available.

6.2 Results of Analysis of the HIS infrastructure and Database

All heath facilities that were visited had a health records office or store for data files, signifying the importance of data. Some health facilities had even created a place to store outpatient cards, a departure from the practice where patients carried their outpatient cards home. Other supportive infrastructures including computers were available, courtesy of the support from implementing partners.

Analysis of the database of the web based health information system (DHIS2) revealed that the Meta data structure and overall organisation of the database had become disorganised. At the time of the review (from 13th March 2016 to 20th March 2016), the database had 80 datasets which collected data on weekly, monthly, and yearly basis. It also had more than 69 million records with more than 23,000 (Twenty-three thousand) users. Out of these users 82% had not logged into the system for one year, meaning that the system was full of inactive users. It was also established that the development of the user roles did not follow the recommended standards, and hence a clear policy for users' access was required. For instance, out of the 8,450 users reviewed, guest role had been attached to 46%, facility online 12% and district online 5% of users. The rest of the roles had less than 5% of the total users in the system. Some users had more than one user role while a total of 890 users were identified as duplicates in the system. Other aspects of the database that showed serious problems included the organization unit. The creation of many administrative units has impacted on the organisation unit management in DHIS2. With 47 Counties and many sub counties, navigation of the system is cumbersome. The counties had no role in maintaining the database and the national level did not even have the power or

numbers to visit the counties to support in the organisation of the data from their counties. Asked about their opinion on this, most participants were not happy about the situation. They stated that since the database was being controlled at a higher level, they often saw changes in the system without consultation. Furthermore, there were periods when the system was slow or totally down yet there was nobody to respond to the issues, or the counties were not clear as to where to seek for technical support.

6.3 Findings Relating to Personnel

The study found out that right at the outset, the new Constitution necessitated the redefinition of the staffing structure of the entire Ministry of Health. In general, there was massive re-organization of staff, with some health workers being transferred to counties while others remained at the national level. At the national level, the department of health information system was subdivided into smaller units (eHealth, Monitoring and Evaluation, civil registration and Health information system). Some of the Health workers that were initially within the DHIS2 core team at the national level were posted to fill various units, greatly weakening the previously strong core team. Due to high number of sub national units, proper induction in new positions were not done. The previously strong leadership at the Ministry of Health headquarters was reduced, since the Constitution did not allow direct supervision. The counties had also reported a lot of industrial actions in the form of strikes due to delay of payment of salaries for the county staffs. Those paid by the national government were however, getting prompt payments. All these, coupled with the counties' loose connections to the National level, had a significant impact on the health information system.

A key finding concerning the staff relocation was ethnicity. It was reported that staff were being requested to work in their home counties. Officers were being posted to take up leadership in their home counties, causing some ethnic tensions. The deputy health records and information officer on one county was from a different ethnic group and felt harassed since people kept on asking him to go to his home county.

6.4 Results of coordination of health information system within the counties

During the unstructured interviews, participants were happy with the support afforded by county health managers through implementing partners. The partners were willing to support in photocopying some tools and providing training opportunities for the health records and information officers. Others were happy with the county governments' attempt to implement various electronic medical records (EMRs). There was increased focus on the importance of health information systems as seen by high demand from the county governments. In terms of data quality, some participants argued that it had become very difficult to document false data since the county government had a small area of jurisdiction and were likely to be aware of the event. Some described this as "putting faces to statistics"- if a death or an epidemic was reported, it was likely that one of the leaders on the county government was aware of the occurrence and so they would know the persons affected by name. The importance of data to the elected leaders at the administrative Ward unit was so high that the county had demanded the inclusion of Ward in the organization hierarchy of the DHIS2.

The importance of data to the county health management teams was evident. In most of the health facilities visited, the data managers were missing because they were busy in meetings. In some communities they even had coined a local name for the data manager; *Ja data* (literally meaning the custodian of data in the local language). In case the *Ja data* was missing, then no one could access or handle issue of data. This was the first time we started noticing growing importance of data, raising the data manger's role to a prominent level.

Despite the apparent increased focus on health information systems, majority of

participants said that the county governments paid more attention to visible infrastructure developments like construction of roads, procurement of ambulances and construction of new hospital units than on addressing the needs of health information systems. Counties had not even printed new tools and yet they demanded information (e.g., data on cancer of the cervix was required but there were no tools to collect the information). They also decried lack of training on the DHIS2 since most of the officers in the field were new and had not undergone training. It was also very difficult to get help from the national government since most of the professional links had been cut and new supervisors were also not well trained.

6.5 Understanding the Results Through the Institutional Incentives Concept

The counties visited had similar findings. This uniformity across counties following the devolution process is enough to suggest that there are institutional arrangements like incentives at play. Incentives may come from many sources and are more than just financial rewards and penalties. They can be positive or negative changes which the individual associates with an action. Some of the common incentives include: opportunities for distinction, prestige and personal power, desirable physical conditions in the workplace, including staff tea, a private office, and a feeling of participation in large and important events [20]. We use this concept of institutional incentives to understand some of the findings in this paper.

A key finding in this paper in the increased data demand from health information systems following devolution. This stems from the fact that the locally elected leaders require information to prepare budgets and monitor projects. Being answerable to the electorate, the leaders require accurate data from the community and health facilities. We argue that the quest for re-election is a good incentive to increase the data demand and use. Despite the increased demand of data, participants interviewed reported having difficulties in acquiring and integrating the necessary information. Information acquisition problems are caused by both the characteristic of the information itself (e.g. confidentiality) and the application of modern technology (inability to mine from databases in use). Most of these problems arise from capacity building. Simple knowledge sharing during meetings were good incentives for capacity building since the officers with knowledge felt acknowledged. We posit that educational based institutional incentives can play a significant role in improving data quality and information use.

In this study we see the emergence of a strong data manager who is the custodian of data (*Ja data*). By having more information on data issues more than others, the data manager starts enjoying special favours like attending all meetings and seminars (where they benefit from the meeting allowances). At times, it is difficult to proceed with any data work without the presence of the data manager. While the intuitional incentives favouring an individual improves knowledge and skills in that individual, we find that this becomes a negative incentive in the growth of the system since it reduces information sharing.

7. Business Benefits/Discussion

Over the last few years, the Ministry of Health of Kenya has embarked on a rigorous process of improving the national Health Information System. This process has so far resulted in the development and adoption of the District Health information software (DHIS2), which is used countrywide. The introduction of the DHIS2 greatly improved the availability of information and has been highly accepted by the stakeholders. However, it was not clear how the devolution of government services was going to affect it. This study shows that significant effects were in terms of personnel, database management, development of data collection tools, data quality and competing interests form other health system building blocks. In preparation of devolution, there was staff movement from

national level to lower levels. Those at the national level were also re-distributed in different units. This had a significant impact on the management of health information system. Of mention is the dissolution of the DHIS2 core team which had previously supported the running and training of officers in health information systems. This led to the observed lack of trainings and lack of supportive supervision. Since the counties were poorly inducted in the software management, some of the officers started making mistakes in the data base leading to a disorganised database that was observed during database analysis. The poor data quality was due to the disorganised database.

At the time of deployment of the DHIS2, the country did not revise the data collection tools, but opted to customise the tools that were in FTP; with the hope of revising them later. However, the process of revision of the tools was very slow, most probably due to the country's new Constitution. Out of the health information systems problems identified, reporting tools were mentioned as the most important. During the study, most respondents alluded to using outdated data reporting tools. Most facilities reported lack of reporting tools. Inadequate training of health works on the health information was mentioned as the next important complaint. This had led to poor understanding of indicators giving inconsistent reports.

Based on the literature reviewed, the research team found that one of the reasons for devolution was to reduce ethnic tensions. Indeed, while devolution can respond to heightened ethnic differences, it is important to note that it may create more problems, as evidenced by situations where hard working officers from different ethnic groupings were left out in favour of home grown incompetent ones. In other words, if devolution is not well done, it may, paradoxically bring ethnic tensions.

It was noted that the county had embarked on large-scale constructions and physical support including ambulances. These management improvements raised the moral of workers, supporting the devolution in general. In terms of health information systems, the participants revealed that hospitals had installed electronic medical records and most workers had been trained on it. This is in keeping with literature which depicts devolution as a tool for improving sub national units [21] by reducing the monopoly of power by spreading it towards the peripheries and to the minorities and improving the poor quality of public services [3, 4].

As expected, the data demand by devolved units for planning and monitoring programs increased significantly. Constant review of data by the county managers facilitated improvement of reporting rates. Participants were happy by the interest of elected leaders in the data of their units. Some elected local leaders were even calling to inquire about the prevalence of certain conditions in their areas of jurisdiction.

The assessment of the DHIS2 database established all the shortfalls within the system that needed to be fixed. Some of the problems required policy guidelines to be put in place to avoid a repetition of such mishaps while others required training. However, the challenges of training adequate staff to manage a countrywide health information system should not be under-estimated. Health systems are complex. A lot of capital investments and yearly commitments to build systems are needed.

8. Conclusion and Recommendations

The study shows that changes brought by devolution were drastic; requiring behavioural adaptations on the part of most of health workers. Achieving an efficient health information system will require concerted effort at every level, from the highest levels of administrative policy making to the day-to-day actions of individual health workers. This means that individuals and decision makers at all levels need to understand the implications of their choices – whether a health worker forgetting to tally in the register, a sub county health information officer failing to enter data in the electronic information system or the national

team failing to maintain the health information system database. The county can facilitate this process by providing appropriate information reporting tools. Staff relocation was massive and the attendant induction may not have been sufficient. The use of advanced technology (DHIS2) that was hosted on a central server and controlled by the national government was confusing, since it strengthened centralization as opposed to devolution, causing some tensions. Significant positive effects of devolution on health information systems included increased data demand and use by the county leaders and increased support from the implementing partners. On the negative side, capacity building of staff and provision of requisite tools for health information system were highlighted as major drawbacks of devolution.

Overall, the positive effects of devolution outweigh the negative ones. However, to gain full benefits, it is recommended that the counties should pay attention to issues of capacity building of staff, printing of reporting tools and sustain the good will from implementing partners. A proper coordination and collaboration between the national and county governments is also recommend. Finally, we recommend that mechanisms should be found to improve the use of DHIS2.

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