BARRIERS TO THE INTEROPERABILITY OF ELECTRONIC HEALTH INFORMATION SYSTEMS IN MALAWI

MASTER OF SCIENCE IN INFORMATICS

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BARRIERS TO THE INTEROPERABILITY OF ELECTRONIC HEALTH INFORMATION SYSTEMS IN MALAWI

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By

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DECLARATION

I, **Christopher Kulanga,** declare that this thesis is my own original work which has not been submitted to any other institution for similar purposes. Where other people's work has been used, acknowledgements have been made.

CHRISTOPHER KULANGA

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Full legal name

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Signature

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Date

CERTIFICATE OF APPROVAL

The undersigned certify that this thesis represents the student's own work and effort and has been submitted with our approval.

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Co-Supervisor

DEDICATION

This work is dedicated to my wife **Immaculate,** my lovely daughter **Tiffany,** my mum (Anajere) and my siblings, and lastly, to the memory of my late dad.

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ABSTRACT

This research study falls in the Health Information Systems (HIS) domain, with a specific focus on electronic HIS (eHIS), including the District Health Information System version2 (DHIS2). The goal of the study was to establish the technical and organizational issues affecting interoperability of eHIS with DHIS2, with key objectives being: to establish the degree of similarity and conformity of eHIS reports to those in DHIS2, to identify common data transfer protocols and standards between other eHIS and DHIS2, and to identify organizational barriers to eHIS interoperability. Addressing eHIS interoperability barriers has the potential to optimize benefits in eHIS investments and make available timely, accurate, relevant and reliable data for decision making in the delivery of health services. The study used the mixed methods approach, and data sources included HMIS reports, system documentation from the Baobab health system and DHIS2, MoH HIS policies and strategic plans, semi structured interviews with district HMIS officers, CMED officers as well as DHIS2 and Baobab health systems developers and administrators. The study revealed the existence of technical and organizational issues to be fixed to attain eHIS interoperability. Specifically, there is need to ensure 100% match in the reporting formats of eHIS to conform to the DHIS2 reports, and to ensure all eHIS are implemented with protocols that exchange data with DHIS2. The MoH should establish and enforce minimum standards for eHIS implementation, coordination and interoperability. Adequate resources to be allocated to CMED to implement endorsed strategies and policies on eHIS.

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LIST OF ABBREVIATIONS AND ACRONYMS

CHAM	Christian Health Association of Malawi
CMED	Central Monitoring and Evaluation Division
CSCW	Computer Supported Cooperative Work
DHIS1.3	District Health Information System version 1.3.
DHIS2	District Health Information System version 2.
DHMT	District Health Management Team
DHO	District Health Office.
DPPD	Department of Planning and Policy Development
EHR	Electronic Health Record
eHealth	Electronic Health
eHIS	Electronic Health Information Systems
EMR	Electronic Medical Records
HIS	Health Information System
HISP	Health Information System Programme
HL7	Health Level Seven
HMIS	Health Management Information System
HTTP	Hypertext Transfer Protocol
HSSP	Health Sector Strategic Plan
ICT	Information and Communication Technology
IDSR	Integrated Disease Surveillance and Response
mHealth	Mobile Health
MOH	Ministry of Health
NHSRC	National Health Sciences Research Committee

NSO	National Statistical Office
Open MRS	Open Medical Records System
SDMX-HD	Statistical Data and Metadata Exchange –Health Domain
SDO	Standards Developing Organization
SOP	Standard Operating Procedure
TWG	Technical Working Group
TYCOON	TYpes and goals of COOperatioN between multimodal interfaces
WHO	World Health Organization
XML	Extensible Markup Language

CHAPTER 1

INTRODUCTION

This chapter introduces the topic of study and provides the general overview of the issues discussed in the study. It contains the background, motivation, problem statement, expected contribution, research objectives, research questions, research context and lastly the structure of the thesis.

1.1 Background

High quality decisions at any level are influenced by the availability of timely, reliable, relevant and accurate data (raw facts) and information (processed data). Such data and information often comes from different sources. The sources may need to exchange the data to enhance completeness, timeliness, availability and accuracy of the data for decision making. Such high quality decisions lead to appropriate and successful interventions culminating to organizational success in a particular field (Wei Choo, 1995), confirming the notion ‘information is power’.

The health sector is one area where complete, timely and accurate data for decision making is needed from time to time; at the point of care, departmental, health facility, district, regional and national levels. Decisions at each of these levels are based on the quality, completeness, timeliness and accuracy of available information at that particular level. Data capturing, storage, management, processing, transmission and

sharing of information related to the health of people and organizations that work within the health sector is done by a Health Information System (HIS) (WHO, 2008).

In this digital era, Information and Communication Technology (ICT) systems have become a core tool in collecting, storing, managing and sharing of information. In health, the adoption of ICT to support healthcare delivery has the potential to positively impact the quality of care, improve healthcare service, and enable scaling-up of healthcare programs especially in hard-to-reach communities in developing countries (Adebesin et al., 2013). ICT systems in health are referred to as electronic Health Information Systems (eHIS).

The World Health Organization (WHO) defines eHealth/eHIS as the use of ICT systems for health to treat patients, pursue research, educate students, track diseases and monitor public health (Department of Health, South Africa, 2012). According to the Department of Health South Africa (2012), this definition covers a vast domain including Electronic Health Records (EHR), routine health management information, vital registrations, mHealth (use of mobile devices in eHIS), health research and telemedicine among others. In this study, the discussion focuses on eHIS as the use of ICT systems in health to capture, process and transfer health related data and reports across systems to enhance information sharing, accuracy, timelines, availability and efficiency.

Many researchers (Chaulagai, 2005; Begoyan, 2007; Garten & Coleman, 2010; Adebesin et al., 2013) have alluded to the benefits of eHIS for clients, providers as well as policy makers. From a clients' perspective, eHIS facilitates access to quality

healthcare services, especially to people in remote and resource-constrained communities. Clients can receive better and safer healthcare when relevant health information is more readily available to care providers when required. Clients also become active participants in ensuring their well-being through access to more reliable, accredited health information. This information is easily accessible through the use of eHIS.

For the provider, eHIS supports informed decision making through the availability of more accurate health information, access to medical knowledge databases and best practices. Multidisciplinary teams of care providers can share health information and coordinate health interventions in an effective manner, thereby reducing unnecessary duplication of efforts. This also saves time and maximizes the use of resources in the long run.

Policy makers benefit from eHIS through access to timely, more accurate and reliable information, upon which healthcare investment decisions can be based. Thus, health service interventions can be directed to where they are most urgently needed. Managers can better monitor and evaluate health intervention programs through access to more accurate national health data summaries.

Despite the many benefits of eHIS, it is observed that uptake of eHIS is low in many countries in the developing world (Adebesin et al., 2013). This is due to several barriers to the adoption of eHIS with the most notable ones being: high cost of acquisition at the initial stage, resistance to change on the part of the health care professionals,

security, privacy and confidentiality concerns of health data, lack of technical skills and inability of eHIS to share information - lack of interoperability) (Ibid).

Inability of eHIS to share information has substantial implication to the success of eHIS and the realization of eHIS benefits. For instance, eHIS interoperability may reduce the investments cost in the long run as it ensures no duplication of efforts and resources within and across health institutions. In general, not all organizations in a particular field will have the same type of ICT systems. This is due to financial capacity, organizational size, institutional needs as well as other preferences for individual organizations. For meaningful collaboration and coordination amongst such organizations, it is imperative that specific organizations in a particular or related field be able to share data and use the information in the various work processes.

Interoperability exists when eHIS share data and information meaningfully, such that data from one system can be used in another system while maintaining the quality, consistency, meaning and security of the shared data. This requires these systems to talk to each other in a systematic and secure mode. This entails technical build up in a way that the systems understand each other. It also entails provision of a communication medium for the systems to talk to each other. In addition, the content of the information being shared is of paramount importance to ensure meaningful, relevance and completeness of the same. All this summed up culminates into the concept of interoperability (Begoyan, 2007).

Interoperability is defined as the ability of different systems to exchange information and use the information exchanged (Whitman & Panetto, 2006; Begoyan, 2007).

Interoperability entails that beyond information transfer from one system to another, the information transferred has the same content, quality and meaning for both systems. The receiving system should be able to perform some operations on the received information making it more useful on the receiving end (Whitman & Panetto, 2006).

In health, interoperability has been defined as the ability of eHIS to work together within and across organizational boundaries in order to advance the health status and the effective delivery of healthcare for individuals and communities (Rossing, 2010; Adebesin et al., 2013). eHIS interoperability has the potential to facilitate the quality and effectiveness of health care services by providing the necessary information at service delivery point and also maximizing the use of resources (Adebesin et al., 2013). More importantly, eHIS interoperability can enhance continuum of care for all individuals seeking medical attention.

Malawi, like many other developing countries has a low penetration of eHIS. The eHIS in use in Malawi can be categorized into Patient level systems and aggregate level systems. Patient level systems are used at the point of care while interacting with the patient, keeping the individual patient records. Different hospitals have different patient level eHIS in place with the most notable ones being the Baobab Health System, Afyapro system, clinical manager, TESMART and OpenMRS.

The aggregate levels systems are used mostly in reporting where the overall total statistics and indicators in specific focus areas are compiled for a shared access by different interested users. DHIS2 is a national wide eHIS aggregate system endorsed and managed by Ministry of Health (MoH) for all health services reporting.

For the facilities with patient level eHIS, some of the reports required by DHIS2 are also produced by these patient level systems. The patient level systems however do not feed their data into DHIS2. As such, there is no interoperability between the various eHIS in the districts with DHIS2. This is a known fact from the discussions within the Ministry of Health's convened meetings with stakeholders in forums for Monitoring and Evaluation and data standards meetings. The study seeks to establish the technical and organizational barriers to the interoperability of the different eHIS with DHIS2, taking Baobab Health system and DHIS2 as case systems being studied.

DHIS2 is used for aggregated data from the smaller facilities within a district and the district hospital. From the districts, aggregated data, in form of specific program reports, is fed into the national DHIS2 centralized server. Some of the patient level eHIS in the hospitals are capable of producing these aggregate reports and ideally send into DHIS2. This however does not happen and it leaves the district HMIS team with a task of collecting manually prepared paper reports from the smaller facilities and the district hospital, which are then entered into DHIS2 manually. The scenario entails that the same information is entered in different eHIS at different time's hence duplicating labor while making the information to sit on fragmented systems. With this setup, penetration of eHIS as well as maximization of current eHIS remain to be challenging, making it difficult to realize the full benefits that come with eHIS. This study sets up to establish the technical and organizational barriers to eHIS interoperability in Malawi.

1.2 Motivation

Having worked in an ICT department for a hospital more than 7 years, deploying and administering eHIS, interacting with stakeholders in eHIS solutions, I noticed that there

is a gap in information flow from one eHIS to another, including the aggregate eHIS such as DHIS2. I also noticed that most eHIS operate in isolation with no link to other eHIS despite the need for information and reports to be shared across the systems. When and where information and reports are needed from one eHIS to the other, paper based reports are compiled or printed and sent over to the other level where they are entered into a different eHIS manually, despite the same information being available electronically in the originating eHIS. This process usually takes longer and more effort as compared to potential electronic transfer of the reports. The process is also susceptible to errors leading to inaccurate information along the manual transmission chain.

The observations in the gaps in information flow in eHIS at different levels inspired me to explore more and find out the barriers to eHIS interoperability in Malawi. The inspiration was driven by the understanding of the many benefits of eHIS interoperability which would be realized, including: enhancement of timely availability of health information for decision making, maximization of eHIS investments by re-using already available system modules to achieve specific goals in capturing and management of information, reducing duplication of efforts by sharing the information across systems instead of re-capturing and reporting the same information in different systems and lastly improvement of accuracy, fidelity, speed and cost of transfer of information.

1.3 Expected contributions

This study will bring insights and recommendations of what needs to be done to ensure eHIS interoperability in Malawi, hence providing an environment where all the benefits

that come with eHIS interoperability are realized. The recommendations will be useful in optimizing the use of eHIS resources in a developing country where initial investments and running costs of eHIS is high and not easily adopted by many health care institutions. In addition, the research will add knowledge to the area of eHIS interoperability in Malawi and many other developing countries.

1.4 Problem Statement

Malawi has various eHIS in use including DHIS2, Baobab Health system, Afyapro, TESMART, Open MRS, Digital Village Clinic among others. These eHIS are not interoperable with each other, let alone DHIS2. The non-existence of eHIS interoperability prohibits the maximum utilization of resources invested in the eHIS. Different sets of hardware and software are deployed at different workstations or facilities serving the same purpose i.e. patient registration. With eHIS interoperability, such scenarios would be prevented by ensuring that information collected at one point or facility is made available at the other stations there by using less hardware and software pieces as well as human resource. In the long term, eHIS interoperability has the potential to reduce the operational costs associated to data and information management as there will be less use of repetitive hardware and software as well as stationery and transport costs.

Lack of systems interoperability also results in the lack of timely and accurate reliable data for decision making at different levels. Interoperability enhances real time information sharing. The absence of interoperability retards information sharing and eventually affects evidence based decision making necessary to improve health

outcomes. The lack of up to date information also leads to misplaced interventions and services which may in the end culminate to unproductive expenditures.

One of the lamented issues in a resource constrained field of health is the duplication of efforts which is very common in the capturing and processing of data. The same patient details, for instance, are captured several times by different persons as a result of non-sharing of the data by eHIS. The presence of eHIS interoperability has the potential to reduce the duplication of efforts while ensuring the quality of the data collected as mistakes that occur in the process of the multiple data recordings are reduced.

The health sector continues to experience the challenges highlighted above due to the non-interoperability of eHIS on the ground. In Malawi, the presence and use of the highlighted eHIS and a well-established DHIS2 provides an opportunity to implement eHIS interoperability which would in turn allow the health sector realize the benefits of eHIS interoperability. Considering the benefits that could be realized once the existing systems were to be interoperable, it is worth researching the existing barriers to eHIS interoperability in Malawi, with the focus on making appropriate recommendations to be considered to facilitate eHIS interoperability and enjoy its benefits.

1.5 Research Objectives and questions

Having explored the potential of eHIS and the many benefits of eHIS interoperability, the research aims at establishing the technical and organizational barriers surrounding interoperability of eHIS in Malawi. Specifically for Malawi, eHIS interoperability would ensure availability of relevant health data at different levels of the health care

system thereby enhancing decision making at the various levels, ultimately improving the status of health care system. This is in line with Malawi's health sector strategic plan (HSSP) for 2011 to 2016 which stipulates, as one of its objectives under Monitoring, Evaluation and Surveillance, as: to provide reliable, complete, accessible, timely and consistent health-related information, and ensure that it is used for evidence-based decision making at all levels of the health system (Ministry of Health, 2010).

According to Adebesin et al. (2013), there are as many as seven levels of eHIS interoperability. Out of these, four levels are regarded as the fundamental categories namely: technical, organizational, semantic and syntactical interoperability. This study focused on the technical, semantic and organizational interoperability, specifically to extract the issues associated with achieving technical and organizational interoperability of eHIS in Malawi. Notice the semantic interoperability is discussed as part of the technical interoperability as they intertwine into each other.

The technical interoperability of different systems deals with the ability of the systems to talk to each other in a meaningful way. Determinants of technical interoperability include the structural design and data exchange protocols in the systems, and also the infrastructure to transport information across systems (Hammond, 2008). Closely related to technical interoperability is organizational interoperability, which deals with willingness and efforts by different organizations to exchange health data (Ibid). Underlying such willingness and desire are issues of policy, resource sharing, competition, privacy and confidentiality fears.

It is worth mentioning that these issues could be system specific and country specific as well. The Baobab health system and DHIS2 have been adopted as case systems for this study.

The study seeks to address the following objectives:

a. To determine the degree (percentage) of similarity/conformity in data elements and their formats in selected system reports between Baobab Health System and DHIS2.
b. To compare the data transfer protocols and standards used by DHIS2 and Baobab Health System; asses availability of common protocols between the two systems.
c. To establish the degree of seamless information exchange (if any) between Baobab Health System and DHIS2.
d. To establish the status of organizational interoperability factors such as eHIS interoperability standards' adoption, eHIS coordination and eHIS interoperability guidelines and enforcement by the Ministry of Health.

The study therefore seeks to address the broad research question:

What are the technical and organizational barriers affecting interoperability of eHIS in Malawi?

Specific research questions are:

a. How much of the transferable data elements and protocols required by DHIS2 reports are available in Baobab Health System reports?
b. What are the data transfer protocols and standards in DHIS2 and Baobab health system that allows data exchange with other systems? How have they been used to explore eHIS interoperability?

c. How much is the degree of seamless data transfer from Baobab Health System to DHIS2?

d. What is the status of organizational eHIS interoperability factors such as eHIS interoperability standards' adoption, eHIS coordination and eHIS interoperability guidelines and enforcement by the Ministry of Health in Malawi?

1.6 Research context

1.6.1 Malawi country profile

Malawi is located in southern part of Africa, with a total area of 118,484 km^2, and a projected population of 16.3 million in 2016 (National Statistical Office, 2010). Approximately 80% of the population for Malawi resides in the rural areas where power supply and computer infrastructure including internet connectivity is very limited and often completely unavailable (Qiang et al., 2011; National Statistical Office, 2012). As at 2012, In 2014, World Bank estimated that only 9.8% of the population in Malawi had access to electricity (Hivos, 2014). This reflects an existing challenge in electricity availability in Malawi which has a direct impact in availability and use of computer hardware to most of the rural health facilities, thus inhibiting eHIS implementation as well as eHIS interoperability. Several organizations have implemented eHIS in secondary health facilities which are usually at the district level (Mwakilama et al., 2014). However, there is little or no evidence of these eHIS exchanging data across each other despite the many benefits that would be realized if eHIS interoperability was implemented (Ibid).

The health service delivery in Malawi is managed by the Ministry of Health (MoH) which has thirteen directorates under it, operating at the central level (Ministry of Health, 2016) . Below the central level, MoH is divided into five health zones which are further subdivided into 29 health districts headed by a District Health Officer (DHO). The DHO and his team form what is called the District Health Management Team (DHMT) which is responsible for the management of the health services at the district level, in line with policies, strategies and guidelines from the central level. The long term goal of the Ministry of Health is to improve the health status of people at all levels in a sustainable manner (Ministry of Health, 2011). The MoH provides about 60% while Christian Health Association of Malawi (CHAM) provides 37% of health care services in Malawi. CHAM is an umbrella body responsible for coordinating all faith based health care service providers in Malawi (Ministry of Health, 2003).

1.6.2 Malawi Health Information System

The World Health Organization defines a Health Information System (HIS) as a system that integrates data collection, processing and reporting of health services to enhance the use of information necessary for improving health service effectiveness and efficiency through better management at all levels of health services. The MoH in Malawi acknowledges that health information is an integral part of national health system and is a basic tool of management and improvement of health status in the country. In the 2015 HIS policy, the MoH further describes the primary objective of HIS as to generate quality information (accurate, complete, timely, relevant and reliable) and make them accessible to all intended users through standardized and harmonized tools across all programs that avoid duplication and reduce the workload

on data capture by already stretched human resources at health facility level (Ministry of Health, 2015).

In many countries including Malawi, implementation of HIS was by trial and error and countries following later started to benefit from the lessons learnt in earlier implementations (Chaulagai, 2005). It is on record that the MoH in Malawi has been implementing a comprehensive and decentralized routine HIS countrywide since 2002. The HIS is coordinated by the Central Monitoring and Evaluation Division (CMED), which is an integral part of the Department of Planning and Policy Development (DPPD) at the MoH. At the district level, HIS is implemented by DHMT while at the health facility level, HIS is implemented through HIS focal persons.

The HIS for Malawi follows a bottom-up reporting and a top-down feedback mechanism (Galimoto, 2007). With this arrangement, health facilities at the bottom of the MoH hierarchy collect data and report to facilities at the higher level, which then in turn analyses the reports and provide feedback and support to the facilities at the lower levels, subject to availability of resources. Other stakeholders also have access to the reports and play a role in providing feedback through the appropriate channels at national or district levels.

The 2003 Malawi Ministry of Health HIS national policy and strategy highlights that the previous HIS interventions were unable to provide the required information and as a result, parallel reporting systems evolved primarily along vertical program lines (Ministry of Health, 2003). The time and effort involved in operating the information system, were taking away program officers' other core responsibilities. This was

worsened with parallel systems duplicating efforts in processing, training and operating the systems which often produced conflicting data (Galimoto, 2007). This made it difficult to achieve national health targets and monitoring of program performance on a regular basis which is very critical to management functions but require reliable information in a timely manner hence defeating the essence of HIS. In response to these issues, the Ministry of Health implemented a comprehensive integrated routine HIS in the entire country from January 2002. The integrated HIS was designed to provide program managers and staff with reports on how well each program is functioning and alert service providers and program managers to take timely and necessary corrective actions. The information is also used to formulate health policies, plans and strategies, set priorities, design health interventions, monitor trends and changes, and assess progress and also to evaluate effectiveness and efficiency of health services. It is evident that the HIS plays a crucial role in informing government and other stake holders on the status of health services in Malawi for appropriate coordination and management of the health services.

Malawi is one of the many countries where data is collected and processed manually at lower levels and then handled electronically as it progresses to higher levels (Galimoto, 2007). Data processing at district and central levels has been computerized using a software called DHIS2. By definition, DHIS2 is a routine data based HIS which allows for data capture, aggregation, analysis and reporting of data (DHIS2 Documentation, 2014). In Malawi, DHIS2 implementation started as a program under the Health Information Systems Program (HISP) and later adopted as a national wide reporting system and managed by the Ministry of Health. All health service providers are expected to report using aggregate standard reporting tools in DHIS2. DHIS2 is

centralized system accessible online to authorized users. Baobab health system is also one prominent system that has been implemented in almost all districts in Malawi at the patient level data collection and processing.

1.6.3 Electronic HIS in Malawi

The introduction of eHIS in Malawi dates back to 2002 when the Ministry of Health developed and implemented a comprehensive HIS to cover information gaps that were in existence as described in prior sections. At around the same time, the Ministry of Health introduced the DHIS1.3 at district and national level (Ministry of Health, 2003). Other institutions also started rolling out patient level eHIS in central hospitals and district hospitals. Some of the eHIS introduced and in use in various hospitals include: the Baobab Health system, Afyapro, OpenMRS, TESMART, the clinical manager and others.

The Ministry of Health (2013) highlights that the implementation of eHIS has been slow due to several factors including:

1. Inadequate financial resources, usually channeled to other priority areas.
2. Poor and inadequate network connectivity and computer infrastructure.
3. Lack of proper administrative and well laid out field specific processes such as adequate trained ICT staff to manage such systems, and lack of documented processes such as data dictionary.

Initially, most eHIS were installed on standalone computers and operated as islands of systems. With time, the approach changed and systems were being implemented in an

integrated approach so as to be able to share data over the network. DHIS2 as the web-based version, for instance, has been moved from the standalone version DHIS1.3.

1.6.4 EHIS interoperability

The MoH in Malawi acknowledges the importance and value of eHIS interoperability for optimal benefits of eHIS at all levels. Malawi, like many other countries has different eHIS solutions and implementers. Mwakilama et al. (2014) document eight independent eHIS implemented in Malawi as in 2014. While there are some efforts in the integration of eHIS systems, the discussion and implementation of eHIS interoperability has been stagnant for some time (Ibid). Mwakilama et al. (2014), points out a number of factors to put in order in order to realize eHIS interoperability. These include applications architecture, security and privacy of health data, network and infrastructure, data dictionary, messaging standards and commitment by partners to effect interoperability. With many eHIS built on different platforms and sitting in silos, eHIS interoperability is a challenge in Malawi.

While the MoH and other partners acknowledge the need and benefits of eHIS interoperability, there is no interoperability of eHIS systems on the ground. The discussion and plans about eHIS interoperability have been around as far back as 2003. According to the Ministry of Health National Policy and strategy (2003), compatibility and interoperability of the different systems through data and communication standards was deemed as key to realizing an integrated health information system. Such discussions have continued to take place in the regular data monitoring and evaluation as well as data standards meetings coordinated by the Ministry of Health and participated by stakeholders implementing eHIS systems. If these systems were able

to exchange data, the health sector would realize a lot of benefits that come with systems interoperability which include optimized use of eHIS resources as well as timely availability of accurate health information.

1.7 Thesis structure

Chapter 1 covers the background to the study and includes the general information on eHIS interoperability, motivation of the study, expected contributions, problem statement, research objectives and questions and finally the study context detailing; Malawi country profile, health care system, HIS and eHIS in Malawi and eHIS interoperability in Malawi.

Chapter 2 presents the literature review and conceptual framework guiding the research study, focusing on eHIS interoperability in developed and developing countries, benefits and challenges of eHIS interoperability, drivers of eHIS interoperability, eHIS interoperability standards and finally the modified TYCOON theoretical framework.

Chapter 3 discusses the methodology used in this study and focuses on the approach to the study, sample size, data collection tools and processes, data analysis, interpretation of results and ethical consideration.

Chapter 4 presents the research findings, explained in relation to the theoretical framework; analyses and discusses the results of the study in relation to the research objectives and questions.

Chapter 5 concludes the study, summarizing the study and the main themes discussed in the preceding chapters. It also presents the recommendations as per the observations and results of the analysis. Finally, theoretical and practical contributions of the study are presented and potential areas of further studies highlighted.

The appendix section includes the letter of ethical clearance to conduct the research, the letters of support to conduct the research in the respective districts, data collection tools and the sample reports from DHIS2 and Baobab health system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the concept of systems interoperability in general and the specifics of eHIS interoperability including the benefits, challenges and drivers of eHIS interoperability. I also discuss the standards of eHIS interoperability with a focus on SDMX-HD standards. Lastly the conceptual framework of the research study is discussed in detail.

2.2 Electronic HIS Interoperability

Several authors emphasize the fact that interoperability goes beyond information transfer across systems but also takes into consideration the ability to share the same meaning of the exchanged information across the systems so as to achieve a common goal (Hura et al., 2000; Ide & Pustejovsky, 2010; Adebesin et al., 2013; NHS England, 2015; Hawkins et al., 2016). Unlike systems integration, which brings different components of the system to work together as one large system, interoperability maintains the independence of the different systems, providing for exchange of information in usable form (AFDTek, 2007).

In this study, I focus on interoperability of eHIS which has been defined by Adebesin et al. (2013) as the ability of electronic health information systems to work together and

exchange data within and across organizational boundaries in order to advance the health status of, and the effective delivery of healthcare for individuals and communities. The Healthcare Information and Management Systems Society (2013) defines eHIS interoperability as the ability of different information technology systems and software applications to communicate, exchange data and use the information that has been shared. In this study, I define eHIS interoperability as the ability of digital or eHIS to exchange data, interpret and use the data that has been exchanged without losing its meaning. The core principle in eHIS interoperability is the sharing and using of information among the different systems while preserving the meaning and usefulness of the shared health service related information (Stroetmann & Stroetmann, 2005). The Health Information and Quality Authority (2013), recommends three perquisites to the realization of eHIS interoperability namely: (1) a set of eHIS interoperability standards including communications and terminology standards based on widely available and implemented international standards; (2) a system of unique identification for individuals, organizations/institutions and health professionals; (3) an electronic health record (EHR) model often regarded as the ultimate goal of eHIS.

In order to realize the value of interoperability efforts and resources, measuring, assessing and reporting interoperability in a visible way is essential and helpful to setting the right priorities in information systems (Kasunic & Anderson, 2004). Such evaluation is helpful if done systematically to inform direction with interoperability implementation over time. This research forms part of such research studies.

2.3 Categories of eHIS interoperability

The eHIS Governance Initiative (2012) outlines four types of eHIS interoperability. First on the list is technical or functional interoperability, which is domain independent and focuses on transporting messages and information from one system to another, there by neutralizing the effects of distance (Whitman & Panetto, 2006; Khan et al., 2013). Technical interoperability is not automatic and does not guarantee that the system receiving the message will be able to use the message received (Hans van & Wiles, 2008). Technical interoperability requires deliberate efforts in: proper project management to accommodate interoperable systems, proper systems designing and specifications to include interoperability architecture and interfaces, testing and validating systems for interoperability and provisions for systems maintenance that incorporates interoperability of systems (Hans van & Wiles, 2008).

The second type of eHIS interoperability is syntactic and semantic interoperability. This interoperability focuses on clear understanding and interpretation of the transmitted data (Aderonke et al., 2013). Syntactic interoperability guarantees the preservation of the data being exchanged i.e. clinical data, while semantic interoperability enables multiple systems to interpret the information being exchanged in the same way through pre-defined shared meaning of concepts (Adebesin et al., 2013). This data exchange which provides a common understanding of processes and data exchanged between communicating systems requires defined standards on message format as well as standards for transfers (Khan et al., 2013).

The third type of interoperability in eHIS is process interoperability, which looks into methods of optimal integration of eHIS into actual setting of work (Gibbons et al.,

2007; Huff & Mattison, 2014). According to Benson, (2012), process interoperability is achieved when human beings share a common understanding across a network, business systems involved and the work processes are coordinated. This has to do with standardization of common processes and data collection methods and tools, incorporating the business processes handled by different systems. Process interoperability defines the degree to which the integrity of workflow processes can be maintained between systems and thus allowing people to benefit from eHIS interoperability in their daily business transactions (Benson, 2012; Tangient, 2016). In a qualitative study on framework for multilevel health care interoperability, Payman Sadeghi (201**1),** recommends that emphasis be put on the processes involved to achieve interoperability, beyond the physical infrastructure and the workforce. Payman's study identified the lack of established procedures of how organizations can execute eHealth interoperability as one of the barriers to eHealth interoperability.

Lastly, the fourth type of eHIS interoperability is pragmatic or organizational interoperability which deals with willingness and commitment of concerned organizations to collaborate in exchanging information, guided by the resources of the organizations and their policies (Adebesin et al., 2013). Organizational interoperability is the highest level of interoperability (ibid). It determines among organizations if the other three types of interoperability will be available and how to best use them (Gibbons et al., 2007). Figure 2.1 below presents a pictorial representation of the four categories of eHIS interoperability.

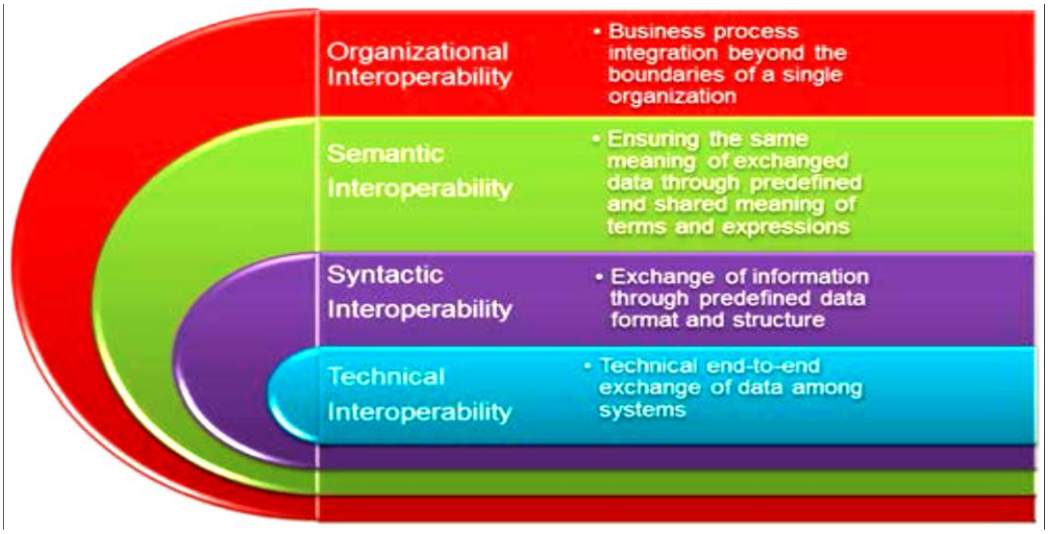


Figure 2.1: Levels of interoperability (adapted from European Telecommunication Standards Institute, 2008)

This study focuses on the technical and organizational interoperability of eHIS in Malawi. The technical aspects in consideration in this study goes beyond information transfer and considers syntactic and semantic facets on eHIS interoperability. This is based on the understanding that there exists many eHIS in Malawi which do not exchange data despite efforts to standardize reporting forms through HIS integration (Galimoto, 2007). In addition, discussions within the Ministry of Health and stakeholders in eHIS interoperability pointed to elements of systems and infrastructure challenges in addition to policy, strategy and legal aspects of systems interoperability. The findings with regards to the barriers in eHIS interoperability will inform the next steps in establishing standards and procedures to effect eHIS interoperability.

2.4 Benefits of eHIS interoperability

EHIS interoperability is driven by many benefits which include but not limited to: (1) optimal use of resources ensuring optimal outputs from investments; (2) enhancement of timely availability of information which is necessary for decision making at different

levels within the health care system; (3) improvement of accuracy, fidelity and speed of information transfer; (4) allowing for flexibility to mix and match or extend systems to new capabilities without having to create whole new modules (TechNet, 2001; Lewis & Wrage, 2004; Rothenberg, 2008; Alison Silverstein, 2009; DeNardis, 2011).

EHIS interoperability has the potential to provide a seamless secure sharing of information with meaning across health systems there by improving the quality of care and eventually the health status of the clients (Watson, 2007). Khan et al. (2013) alludes to the fact that improved delivery of services with optimum interoperability can bring highest standard of accuracy and effectiveness in health care. EHIS interoperability enables completeness and timely availability of health information across platforms allowing for timely and relevant evidence based decisions at different levels within the health care system (eHIS Governance Initiative, 2012; Adebesin et al., 2013). In addition, eHIS interoperability allows for information to be recorded once, and then shared across many eHIS hence reducing redundancy and duplication of efforts with data compilation, validation and other associated processes, eventually resulting in efficiency and effectiveness in handling cases as well as minimizing the risk of errors that would arise from multiple recording of the same information in different systems (Dobrev, 2010; eHIS Governance Initiative, 2012).

EHIS interoperability comes in with relevance in the Malawi health sector which is challenged with a deficit of health staff who have to manage information collection and reporting in addition to the huge patient workload. EHIS interoperability also allows different systems and applications to communicate with one another, which lets health care providers access and integrate the information regardless of which system the data

is stored in, thereby enhancing coordination in the delivery of health care at a lower cost than traditional means of exchanging hard copy files (Aderonke et al., 2013; Iroju, Soriyan, Gambo, & Olaleke, 2013). A qualitative study on Integration of Health Information Systems in Malawi, conducted by Galimoto (2007) revealed that providing available electronic data to decision makers could help improve use of the data for decision making as opposed to scenarios where data was made available in paper based formats.

Lastly, eHIS interoperability has the potential to reduce the development and implementation costs of eHIS. With interoperability in place, software developers will not need to do a lot of work to build new applications as eHIS applications can be developed to handle information transferred from other systems, effectively reducing the cost of development (DeNardis, 2011; eHIS Governance Initiative, 2012).

2.5 Challenges to eHIS interoperability

While eHIS interoperability enhances efficiency and convenience in health data availability and usage, there are challenges associated with eHIS interoperability. Several authors allude to the fact that eHIS interoperability remains a challenge despite several global health and eHIS stakeholders' continued efforts to emphasize the important role of eHIS interoperability to improve health care delivery (Pardo & Burke, 2009; Shank, 2009; Benson, 2012; Adebesin et al., 2013; Health Information and Quality Authority, 2013; HIPAA, 2015). The barriers to eHIS interoperability range from organizational willingness to invest in eHIS interoperability, to technical hindrances within eHIS.

One of the challenges to eHIS interoperability is the complexity of the Health Information Systems leading to many specialties and sub specialties. The heterogeneity of the HIS often arises from the complexity of the human body requiring multiple specialties and large datasets in various formats such as numerical measurements, free text narratives, structured text, multimedia diagnostic images, clinical codes as well as financial codes (Adebesin et al., 2013).

An additional challenge to eHIS interoperability is the lack of willingness by organizations to invest and implement eHIS interoperability. Most organizations are non-committal to invest and engage in eHIS interoperability and as such there exists multiple independent islands of eHIS (Rossing, 2010; Adebesin et al., 2013). The presence of a myriad of legacy systems based on different data formats and structure, incompatible operating systems, application servers and databases is another challenge to eHIS interoperability (Adebesin et al., 2013). Technology evolves and as new software comes in, there is also need for new hardware hence continuous investment in interoperability of eHIS which organizations are reluctant to spend (Adenuga et al., 2015). The widespread adoption of interoperable eHIS solutions is also being constrained by genuine concern for privacy, security and confidentiality of personal health data (Abeloos, 2010; Adebesin et al., 2013). Rossing (2010) points out that as our ability to share data across borders increases, the risk to compromise patient privacy and personal health data also increases and there is need for stringent privacy and confidentiality protection through the endorsement and enforcement of appropriate law as a pre-requisite to eHIS interoperability.

Lastly, another obstacle to interoperability arises from the lack of standards to guide the implementation of information exchange. Due to the complexity of HIS, it is imperative to have standards that define the content and types of health information to exchange as well as common protocols for the information exchange (Whitman et al., 2006; Abeloos, 2010). It is important to note that the eHIS standards often involves competing and sometimes overlapping standards initiatives taking place in different institutions (Rossing, 2010), many of which charge fees to access or implement the standards leading to low usage of the existing standards (Adebesin et al., 2013).

2.6 Drivers of eHIS interoperability

Discussing the challenges to eHIS interoperability opens up an important discussion on what needs to be done in order to achieve eHIS interoperability and realize the benefits highlighted in prior sections. In the eHIS strategy toolkit, the WHO and ITU identified seven components as drivers of eHIS interoperability (Chan, 2012). These drivers are crucial catalysts to achieving eHIS interoperability even within the context of the aforementioned eHIS interoperability challenges. Five of the seven components are classified as the enabling environment and the remaining two are the necessary physical infrastructure or ICT environments (Adebesin et al., 2013). The seven components have become strong pillars in the implementation of eHIS strategies and policies in steps to achieve eHIS interoperability by Ministries of Health in several countries such as Zimbabwe, South Africa, Nigeria, Kenya and others (Ministry of Health Zimbabwe, 2011; Department of Health, South Africa, 2012; Federal Ministry of Health Nigeria, 2014).

The first driver of interoperability is leadership, governance and multi sector engagement. Governance provides for the necessary decision making rules and procedures that give the direction, coordination and oversee interoperability initiatives in many countries, including Malawi, where health services delivery is primarily the government's responsibility (Rossing, 2010; Chan, 2012; Adebesin et al., 2013). Stakeholder engagement is particularly important because the health sector is a combination of both public and private institutions who all have to collaborate in a coordinated manner to advance the agenda of eHIS interoperability. In Malawi, the government is the primary health care provider and provides the strategic direction, leadership, coordination and management of the overall health care system. It is therefore very important that the discussion and implementation of eHIS interoperability be one of the core elements of the government in the management of health care systems. In the absence of this driver, it is difficult and almost impractical to have pragmatic eHIS interoperability in addition to gaps that may be evident in syntactic and semantic interoperability.

The second driver of eHIS interoperability is strategy and investment. Strategy refers to the development of national roadmap that guides the coordination of eHIS initiatives aligned with the country's health priority areas to achieve maximum benefits to eHIS interoperability (Ministry of Medical services, Public Health and Sanitation Kenya, 2011; Adebesin et al., 2013). The eHIS strategy should identify interoperability goals and provide a plan for actions to achieve the goals. With the strategy in place, funding for eHIS initiatives should also be aligned to the identified eHIS interoperability goals hence the investment part of this driver (Chan, 2012; Adebesin et al., 2013). It is evident that the different authors agree with the fact that eHIS interoperability can be achieved

with a well-defined strategic direction which ensures good and meaningful investment in interoperability to achieve desired results. Malawi has made efforts in policies and strategies to guide HIS from the beginning of formalized HIS around 2002. This study will look into how much of those efforts are directed towards eHIS interoperability and the outputs achieved so far.

Another driver of eHIS interoperability is the availability of legislation and policy necessary to handle challenges and risks that come with eHIS interoperability (Chan, 2012). A legal framework which can enhance and support the exchange of health care information can address the challenge of privacy, security and confidentiality of health care information (Adebesin et al., 2013). There should be a deliberate mechanism to ensure compliance with eHIS interoperability policies and regulations (Chan, 2012). Workforce is the fourth driver of eHIS interoperability. Workforce is required to ensure that the necessary health informatics knowledge and skills are available to implement eHIS initiatives (Adebesin, 2014). Adequate training and education programs are essential to build a workforce that is capable of designing, building, and operating interoperable eHIS together with technical expertise to participate in standards development and localization of international standards to meet local requirements (Adebesin et al., 2013). According to WHO/ITU eHIS strategy (2012) a good workforce entails making knowledge and skills available through internal expertise, technical cooperation or private sector. To work with different systems on different platforms and locations to exchange data, there is need for knowledgeable workforce that understands the process and can translate the requirements for systems interoperability into real operational interoperability processes (Chan, 2012).

Standards come as the fifth driver of eHIS interoperability. A standard is an agreed upon repeatable way of doing things (Gramstad, 2007). Standards is often argued to be the most critical driver of interoperability providing the uniform definitions and operations required in eHIS interoperability hence they act as a backbone to eHIS interoperability (Adebesin, 2014). The adoption of eHIS standards to support interoperability should be coordinated at national level, preferably through an independent governance structure (Adebesin, 2014). Standards enable consistent and accurate collection and exchange of health information across health systems and services. In this study, interoperability assessment was investigated with respect to compliance to eHIS interoperability standards, specifically SDMX-HD standards.

The sixth driver of eHIS interoperability is the physical infrastructure that forms the foundation for the exchange of health information across geographical and health sector boundaries (Adebesin et al., 2013). Funding should be set aside for the acquisition of physical infrastructures including power sources, the computer hardware and network connectivity that will enable secure exchange of health care information (Chan, 2012; Adebesin et al., 2013). Infrastructure includes the physical network infrastructures, core services and applications that underpin national eHIS environment. As at 2014, World Bank estimated that 9.8% of the population in Malawi had access to electricity. In its 2014/2015 assessment of network penetration and costs, the ITU reports very low penetration of internet in Malawi (6.1%) and one of the most expensive in the world (ITU, 2014; Lange & Lancaster, 2015). This reflects an existing challenge in electricity and network availability and cost in Malawi which has a direct impact in availability and use of computer hardware to most of the rural health facilities.

The last driver of eHIS interoperability is services and applications. This component represents the tangible means for enabling necessary applications, tools and services that will facilitate secure exchange of health information (Adebesin et al., 2013). This entails bridging applications to enhance health information exchange.

2.7 EHIS interoperability status in developed and developing countries

The state of eHIS interoperability varies from country to country, both in the developed as well as the developing countries. There are however common trends associated with developed or developing countries with respect to the adoption level of eHIS interoperability. The presence of eHIS interoperability begins with the establishment of the eHIS themselves. In general, eHIS implementation is advanced in most of the developed countries (Olsson et al. 2004; Guijarro, 2007; Rossing 2010; Jakab, 2016). A survey conducted in European countries by WHO in 2015 indicated that 59% of the countries had national wide eHIS system, with the 69% of these being regulated by national legislative guidelines (Jakab, 2016). Over 78% of the national eHIS systems are interoperable with other systems within the specific countries as well as within the European region (Ibid).

The majority of the developed countries also have a very sound adoption and implementation of eHIS standards, with over 83% of the countries in the survey having adopted more than one eHIS interoperability standards, which is a key driver to the implementation of eHIS itself (Ibid). Estonia is one of the model countries, being the first to implement a national wide eHIS in 2008 and implementing full scale interoperability with other systems in 2009, enforced by law and ensuring that both public and private health care providers upload data into the national eHIS, and

achieving a 98% record of the health data available in the national eHIS (Jakab, 2016). Estonia deliberately implemented a robust ICT infrastructure which links more than 170 decentralized databases in health, education, elections and other services using X-road infrastructure which allows for further addition and adjustments of the databases and other services while ensuring seamless information exchange across the databases (Ibid). Similar initiatives have also been highlighted for countries such as Sweden, Finland, Norway, Ireland, Portugal, Belgium and other countries. (Olsson et al., 2004; HIQA, 2011; Jardim, 2013; Jakab, 2016;). It is worth noting that there are continuous regional efforts to help countries within the European region to advance eHIS interoperability (Olsson et al., 2004; Society, 2006; Jakab, 2016).

The status of eHIS interoperability in the developing world, particularly Africa is very low and often undocumented (Mars & Seebregts, 2008). Over 26 African countries including Malawi use DHIS2 as a national wide eHIS for reporting (DHIS2 documentation, 2014) There are however many standalone eHIS being used at service delivery points, most of which are implemented by non-governmental entities and usually exist in form of projects with specific timespans (Mars & Seebregts, 2008; Anon, 2010; Mwakilama et al., 2014; Adenuga et al., 2015). There are a few examples of partial eHIS interoperability in countries such as Rwanda and South Africa (Mars & Seebregts, 2008; Moodley et al., 2014).

Most countries, such as Ghana, Rwanda, South Africa, Malawi, Zimbabwe, Kenya and Uganda have developed eHIS strategies and policies which include eHIS standards adoption and efforts to advance eHIS interoperability at national levels (Ministry of Public Health and Sanitation Kenya, 2011; Ministry of Health Zimbabwe, 2011;

Department of Health, South Africa, 2012; Ministry of Health, Malawi, 2013; Moodley et al., 2014). Some of the issues attributed to the low penetration of eHIS interoperability in African countries include: (1) lack of resources to implement national sustainable eHIS ; (2) extreme shortage expertise in medical informatics; (3) lack of eHIS interoperability standards adoption and localization; (4) lack of eHIS national policies and their effective enforcement; (5) lack of proper ICT infrastructure to facilitate eHIS interoperability; (6) lack of proper legislative laws to enforce eHIS policy and its associated implementation standards and (7) lack of proper coordination in the implementation of eHIS in the countries (Mars & Seebregts, 2008; Anon, 2010; Adebesin et al., 2013; Moodley et al., 2014). Moodley et al. (2014) however notes that there is growing interest by African countries to implement eHIS interoperable systems guided by set interoperability standards and accompanying policies and legislature. Such efforts are evident in the Malawi case as outlined in various policy and strategic documents and MoH Technical Working Groups (TWG) discussions (Ministry of Health, 2013).

2.8 EHIS interoperability standards

As discussed in the preceding sections, one of the key prerequisites and driver to achieving eHIS interoperability is the presence of eHIS interoperability standards, including communications and terminology standards based on widely available and implemented international standards. This section focuses on the key standards that guide the implementation of eHIS interoperability. The International Organization of Standards (ISO) defines a standard as a document, established by consensus and approved by a recognized body, that provides for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at achievement of the

optimum degree of order in a given context (ISO, 2004). A standard provides requirements, specifications, guidelines or characteristics that can be used consistently and repeatedly to ensure that materials, products, processes and services are fit for their purpose (Adebesin, 2014).

Standards are used in information management and sharing and have a crucial role to play in health systems interoperability (Fenton et al., 2013). In general, standards are categorized into two namely: proprietary standards, which are developed and used for private purposes and are copyright protected; and open standards which are made available to the general public (free of charge or at a nominal fee) and are developed or approved and maintained via a collaborative and consensus driven process (Adebesin, 2014). Open standards facilitate interoperability and data exchange among different products or services and are intended for widespread adoption (Ibid). Most standards are developed by different designated institutions or organizations called Standards Developing Organizations (SDOs) who have specific specialty with the specific field of standards being developed. Some of the SDOs that develop eHIS interoperability standards are World Health Organization (WHO), Health Level 7 (HL7), the International Standard Organization (ISO) health Informatics technical committee (ISO/TC215) (Glickman, 2010; DeNardis, 2012; Adebesin et al, 2013; Shores et al., 2016).

With regards to eHIS interoperability, eight other categories of standards are crucial for a full implementation of interoperability between eHIS. For the purposes of this study, five relevant categories are explained as they are in line with eHIS that involves aggregate data while the other three involve patient level data exchange. The first

category is interoperability framework and infrastructure standards, which provide for a guiding structure for different systems or agencies to share data for the optimal benefit of the users (Guijarro, 2007). This category of standards is important in establishing minimum infrastructure requirements for eHIS implementation to support eHIS interoperability.

Identifier standards come as the second category for eHIS interoperability dealing with unique identification of various entities such as patients, health care providers and health care institutions, with an observed importance of identifying the source and destination as well as the object of concern when transferring health information (Begoyan, 2007; Rossing, 2010; Adebesin, 2014). Establishing the existence of unique facility and service identifiers is one key element of the study to enable the assessment of the eHIS interoperability status for Malawi.

Third on the list of eHIS interoperability standards categories is the messaging and information standards, which facilitate the secure transmission and receipt of information between eHIS, including the acknowledgement that should be sent by recipient of the information received as well as warnings that should be generated when the message has not been delivered, i.e. if it is declined (Witting & Moehrke, 2012).

The next eHIS interoperability standards category is the structure and content standards, which specifies the data types, field lengths and the content of the data fields in these documents such as HIS reports, ensuring that health data is presented in a consistent manner by software applications enhancing semantic interoperability in eHIS (Lincoln, 2000; Hammond, 2005).

The fifth category of eHIS standards are the security and access control standards, which enable the secure transmission and delivery of health care information so as to ensure that personal health care information is protected from unauthorized access, providing for privacy and confidentiality of eHIS information which is one of the challenges of eHIS interoperability (Adebesin, 2014).

Most authors allude to the fact that eHIS interoperability standards adoption in Africa is very low and under researched, despite the knowledge of its critical role in the implementation of eHIS interoperability, ultimately contributing to the low levels of eHIS interoperability in the continent (World Health Organization, 2008; DeNardis, 2012; Yamey, 2012; Tomlinson et al., 2013; Adebesin et al., 2013; Barker et al., 2016). An acadamic study conducted by Adebesin et al (2013) and other literature revealed that the low adoption of eHIS interoperability standards in developing countries and Africa in particular, is attributed to several factors which include: (1) limited participation by African countries in standards development hence inability by these countries to shape the direction of standards adoption in their countries; (2) lack of human resource capacity to facilitate the localisation of the standards to meet specific local country specifics; (3) lack of appropriate experiences in the interpretation of the standards often leading to incorrect implementation from that intended by the standards developers; (4) lack of understanding of the importance of eHIS standards and prioritisation of their use at national level often resulting from under developed eHIS accompanied by lack of eHIS facilitating policies and strategies; (5) lack of foundational structures necessary for standardised implementation of eHIS and lastly; (6) lack of implemetation guidelines on how to use the standards which leave some of the implememnters of the standards with a gap in the proper implementation of the

standards (Hammond, 2005; IFAN, 2008; Galimoto, 2007; ITU-T, 2009; Chawani et al., 2011; Adebesin et al., 2013).

2.9 The Statistical Data and Meta data Exchange–Health Domain standard (SDMX-HD)

The Statistical Data and Metadata Exchange–Health Domain (SDMX-HD) is a standard for the exchange of health care indicators, reports and other aggregate health information across eHIS (Kariuki et al., 2013). SDMX-HD is a crucial standard for transmission of data as it provides the definitions of the data sets, thereby allowing for both syntactical and sematic interoperability to be achieved. This standard is relevant for this study as it deals with information sharing at aggregate level, which is the focus of this study with regards to the two case systems being studied, Baobab Health system and DHIS2.

By definition, SDMX-HD is an International Standards Organization (ISO) standard for exchanging and sharing statistical and meta data among organizations in the health domain (Anon, 2014). There are several reasons that SDMX-HD is recommended and used as a data exchange protocol. Some of these reasons, according to Xavier (2009) are:

i. SDMX-HD allows for the exchange of indicator definitions and metadata without any associated data, for the sake of making publicly available standardized indicator definitions to help harmonize data collection processes. This allows for wider use of the standard across the health domain without pre-set data elements.

ii. SDMX-HD defines a core set of common concepts and code lists that must be used in the SDMX-HD message to be compatible with the standard, whereas a list of supplemental custom concepts and code lists is provided by each agency whenever broad agreement on these concepts has not yet been reached. This provides for the core list of concepts and codes across the health domain while providing for optional additional concepts and code lists specific to particular health domains.

iii. SDMX-HD allows the exchange of incomplete matrices of data. Even though an indicator definition may recommend data collection disaggregated by gender (males, females), a particular country may only be able to report the total figure, or data might not be available on a regular basis, thus creating gaps in the time series. SDMXHD covers this by making use of special missing values to distinguish between an actual indicator values of 0, an indicator value that is reported to be missing (cannot be obtained), or an indicator value that is not reported but may exist (absent from the data set).

2.10 Conceptual framework for eHIS interoperability

By definition, eHIS interoperability is about the cooperation of independent eHIS to share and use data meaningfully. In order to fully understand the interoperability and cooperation of systems, several theories can be used to explain linkages and relationships in the components of the systems. The process of explaining the linkages and cooperation of systems is often called the development of Computer Supported Cooperative Work (CSCW) (Guareis & Ferreira, 1999). The design, implementation and interaction of cooperative software systems has used models and theories that have for a long time been recognized as an important aid to the same (Guareis & Ferreira,

1999). Despite the existence of such numerous models and theories, there is no clear consensus as to the set of concepts and abstractions that underlie such models and theories (Ibid). The development of Computer Supported Cooperative work has been acknowledged to be a non-trivial task due to its nature to involve two distinct areas namely: social sciences and distributed systems (Ibid). Several theories such as coordination theory, activity theory, task manager theory and action/interaction theory analyze the linkages, interactions, relationships and coordination of actors and activities in single enterprise or integrated software systems (Malone et al., 1990; Kuutti, 1991; Guareis & Ferreira, 1999).

Going beyond an integrated software system, there is need for a model that can bridge two or more software systems. One such model or framework that can be used to describe and analyze interaction and coordination of multiple independent software systems is the TYCOON conceptual framework. TYCOON is an acronym for TYpes and goals of COOperatioN between modalities (Martin et al., 1995). TYCOON is a framework for the study of development of multimodal systems (Martin & Kipp, 2002). Martin (1998) defines a modality as a process of analyzing and producing chunks of information. Independent software applications could be regarded as multimodal interfaces or systems from which modality/analysis could be done. With independent software systems regarded as modalities, the TYCOON framework can be used to analyze the various types and goals of cooperation or coordination between the software systems across different platforms. The TYCOON conceptual framework is ideal for modeling the interaction, cooperation and operations of multiple software systems with an aim of achieving specific goals of such cooperation. The TYCOON

framework was first proposed by Jean Claude Martin (1995) in his paper titled: "TYCOON: Theoretical framework and software tools for multimodal interfaces."

From the theoretical point of view, development of multimodal systems addresses several issues such as content selection (what to look for), modality allocation (which modality to check from), modality realization (how to do the analysis) and modality combination (Dowell et al., 1995; Martin, et al., 1995). From the software tools point of view, modality concept looks into the combination of multimodal interfaces (Dowell et al., 1995).

TYCOON distinguishes five types of cooperation between modalities namely: transfer, equivalence, specialization, redundancy and complementarity (Martin & Béroule, 1998). The five types of cooperation can be viewed as different rules for combining modalities to achieve specific goal(s) (Martin, 1997). Some of the goals achieved in the cooperation of software systems when they share chunks of information include: availability, completeness, reliability, timeliness, efficiency, privacy, accuracy and security of the information (Martin et al., 1995; Martin, 1998; Martin & Kipp, 2002). The five types of cooperation were arrived at after studies in Psychology, Human Computer Interaction and Artificial Intelligence (Stanciulescu, 2008). The five types are described in detail below:

Transfer: A chunk of information produced by a modality or system is used by another system (Martin, 1998). In software systems, complete set(s) of information packages may need to be transferred from one system to another to achieve a specific goal(s). The information packages may act as input to processes as well as output to other processes. Either way, a communication channel is required to achieve the transfer. The

demographic details of a patient, for instance may have to be transferred onto a diagnosis level from the registration level (Martin, 1997). Similarly, the diagnosis information may have to be transferred onto the patient history summary to be kept in the patient records for access by other levels. In many cases, transfer of information aims to achieve the goal of availability of the information package as well as faster interaction and sharing of resources or information (Martin, 1998).

Equivalence: In equivalence, a chunk of information from the modalities may be processed as an alternative by either of them (Martin, 1998). Information package from a survey may for instance be used as demographic data of particular patients as long as the relevant pieces are available. These can be extracted or taken as a whole of the information package from the other source (Martin & Kipp, 2002). Equivalence achieves goals such as timeliness, efficiency and completeness in software systems (Martin, 1998).

Specialization: In specialization, a specific chunk of information is always processed by the same modality (Martin, 1998). Such a modality is specialized to produce such chunks of information. A laboratory module for instance is specialized to run specific samples and produce the results. Specialization achieves reliability, privacy as well as accuracy (Martin,1998).

Complementarity: Different chunks of information are processed by each modality but have to be merged (Martin, 1998). The merged information pieces result into a complete meaningful set of information (Ibid). In a Health Information System for instance the demographic information and the diagnosis information combined forms the patient

history of the individual. Complementarity achieves completeness, efficiency, availability and timeliness of information (Martin, 1998).

Redundancy: The modalities produce exactly the same information (Martin, 1998). This means, both pieces of information are the same and can be used for the same purpose. Redundancy modality achieves reliability and availability of information (Ibid).

The different types of cooperation (excluding) transfer can be compared through the two dimensions of fusion and transmitted information as shown in table 2.1 below.

Table 2.1: A summary of the different types of cooperation between modalities. (Source: Martin, 1998)

	Same information	Different information
No fusion	Equivalence	Specialization
Fusion	Redundancy	Complementarity

Equivalence and specialization exclude fusion (Martin, 1998) i.e. the information chunks produced do not need to be merged while redundancy and complementarity requires fusion. Equivalence and redundancy requires transmission of same information while specialization and complementarity requires transmission of different information (Martin, 1998). A major dimension of the TYCOON framework is the achievement of goals by analyzing and effecting the cooperation and coordination between modalities. Desired goals in software systems include but not limited to: Reliability, efficiency, security and privacy, sharing (interoperability), accuracy,

completeness, effectiveness, availability and others (Martin, 1998), some of which can be well assessed with the TYCOON framework. Table 2.2 below shows how the various combination of the five types can lead to achieving some of these goals.

Table 2.2: A theoretical framework for studying multimodality (Source: Martin, 1998)

Goals						
Reliability						
Efficiency						
Security						
Sharing						
Availability	xxx					
Accuracy					xxx	
Completeness						xxx
Timeliness						
	Transfer	Equivalence	Specialization	Redundancy	Complementarity	

Types of cooperation

In the illustration above, modalities may cooperate with each other according to several types of cooperation (X-axis). Each type may be involved in several goals for maximizing the system(s) in question (Y Axis). The shaded boxes highlight the goals that may be achieved by the types they are aligned to. For instance 'Transfer' as a type of cooperation is more associated with the goal of making 'available' the information than it is with accuracy.

For this study, the TYCOON framework fits well as we look at the interaction between health information systems to achieve the goal of interoperability. The framework falls short of the analysis of the interaction of the eHIS interoperability with respect to health information standards for data exchange. An extension of the framework to include the

Health Information standards was considered, culminating to an extended framework called ‘modified TYCOON’ framework.

The modified TYCOON theoretical framework takes aboard the five concepts discussed above, and analyses the cooperation of these using the eHIS standards for data exchange. In this study, the modified TYCOON framework makes use of the WHO’s SDMX-HD, which enhances electronic data exchange and also defines standards for software development in health. The modified TYCOON framework helped to identify equivalent, specialized, complementary and redundant modules in the two systems. The SDMX-HD data exchange standard was used to analyze the identified modules in the two systems to establish the transfer capabilities, culminating into recommendations on requirements for any eHIS to exchange data with DHIS2. Figure 2.2 below depicts the various types of modalities presented in the modified TYCOON framework with the SDMX-HD standard to facilitate the exchange of information across different systems.

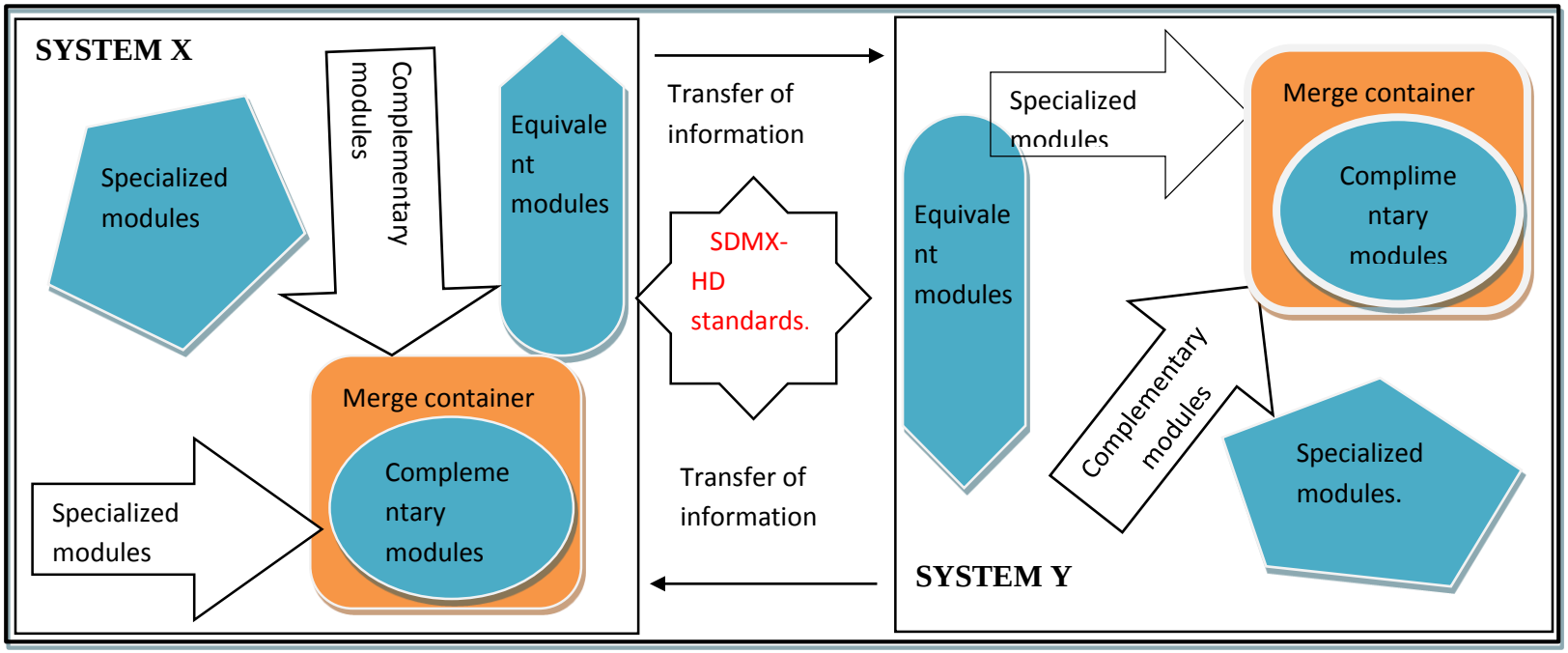


Figure 2.2: The modified TYCOON framework – A combination of the TYCOON theoretical framework and selected SDMX-HD standards

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the key issues around how the study was conducted. To start with, the main types of research methods are discussed, followed by a detailed explanation and justification of the selected research approach for this study. The data collection tools, data collection process, data analysis and interpretation as well as the ethical consideration are also discussed in this chapter.

3.2 Research methodology basics

Creswell (2003) defines research methodology as the process of conducting the research study while Kothari (2004) defines the same as a way to systematically solve a research problem. The two definitions have the same element which is 'how to conduct the study'. Three main research methodologies exist namely: Quantitative, Qualitative and Mixed methods (Creswell, 2003). Related to research methodology is the concept of research methods which refers to the techniques employed in conducting the research such as interviews, document analysis, participant observation, experiments and others (Kothari, 2004). According to Creswell (2013), quantitative methods employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data. In brief, quantitative research is based on the measurement of quantity or amount. Qualitative methods

employs strategies of inquiry such as narratives and ethnographies collecting open ended data (Creswell, 2003). Creswell (2003) describes mixed methods as an approach in which the researcher tends to base knowledge claims on pragmatic grounds - consequence oriented, problem-centered and pluralistic. Mixed methods makes use of both qualitative and quantitative viewpoints with an aim of breadth and depth of understanding and confirmation of findings (Kothari, 2004).

3.3 Research approach

In this study, mixed methods was used to allow for an in-depth investigation to respond to the set objectives and research questions which constitutes both quantitative and qualitative aspects. This was important to provide inclusive recommendations on eHIS interoperability in Malawi, as one of the products of the study. The choice of the mixed methods was in line with the aim of the study which was to establish the technical and organizational barriers to eHIS interoperability which was expected to generate and analyze both quantitative and qualitative data. Mixed methods was chosen because it allows a researcher to have a pragmatic view of the study (Johnson et al., 2007). The pragmatic (practical) view of situations allows flexibility by realizing that outcomes are as a result of actions, situations and consequences rather than antecedent conditions (Creswell, 2003). In this study, Pragmatism also allowed the linking of theory of eHIS interoperability to practice or actual observations of eHIS interoperability on the ground (Buch & Elkjae, 2015). In addition, mixed methods approach also helped the researcher utilize complementarity of data collected from both the qualitative and quantitative approaches (Lisle, 2011), hence allowing for a deeper and broader understanding of the issues surrounding interoperability of eHIS in Malawi. As Hesse-Biber (2010) explains, one method in the mixed methods may inform the other method

thereby enriching the results and developing the research project by this synergistic effect. The study employed the convergent parallel in which both the qualitative and quantitative approaches were done concurrently in all phases of data collection as well as analysis and then merged at interpretation to inform the whole research study (Creswell & Plano Clark, 2011). The choice of the convergent parallel gave room to the researcher to form a more complete understanding of the topic and corroborate quantitative scales.

3.4 Sampling technique

The study was conducted in four selected districts namely Dedza, Ntchisi, Dowa and Lilongwe. The districts were selected because they had been using the Baobab health system and DHIS2 for more than three years prior to the study and hence had sufficient experience in both systems. In addition, the districts were within reach of the researcher allowing for multiple visits to do observations and interviews as well as validate previously collected data. More importantly, Lilongwe harbors CMED; the MoH division responsible for coordinating eHIS implementation and managing DHIS2, as well as the offices of Baobab health trust, the organization that develops and deploys the Baobab health system.

The study employed a purposive sample selection method which is also referred in other literature as Bellwether or block or deliberate sampling. Purposive sampling, involves the non-random, deliberate selection of a sample subset known from prior experience to have specific desired knowledge or skills (Gould, 2002). For this study, purposive sampling was chosen because the study aimed at interacting with specific technical people involved in the programming and use of the eHIS. With such a small population

and pre-defined required skills, purposive sampling was ideal to get the correct information from the study. Coupled with purposive sampling and used in this study, was expert sampling in which specific individuals from the sample size were selected for specific components of the research in accordance with their expertise in eHIS development, deployment, coordination and interoperability as per the subject line of the study (Kothari, 2004).

In particular, DHIS2 and Baobab health systems programmers, administrators, district HMIS officers and statistical clerks, were the target audience for the sample. In addition, policy makers and heads of institutions building and providing eHIS were purposively selected for interviews to gain an insight into the organizational issues affecting eHIS interoperability.

3.5 Sample size

To ensure validity and reliability of the sample, specific personnel with specific roles and skills from CMED, DHIS2 development team, Baobab health system development team, District HMIS Officers and statistical clerks from the sampled districts were selected to form the sample. It was estimated that twenty five people from these selected institutions would be interviewed, the composition of which was: four officers from CMED, four from DHIS2 programming team, three HMIS officers and five statistical clerks from the three districts, six personnel from Baobab health system development and deployment team, and lastly three programmers from other eHIS development team. During the data collection exercise, three senior officers from CMED, three HMIS officers, five statistical clerks, five people from Baobab health system development and deployment team, three people from other health care systems

(Afyapro), two DHIS2 programmers were interviewed. This means a total of 21 people were interviewed out the planned 25 representing an 84% coverage in the audience for interviews. Considering the skill level and the specificity of the target sample size, 84% was significant for a fair representation of accurate and relevant results.

3.6 Data collection

Data collection is a vital step in research as it is a process of gathering the elements which will inform the research. As a mixed methods research, one of the very important premise is that it allows the collection of qualitative and quantitative data hence answering the research question in the best way possible. As Andrew & Halcomb (2009) explains, the relative priority of datasets and stages of integration as well as careful planning of mixed data collection are critical issues in the data collection.

In general, there exists three main data sources namely: Primary, secondary and tertiary sources. By definition, primary data are those collected afresh for the first time and thus happens to be original in character while secondary data are those which have already been collected by someone else and which have already been processed through statistical process (Kothari, 2004). Typical examples of primary data collection processes include observations and interviews while typical examples of secondary data include document analysis as well as literature reviews (Kothari, 2004). Tertiary data sources are those that compile or digest secondary data sources and typical examples include dictionaries, encyclopedias, manuals, handbooks, directories, abstracts as well as indexes (Feather & Sturges, 1997; Prytherch, 2000).

This study involved data collection both from primary sources as well as secondary sources. The specific data collection tools used included document analysis, semi-

structured interviews, analysis of specifically selected eHIS reports (ANC, HMIS-15, IDSR,HIV/ART) and participant observation. The interview guides and the aforementioned selected HIS reports are presented in appendix D and E of this document respectively.

3.6.1 Semi structured interviews

Semi structured interviews are an ideal way of data collection in qualitative studies as they allow the researcher to be flexible with interviewees while being focused to the area of interest (Kothari, 2004). This was one of the primary sources of data in the study. Interviews were held with HMIS officers, statistical clerks, CMED officials, DHIS2 developers, Baobab health system developers and deployment officers.

3.6.1.1 Interviews with HMIS Officers, Program Coordinators and Statistical Clerks

Interviews were conducted with District HMIS officers in three districts namely Dedza, Dowa and Ntchisi. These districts were chosen because I had established that they have had the Baobab health system (with Outpatient department, ART and ANC modules) and DHIS2 system in use for more than three years hence they were established and experienced in the use the two case systems. In addition, these districts were within reach of the researcher, allowing for data collection and validation within the time and financial limits of the researcher. The administrative setting and operational nature of health systems in these selected districts is very similar to other eHIS in other districts hence these selected districts provided a representative picture of the rest of the districts in Malawi. The purpose of interviewing the HMIS officers was to establish their roles in the eHIS operations in the district, understand how the available eHIS interact with

DHIS2, and understand their experiences, challenges and opportunities in using available eHIS including DHIS2.

I structured the interviews to meet with the HMIS officers and program coordinators first, and then statistical clerks later in each district. This gave an opportunity to understand the bigger picture at the onset, allowing for more probing during the subsequent interviews with the statistical clerks. During the interviews, the interviewee was given a copy of the interview guide for reference and clarifications during the interview. Based on the responses to the questions, further probing questions were asked. All responses were recorded on a master interview guide for analysis.

One challenge encountered was that some of the program coordinators that I had planned to interview were not available for the interviews. However, I learnt while interviewing the HMIS officers and the statistical clerks that even though the program coordinators are supposed to enter their program reports into DHIS2, most of them do not and usually opt to give the reports to the HMIS officer and statistical clerks to enter the data. As such, the absence of the program coordinators for the interviews did not have a substantial effect on the outcomes of the study. Findings from these interviews are presented in chapter 4.

3.6.1.2 Interviews with eHIS developers

Understanding technical issues in interoperability cannot go without understanding the structure and operations of the eHIS. To have that understanding, I interviewed the people behind the actual development and maintenance of the two systems: DHIS2 and Baobab health system. In addition to the system developers, system administrators and deployment officers of the two systems were also interviewed. According to Rowley

(1995), system developers and administrators are responsible for making critical programming and non-programming configurations and changes that enhance systems interoperability. In addition, systems administrators interact quite a lot with the end users hence act as a bridge between programmers and end users, passing on and facilitating interoperability steps in the systems (Millerand & Baker, 2010).

A total of four DHIS2 system administrators were targeted to be interviewed but at the time of conducting the interviews, only two were available. A detailed interview was also conducted with two programmers, two system administrators and one systems deployment officer from Baobab health system. The interviews with the programmers were meant to capture the software architecture, programming language and capabilities of the systems to exchange data with other systems. The interviews with the system administrators were meant to understand the reporting capabilities of the systems, the eHIS interoperability standards being followed, the data exchange interfaces (if any) in the two systems and data exchange achieved so far for the systems. During the interviews, I also had an opportunity to learn more of the systems operations, a skill which was later used to extract and analyze reports from the systems with much ease.

3.6.1.3 Interviews with CMED coordination team

The Central Monitoring and Evaluation Division (CMED) is responsible for the coordination of all HIS in Malawi and ensuring that programs use DHIS2 for reporting (Ministry of Health, 2013). To get a full insight of the administrative issues affecting eHIS interoperability, three officials from CMED were interviewed. The number of officials interviewed was one less than targeted due to unavailability of some of the

staff members. The interviews with these individual officers were the longest, often requiring further probing questions.

3.6.2 Document analysis for both systems

Kothari (2004) defines document analysis or content analysis as the data collection method which involves analyzing the contents of documentary materials that have either been printed or recorded verbally. Existing archival records often provide insights into issues that cannot be observed in another way if the documents are accessible and accurate. According to Bell (2005) for a complete and relevant document analysis, the researcher has to exercise caution to have a clear idea of what information they are looking for as the documents may present plenty other information that may distract an unorganized reviewer. The following documents were studied and analyzed: (1) The 2003 HIS policy and strategy; (2) The 2011-2016 Malawi eHIS strategy; (3) The 2011 -2016 Malawi Health Sector Strategic Plan; (4) The 2011- 2016 HIS strategic Plan; (5) The 2003 Indicator handbook; (6) The 2015 revised indicator handbook; (7) The DHIS2 documentation guide; (8) The DHIS2 developer manual; (9) The DHIS2 end user manual and (10) The DHIS2 implementation manual. Of particular focus in the document analysis were elements that were in line with eHIS interoperability within the documents. To respond to objective 1 and 2, a selection of four program reports were extracted from DHIS2 and Baobab health system and analyzed for conformance in data elements, data exchange protocols and standards. The sampled reports were ANC, HIV/ART, IDSR and HMIS-15. The document analysis from these reports generated a lot of quantitative data responding to objectives 1 and 2 of the study.

3.6.3 Observation of transfer of reports between the two systems

For a detailed understanding of the two case systems in the study, their reporting formats and the data exchange protocols and capabilities were studied. For DHIS2, I requested a user account on DHIS2 so I could log in and see the reporting formats for all reports. Through the chats with HMIS officers and also checking in the system, I learnt that DHIS2 has over 40 reports that it expects from a range of programs in the health facilities. For the sake of the study, four selected reports namely HIV/ART, ANC, IDSR and HMIS-15 were identified for the comparison. These reports were representing some of the commonly reported services and available in the two systems in question (except HMIS-15 which was not available in the Baobab Health system) and hence their relevance for comparison. To understand how the Baobab health system works, I scheduled exploratory sessions with some of the Baobab health system users in one of the districts where the system is implemented. Together, we went through the process of extracting specific reports from the system. We also attempted sending data into DHIS2 as per a functionality made available in the system. The outcomes of these sessions are described in the research findings chapter.

3.6.4 Review and analysis of interoperability discussions with Data Standards Technical Working Group

The Ministry of Health through the CMED established a Data standards Technical Working Group with an open membership to all stakeholders implementing eHIS. The TWG holds meetings every quarter and issues about eHIS including interoperability are discussed. The researcher has been a member of this grouping since June 2009 and has participated in the meetings and discussions about eHIS interoperability. For the purpose of this study, I reviewed and analyzed the minutes of previous meetings with a

focus on eHIS interoperability and the actions taken. The discussion chapter has more details pertaining to this element.

3.7 Data analysis

The study followed the convergent parallel approach of mixed methods with data being collected and analyzed in parallel for both the quantitative and qualitative components. Data analysis was done based on the theoretical framework, the research objectives and research questions of the study. Quantitative data emanating from the data elements and formats in the corresponding reports in DHIS2 and Baobab health system, was pasted in an excel workbook designed to mirror the corresponding reports. The selected reports were ANC, HIV/ART/ IDSR and HMIS-15. The analysis utilized excel formula to establish the degree of conformance in data elements and formats of the corresponding reports in Baobab health system to those in DHIS2, in line with the objective 1 and 3 of the study. The qualitative data from the interviews and literature review were summarized into main themes of eHIS exchange protocols, eHIS coordination, eHIS interoperability standards adoption, eHIS infrastructural capacity and eHIS standard operating procedures (SOPs) for interoperability. The information from these themes was used to answer the research questions and objectives 2 and 4 of the study.

3.8 Interpretation

The interpretation of the research findings was based on the TYCOON theoretical framework and the study objectives. Quantitative data from the excel workbook analysis were used to explain the presence and relevance of the five concepts of the modified TYCOON framework of transfer, specialization, equivalence, redundancy and complementarity in the Baobab health system and DHIS2. The presence or absence

of these concepts in the corresponding reports in the two systems was key to determine the degree of gaps or opportunities in interoperability between the Baobab health system and DHIS2. The quantitative analysis was also in line with specific objectives 1 and 3 and the excel formulae calculations had direct links and explanation to the degree of conformance of the corresponding reports. The qualitative themes formulated in the data analysis were used to explain the status of concepts relating to organizational interoperability as presented in the data analysis section above. The interpretation of the status of these themes was complimented by the related concepts discussed in literature review.

The results from the qualitative and quantitative analysis were combined and key points addressing the research questions and objectives were picked and explained research findings and discussions.

3.9 Ethical consideration

The research study followed all the required research ethics procedure. The Ministry of Health and the respective districts where data was collected were informed and letters of support were requested ahead of the actual data collection. Copies of these letters are presented in appendix A of this document. The letters of support were collected after a thorough briefing of the study, expected areas of support, specific departments and potential respondents for the study as well as the mode of data collection for the study. Baobab health trust, who develops the Baobab health system were requested for permission to conduct the study using their system and they gave the permission for the same. The researcher also sought approval from the National Health Sciences Research Committee (NHSRC) which evaluates all health related research works and approves

if all requirements are met. A copy of the NHSRC approval letter is attached in appendix B of this document. All respondents were requested to read and if in agreement, sign the consent form which is attached in appendix C of this document.

CHAPTER 4

RESULTS AND DISCUSSIONS OF THE FINDINGS

4.1 Introduction

This chapter discusses the findings of the research study as per the methodology described in the previous chapter and in line with the modified TYCOON conceptual framework. I also present the status of interoperability standards implementation with respect to the Baobab health system and DHIS2. Finally, a discussion on the research findings with respect to the study objectives and research questions are presented.

4.2 Research findings

In this section, I present the research findings in relation to the conceptual framework presented in chapter 2 as well as the study objectives.

4.2.1 Transfer of information from the Baobab Health system to DHIS2

One of the concepts of information exchange between software systems as outlined by the modified TYCOON Framework is called Transfer, described as the ability to move specific pieces of information from one system to another (Martin & Béroule, 1998). Transfer of information is meant to achieve availability of information in the receiving system. In the context of this study, transfer is the ability to move specific health program reports from Baobab health system into DHIS2. DHIS2 has more than 40 program reports, most of which are expected to be entered on monthly. Figures 4.1 to 4.4 below depicts some of these reports:

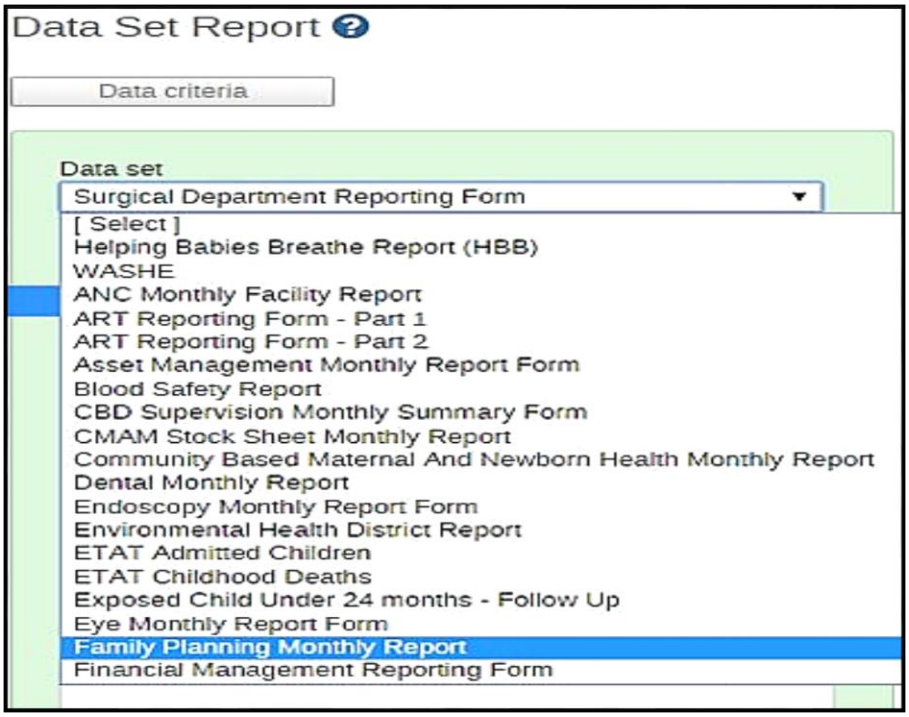


Figure 4.1: DHIS2 data set reports 1

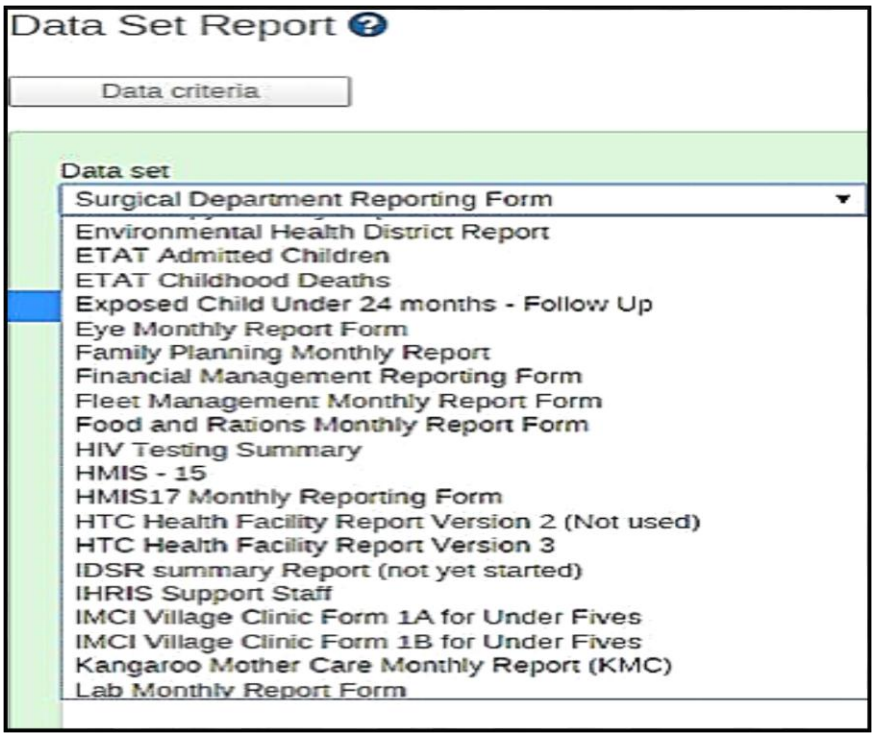


Figure 4.2: DHIS2 data set reports 2

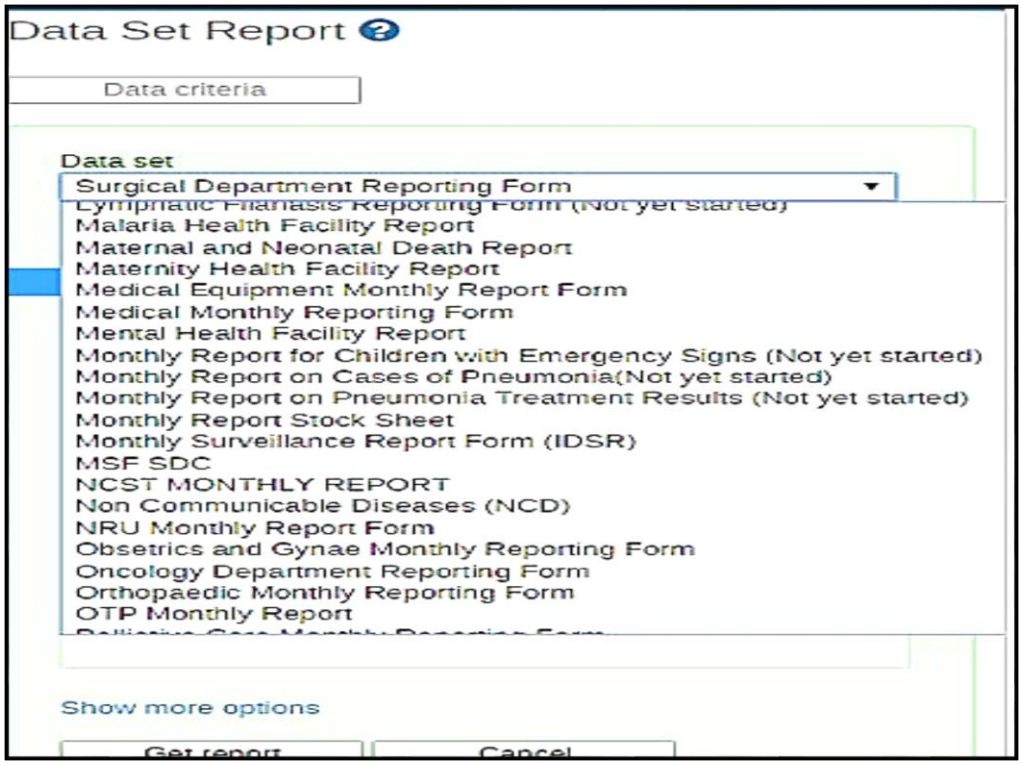


Figure 4.3: DHIS2 data set reports 3

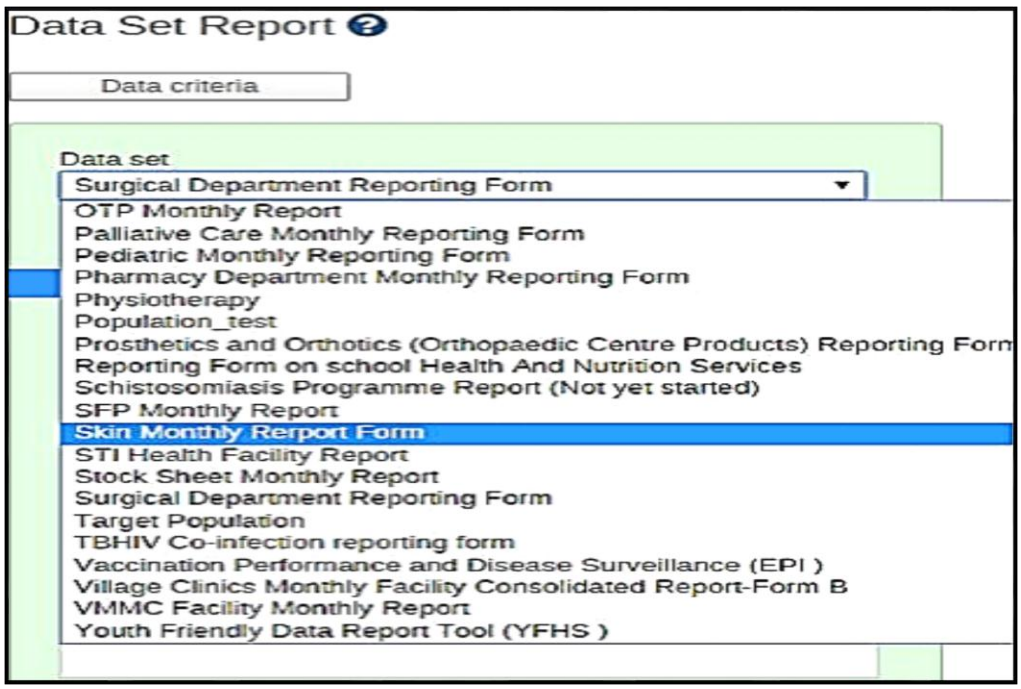


Figure 4.4: DHIS2 data set reports 4

Meaningful transfer of information in this context is the compilation and sending of specific reports in the Baobab health system that are required in the DHIS2 system. Some of the reports expected by the DHIS2, which can be produced by the Baobab health system include: HMIS-15, IDSR, HIV/ART, and ANC. The Baobab health system is able to compile the above named reports for a possible transfer into DHIS2. During the data collection exercise, I was able to see the Integrated Disease Surveillance Response (IDSR), HIV/ART and ANC reports compiled by the Baobab health system with a flexibility to extract by a specified time period. The HMIS-15 report was not available from the setting of the Baobab health system where I was making observations.

Baobab Health Trust have built a system module (functionality) to allow for exchange of data from the Baobab health system into DHIS2. This was done on a test environment and proved to be working. At the time of conducting this research, the functionality had not been implemented for the deployed modules in the health facilities. The functionality is built on the premise that the Baobab health system compiles the various DHIS2 format accepted reports and makes them available upon a selection of the report and period of reporting. Once the report has been pulled out, a user can push the report into DHIS2 by tapping/clicking on button labeled “Update DHIS2” within the Baobab health system. The process requires that the different reporting modules of the Baobab health system such as HIV/ART, ANC, and OPD be connected to the DHIS2 server. At the time of conducting this research, the Baobab health system was not connected to DHIS2. In addition the Baobab health system was deployed in independent non linked modules i.e. OPD, ANC, ART, and Pharmacy in the various health facilities, each of which produces the relevant reports for the respective program services. Access to these

modules is possible on designated computers within each department. With this setting, it is difficult to consolidate the HMIS-15 report in the Baobab health system. The HMIS-15 report is a summarized compilation of the different program services reports such as OPD, ANC, Family Planning, Malaria and others. To compile the HMIS-15 report in an eHIS, it then requires that these program services be linked to each other and able to pull specific data from the modules as per HMIS-15 report format. The HMIS-15 report is a very important report in HIS as it consolidates statistics from multiple health programs and therefore provides the overview performance of all the health service programs over a specific time in one report. Efforts were made to get the HMIS-15 report from Afyapro, another patient level eHIS that works similar to the Baobab health system and is used in some hospitals in Malawi.

The Baobab health trust have developed a module for data transfer into DHIS2. This module had been tested in a test environment and proved to be working. The modules deployed in the live version of Baobab health system in the district hospitals already have the provision of a button to push data into DHIS2 but not activated yet.

> "We have shown a proof of concept that it is technically possible to achieve interoperability between our system (Baobab health system) and DHIS2, and we have demonstrated the same through the annual eHealth innovation fairs. We await the eHIS interoperability Standard Operating Procedures and the authorization of the Ministry of Health to implement interoperability of our system with DHIS2 on the ground". Baobab health system deployment manager.

Thus technically, transfer of information from the Baobab health system is possible as observed in the test environment. Operationally however, this has not been

implemented as there are several administrative processes to be addressed first, including the availability of Standard Operating Procedures to guide the process of transfer of information from the Baobab health system into DHIS2. Fig 4.5 to 4.8 below are screenshots of the step by step process of extracting a report and attempting to transfer into DHIS2 from one of the district hospitals where Baobab health system was implemented.

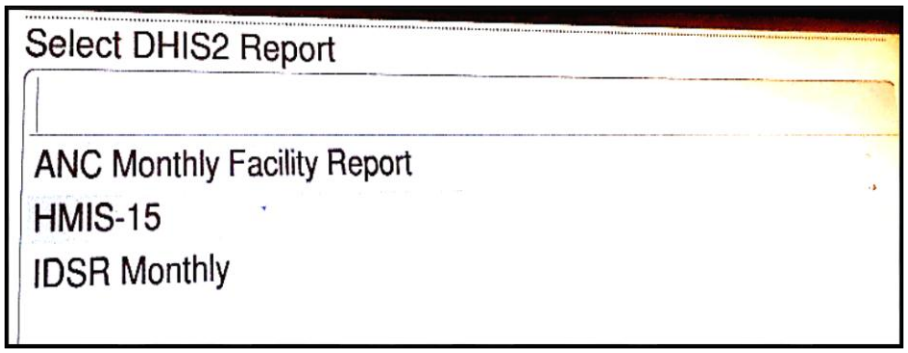


Figure 4.5: A selection of reports from the Baobab health system

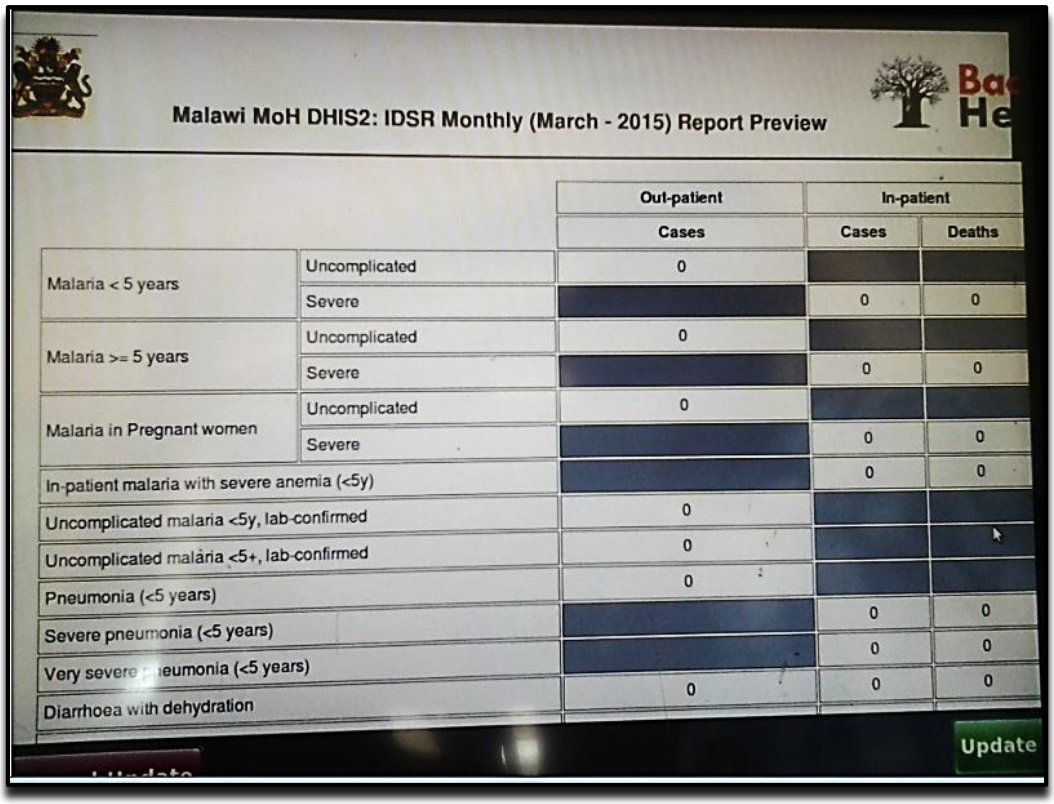


Figure 4.6: The IDSR report from the Baobab health system

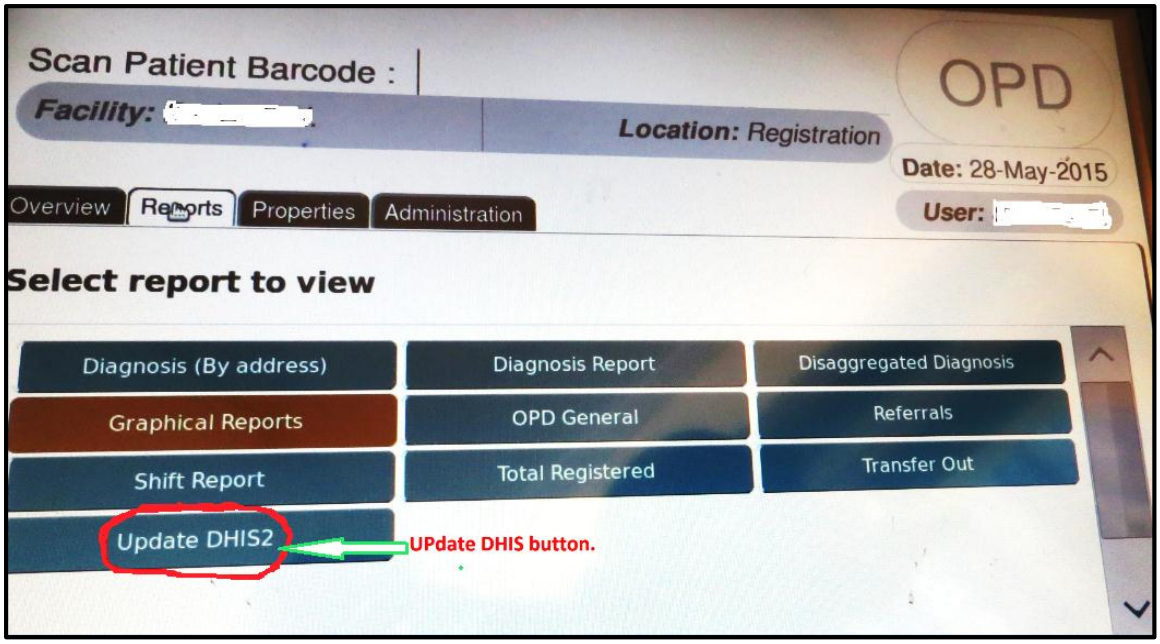


Figure 4.7: The DHIS2 update button on Baobab health systems

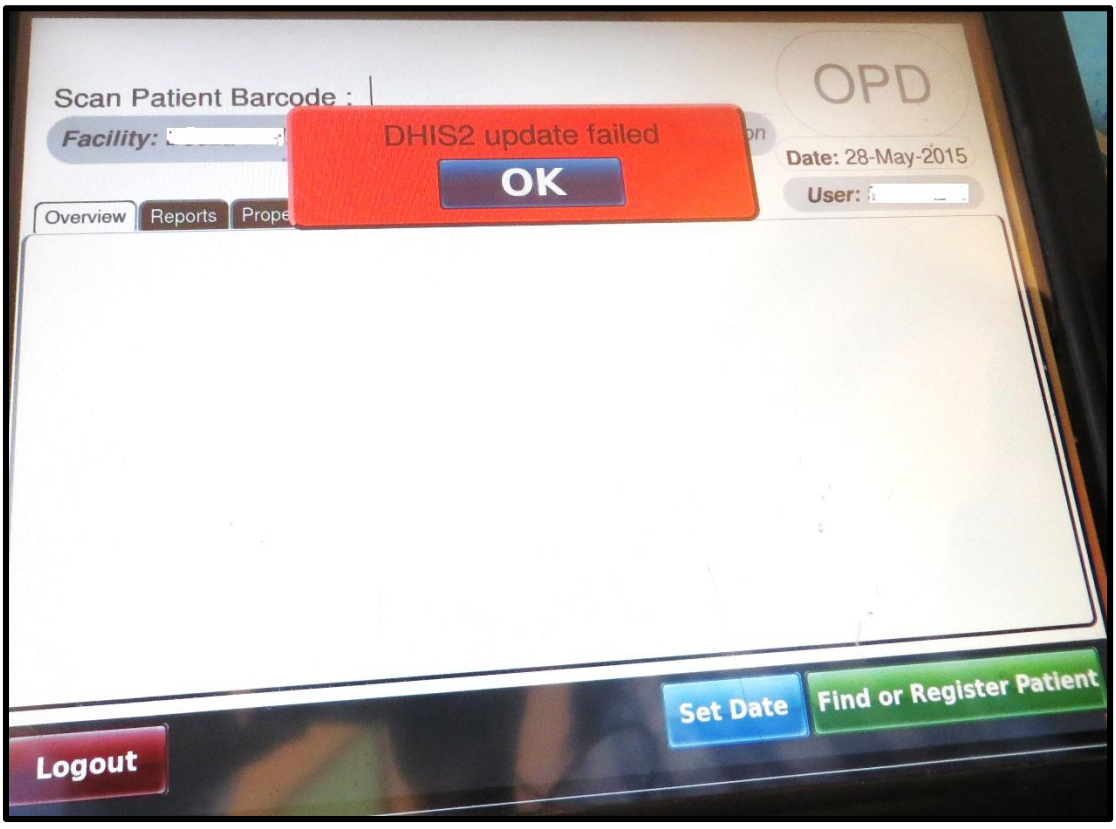


Figure 4.8: The live trial of DHIS2 updating from Baobab health system

4.2.2 Equivalence of the reports from the two systems

Equivalence is another concept that defines the relationship and goals of interacting software systems. Equivalence looks at the production of similar reports in two or more independent systems, which can be exchanged and used by any of the systems. Equivalence is meant to achieve timeliness, efficiency and completeness of information in software systems. In the context of the two systems being studied, equivalence is the presence of the same specific reports in both the Baobab health system and DHIS2 which can be used by either of the systems. The equivalent reports have to be in the same format and design such that they can be used in both systems with the same meaning and interpretation as well as maintaining the uniformity of design and presentation. Equivalence in this case focuses on examining the conformity of reports produced by Baobab health system to be transferred into DHIS2. The DHIS2 reports were taken as the gold standard for comparison as they are approved and used by Ministry of Health for reporting of health programs.

Conformity was examined by comparing the number, presentation, positioning and data types of data elements and indicators in respective reports. Four representative reports from the Baobab health system were selected to check their conformity to DHIS2 corresponding reports. The selected reports were: Antenatal Care (ANC), HIV/ART, IDSR (From Baobab health system) and HMIS-15 (from Afyapro system as the Baobab health system HMIS-15 report was not readily available), These four reports are compiled by all health facilities and are available in both the DHIS2 and the Baobab health system, hence their justification for selection in this study. In addition, the HMIS-15 report summarizes over 80% of other program services statistics hence it is good representation of the reporting system of health services in the health facilities.

A sample of the HMIS-15 and the other sampled reports are attached in appendix E of this document.

To compare and establish the degree of conformity of the corresponding reports, an excel workbook was developed with a side by side (mirror) representation of corresponding reports. The excel workbook was chosen as reports from both systems are available in excel and hence the format of the reports was adhered to during analysis. In addition, excel offered a mirrored presentation of corresponding reports with an extra custom functionality of comparing the similarities and differences, and quantifying them, while adding important comments for describing observed trends to the work book. Excel formulas were used to calculate the number of similar elements and express them as a percentage of the bench mark system reports, which was DHIS2 reports.

The focus was on the degree to which the reports match in the data elements and indicators as well the format. This involved checking for the following in the corresponding reports:

a. Presence of corresponding data elements and indicators in the two systems' reports.

b. Position of the data elements and indicators in the two systems' reports.

c. Presence of additional data elements and indicators in the Baobab health system reports.

d. Missing data elements and indicators in the Baobab health system reports but available in the DHIS2 system reports.

e. Positions of calculating aggregates (i.e. sectional aggregates) in the reports.

f. General outline of the reports.

The above elements were used to calculate the percentage match of the selected corresponding reports. Table 4.1 below summarizes the comparison of the selected reports in terms of their data elements from the two systems.

Table 4.1: Comparative analysis of Baobab Health system and DHIS2 corresponding reports

Report name	**DHIS2**	**Baobab health system (Afyapro for HMIS 15 report only)**				
	Number of data elements	Number of same data elements	Number of additional data elements	Number of expected but missing data elements.	Difference in the expected data elements	% degree of similarity of data elements to DHIS2
HMIS 15	108	108	28	0	0	100%
ANC	54	51	2	3	3	94%
IDSR	30	30	0	0	0	100%
HIV/ART	110	92	5	18	18	84%

From the table 4.1 above, IDSR report from the Baobab health system and HMIS-15 from Afyapro had all (100%) the data elements available on corresponding reports in DHIS2. The ANC and HIV/ART had 94% and 84% of the data elements in the Baobab health system matching those of DHIS2 respectively. The HIV/ART report had a lower score in match as it had a whole section of indicators missing on the Baobab health system version of the report but available on the DHIS2 version. Figure 4.9 below shows the graphical representation of the similarities in core data elements in the corresponding reports in the Baobab health system, Afyapro and DHIS2.

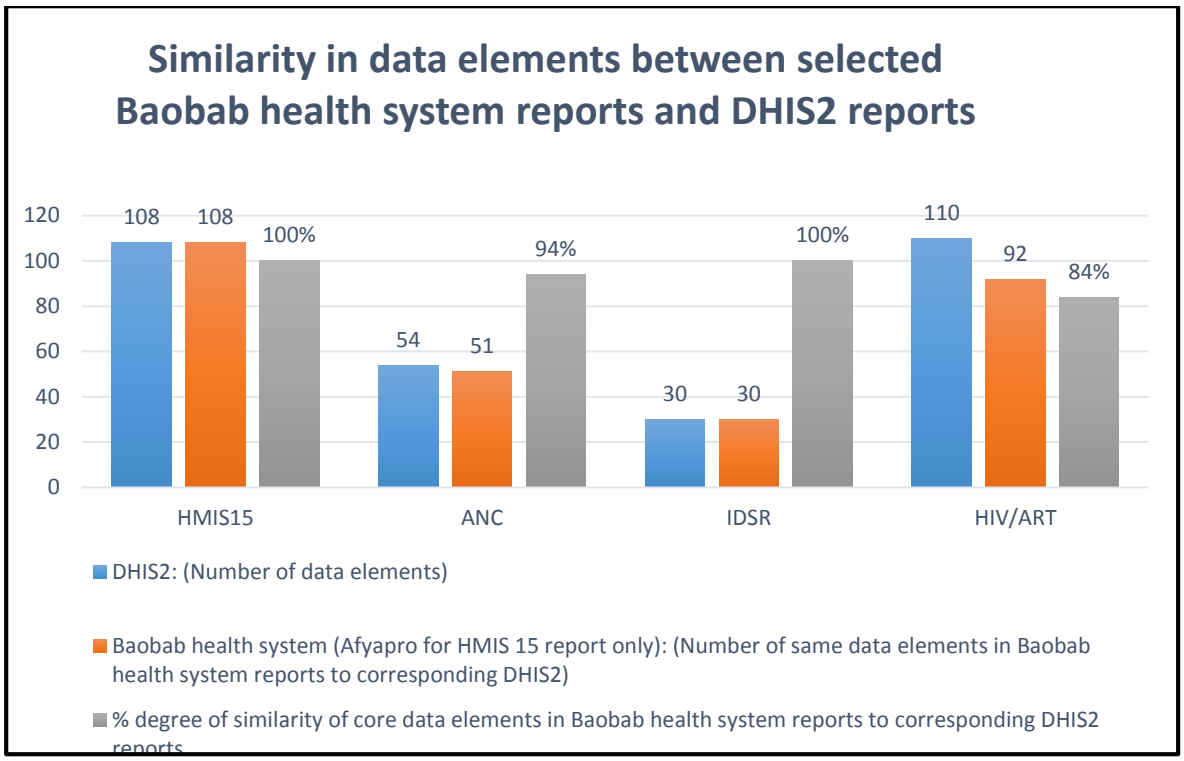


Figure 4.9: Similarities of core data elements in Baobab health system and DHIS2

The 100% match in some of the reports meant that all the data elements available on DHIS2 report were also available on the Baobab health system report in the same format, naming and structure. With the exception of the IDSR, the Baobab health systems reports were observed to have additional data elements which were not available on the DHIS2 corresponding reports. The additional data elements were mostly observed in age categories, with the Baobab health system reports having additional age categories in some sections. Again, there were additional data elements added as an option "Unknown" for some sectional options on some status reports in the Baobab health system reports. Table 4.2 and figure 4.10 below shows the number of additional or missing data elements in the Baobab health system as compared to the corresponding reports in DHIS2.

Table 4.2: Number of additional or missing data elements in the Baobab health system as compared to corresponding reports in DHIS2

Report name	DHIS2	Baobab health system (Afyapro for HMIS 15 report only)			
	Number of data elements	Number of same data elements	Number of additional data elements	Number of expected but missing data elements.	Difference in the expected data elements
HMIS 15	108	108	28	0	0
ANC	54	51	2	3	3
IDSR	30	30	0	0	0
HIV/ART	110	92	5	18	18

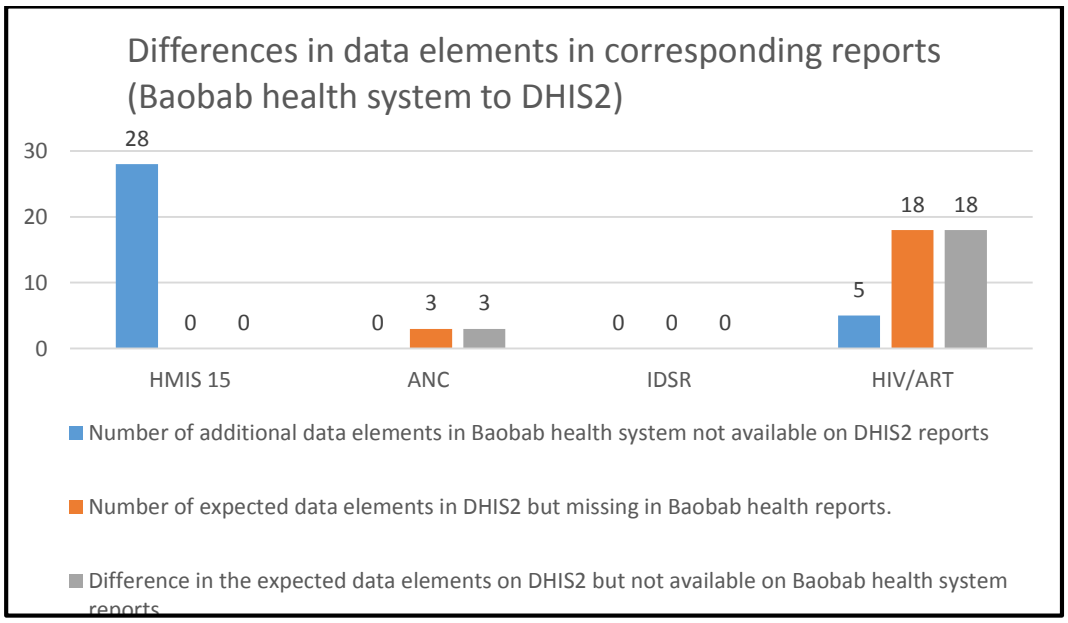


Figure 4.10: A graphical presentation of the additional and missing data elements in Baobab and Afyapro systems in comparison to DHIS2 corresponding versions

A major difference was observed in the aggregation of sectional data elements. In the DHIS2 system, ANC and HIV /ART reports have a lot of section aggregates summing up the statistics in those particular sections. Most of these aggregates are missing in the

corresponding Baobab health systems reports. The formats of the two systems reports are very much the same with minor differences coming in due to the additional elements and the missing aggregates. Table 4.3 below presents the degree of conformity in formats of the corresponding reports in the Baobab health system and DHIS2.

Table 4.3: Degree of conformity in format of the corresponding reports in Baobab health system to those from DHIS2

	DHIS2	**Baobab health system (Afyapro for HMIS 15 report only)**		
	Number of data elements	Number of same data elements	Data elements indicators at a different position than DHIS2.	Format & position similarity (%) to DHIS2.
HMIS 15	108	108	0	100%
ANC	54	51	2	92%
IDSR	30	30	0	100%
HIV/ART	110	92	18	84%

Figure 4.10 below presents the graphical presentation of the conformity of these corresponding reports in terms of position of data elements and formats of the reports.

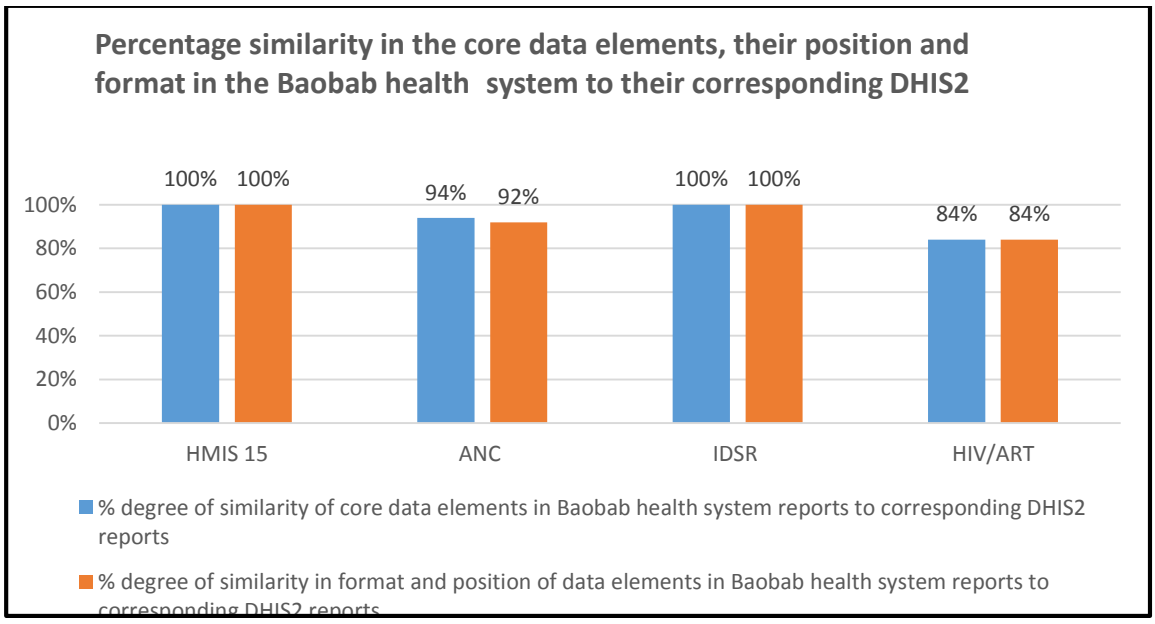


Figure 4.11: Percentage degree of similarity in data elements and formats in corresponding reports in Baobab health system and DHIS2

Overall, the results show a high degree of adherence of the Baobab health system to the reporting formats of DHIS2 hence a high equivalence rating for the corresponding reports between the two systems. The conformity of these reports collaborates with the findings from the interviews with statistical clerks and HMIS officers who explained that they are able to pull the electronic report from the Baobab health system and copy its contents or print onto the paper reporting form for entry into DHIS2 without difficulties as the Baobab health system report mirrors the MoH report.

> "In some cases, I usually download the report from Baobab health system, print it and then enter into DHIS2 from the printed report. Some of the reports like the IDSR, ANC and HIV/ART are very similar and if people have used the Baobab health system faithfully, then it is a complete report to go into DHIS2". HMIS officer, Ntchisi DHO.

There is, however, room to work on the Baobab health system reports to get all the reports to 100% match and hence achieve a 100% equivalence for the reports. There is also need to customize some of the Baobab health system reports from the other departments particularly the Out Patient Department (OPD) to match with the corresponding DHIS2 reports. Currently the OPD statistical reports from the Baobab health system does not match the corresponding sections of the DHIS2 OPD sections of the HMIS-15 report.

4.2.3 Specialization in reporting functionalities of the two systems

Specialization involves the production of specific chunks of information by one system which can then be transferred and used in other systems. The Baobab health system is a patient level system, handling patient data unlike DHIS2 which handles aggregate data compiled by other systems including manual entry of aggregated data into DHIS2.

In this context, Baobab health system is specialized in handling patient level information, which can in turn be used to produce the aggregate reports required by DHIS2. Specialization in this context exist on the premise that the Baobab health system has the capacity to manage patient level data and produce aggregate reports usable by DHIS2. It is worth noting that while there are specific reports produced by the Baobab health system only, such as pharmacy reports, laboratory reports, financial reports and others, some of these are not required by DHIS2 and as such they do not qualify to be discussed as specialized modules in this context.

DHIS2 on the other hand has the capacity to produce and present the information from various reports in the form of graphs and charts which are displayed on the dashboard interface of DHIS2. This presentation is very useful for program managers and other interested people to have an interpretation of the reports and determine trends and requirements in health services on the ground. This special capacity to handle statistical compilations and presentation is useful in facilities using the Baobab health system as well. Thus DHIS2 is specialized in the production and presentation of the statistical reports from the aggregate reports it receives. The study found that there is no exchange of this statistical information from DHIS2 to Baobab health system or indeed any other system.

> "There is really not much need for DHIS2 to send data back to other eHIS because by design, DHIS2 as an aggregate system gets data from these eHIS and is accessible over the internet to all authorized users who can access the special statistical reports and analysis from DHIS2 at any point from any place". DHIS2 programmer.

4.2.4 Complementarity and redundancy in reporting for the two systems

Complementarity and redundancy are two more concepts in the modified TYCOON framework. These were also examined in the interaction of the Baobab health system and DHIS2 in this study. Complementarity involves the production of chunks of information by individual systems which have to be merged for a complete set of information or report. Each of the systems in question produces part of the report as determined by its capacity. The Baobab health system and DHIS2 produce complete sets of reports such that there is no need for partial reports to be produced and merged from each of the systems. As such, complementarity concept does not apply in the relationship of the Baobab health system and DHIS2.

Redundancy on the other hand involves different systems producing exactly the same pieces of information and shared across the systems with a goal of enhancing reliability and availability of information. While the Baobab health system and DHIS2 produce the same reports, the idea is not to have both produce the same report and share it across the systems. Rather, in circumstances that both produce the same report, the report produced by one of the systems is sufficient for use in either of the two systems. Therefore, the concept of redundancy does not apply in this particular context.

4.2.5 The use of SDMX-HD standards in data exchange between the two systems

The study used the modified TYCOON framework in order to assess data exchange with reference to a set of data exchange standard namely, SDMX-HD. According to the DHIS2 technical documentation, DHIS2 accepts data in different formats such as text, images and many others (DHIS2 Documentation, 2014). This is possible because

DHIS2 uses several data exchange protocols or standards that accommodates all these formats. Some of the data exchange formats that DHIS2 uses are HTML, XML, JSON, PDF, IXF, DXF and PNG (Ibid). These data formats are exchanged in and out of DHIS2 through several protocols such as HTML, XML, JSON, JSONP and SDMX-HD. Figure 4.12 below is a sample of data import into DHIS2 through XML

```
1. http://guest:Guest007@venus.DHIS2
   .org:8081/dhis/api/dataSets/JQWU2QnEfqU.xml
2. <d:dataSet xmlns:d="http://DHIS2 .org/schema/dxf/2.0" d:code="KF_HOSP"
   d:name="OpenMRS_Import"
3. d:lastUpdated="2012-03-05T08:56:55.748+0000" d:link="http://venus.DHIS2
   .org:8081/dhis/api/dataSets/JQWU2QnEfqU"
4. d:internalId="26" d:id="JQWU2QnEfqU">
5. <d:periodType>Monthly</d:periodType>
6. <d:mobile>false</d:mobile>
7. <d:version>60</d:version>
8. <d:expiryDays>0</d:expiryDays>
9. <d:shortName>OpenMRS_Import</d:shortName>
10. <d:dataElements>
11. <d:dataElement d:code="DE002" d:name="OPD Old Attendance"
    d:lastUpdated="2011-12-20T17:50:35.836+0000"
12. d:link="http://venus.DHIS2 .org:8081/dhis/api/dataElements/kUow9Xi0UId"
    d:internalId="42" d:id="kUow9Xi0UId"/>
13. <d:dataElement d:code="DE005" d:name="IPD Admission" d:lastUpdated="2011-
    12-31T08:48:08.526+0000"
```

Figure 4.12 A: Sample data exchange protocol, Source: DHIS2 user manual 2014

```
14. d:link="http://venus.DHIS2 .org:8081/dhis/api/dataElements/FGrGBm8GgcF"
    d:internalId="51" d:id="FGrGBm8GgcF"/>
15. <d:dataElements>
16. <d:organisationUnits>
17. <d:organisationUnit d:code="DDU" d:name="DDU Hospital"
    d:lastUpdated="2012-03-05T07:32:07.663+0000"
18. :link="http://venus.DHIS2 .org:8081/dhis/api/organisationUnits/foWjiZNEduu"
    d:internalId="25" d:id="foWjiZNEduu"/>
19. </d:organisationUnits>
20. </d:dataSet><d:dataSet>
```

Figure 4.12 B: Sample data exchange protocol, Source: DHIS2 user manual 2014

In terms of data exchange from other systems into DHIS2, SDMX-HD is very much recommended and used in most instances where DHIS2 interoperability has been achieved. The comparative advantages of using SDMX-HD over the other exchange protocols have been explained in literature review of this document.

Baobab health system is a patient level system and mostly uses HL7 standards for the various sub domains within the system. By design, HL7 standards serve the purposes of patient level data management. At an aggregate level where reports and indicators are compiled from the individual patient records, another standard such as SDMX-HD is better suited to carter for the needs of aggregate data transfers. Having one standard at the patient level and no standard for aggregate level data transfer therefore has an impact in the effectiveness of data transfer at aggregate level. Baobab health system has an inbuilt module for transferring reports into DHIS2. This module was tested in a demonstration mode and proved to be working. During the testing of this module, the

JSON protocol of data exchange which is also supported by DHIS2 was used. The JSON protocol worked perfectly well in transferring the aggregated reports from Baobab health system into DHIS2 because DHIS2 also supports JSON protocol. While this worked well in the testing environment, further explorations will have to be made at the stage of national wide implementation of data exchange from Baobab health system into DHIS2.

> "One of the challenges encountered in developing the interoperability module was the lack of guiding technical documents such as data dictionary and an up to date HIS indicator handbook". Baobab Health system developer.

For future roll out of the data exchange, the SDMX-HD and other protocols such as the Open Health Information Exchange (OpenHIE) will have to be considered to enjoy the outlined benefits as well as the usability of the SDMX –HD which does not worry about the details of the XML format which may be sophisticated. In addition, the SDMX-HD is integrated into the visual studio 2008, one of the common and widely used software development platforms, and hence it makes it easy to debug and incorporate into the entire development project.

4.2.6 EHIS interoperability efforts by Ministry of Health

In addition to Baobab health system, there are other eHIS implementations in Malawi. The Ministry of Health through CMED coordinates the implementation of these systems. None of these systems on the ground exchanges data with DHIS2 except for DHIS2 tracker and DHIS2 mobile which are subs systems of DHIS2 itself..

> "Only DHIS2 tracker and DHIS2 mobile, which are sub-systems of DHIS2, exchange date with DHIS2. The rest of the systems do not exchange data with DHIS2". CMED official.

The HMIS coordinators in the districts expressed little knowledge on the concept of eHIS interoperability, but acknowledged that data exchange between the Baobab health system and DHIS2 would have more benefits to their work.

> "I think there would be a lot of benefits we would enjoy if were able to transfer data from the Baobab health system to DHIS2 even by copying in a USB memory stick and transferring into DHIS2. I think we would have reports with less errors, timely reporting, less duplication of efforts as well as minimize cases of missing reports". Statistical clerk –Dedza DHO.

> "I don't know why the Baobab health system does not exchange the data with DHIS2 but I think the reason could be because we seem to be in the pilot implementation of the Baobab health system. There are more additional modules being made to the Baobab health system each year and may be the system has not matured". HMIS officer –Dowa DHO.

According to CMED, the main reason for lack of eHIS interoperability is the lack of interoperability standards and guidelines and their enforcement.

> "We have made strides in eliminating parallel reporting in eHIS and have achieved up to 95% reporting rates in DHIS2 for some reports. We are now working with stakeholders to develop the eHIS interoperability Standards Operating Procedures (SOPs) to enhance eHIS interoperability which is currently not possible across systems and DHIS2". CMED official.

This deficit is also evident by the absence of interoperability supporting documents to eHIS implementation such as the data dictionary. Also missing is a pre-set standards and guide for minimum software and hardware requirements for eHIS. Some tangible documents which have been made available with a direct influence on eHIS standards include the HIS policy, HIS strategic plan, eHIS strategy and the revised indicator

handbook. The implementation of some of the policy issues and strategic plan are on track while others are behind schedule.

4.2.7 EHIS coordination in Malawi

While CMED acknowledges that it has the responsibility of coordinating the implementation of eHIS in Malawi, it also acknowledges that the eHIS in Malawi are not well coordinated. From the interviews conducted some of the challenges leading to poor coordination of the eHIS include:

i. The existence of many partners in health with varying priority areas and focus.
ii. Existence of other NGOs which do not go through the MoH when implementing eHIS solutions.
iii. Non-existence of guidelines to eHIS solutions.

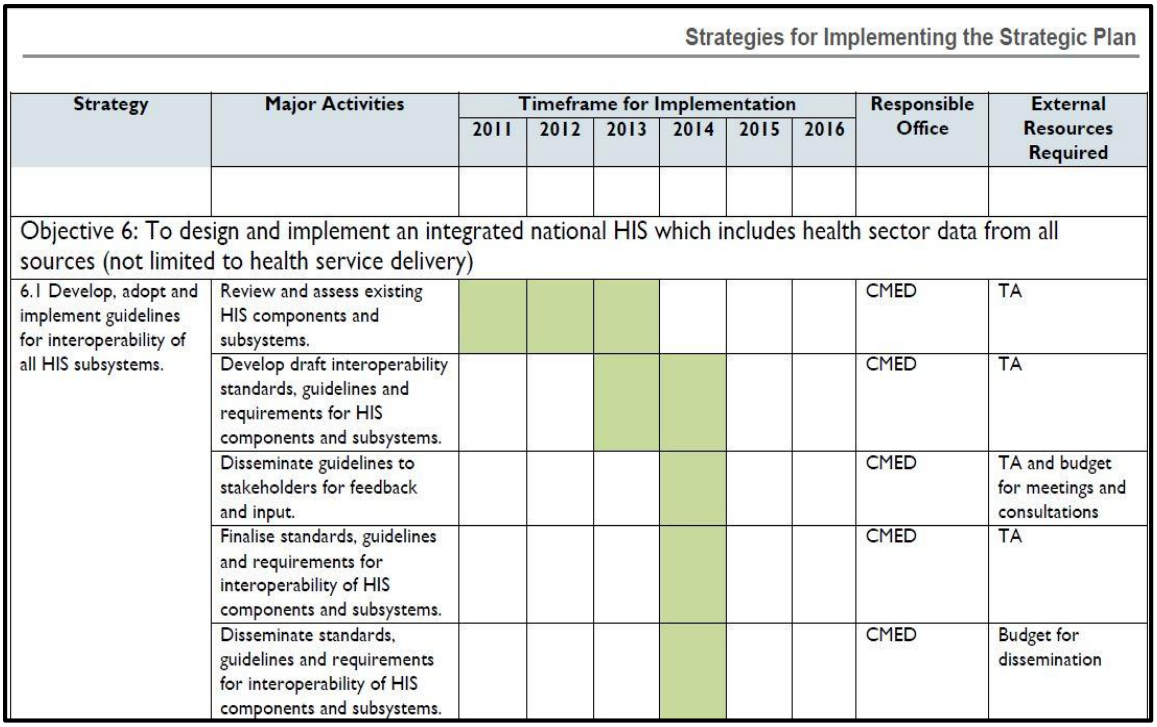
> "The conduct of some implementing partners of not going through the CMED when introducing eHIS systems presents a challenge in coordinating eHIS. We also have not established minimum standards for scrutinizing and approving eHIS being introduced. We are in the process of developing and enforcing procedures and policies which will enhance and strengthen eHIS coordination across the country". CMED official.

The suggested solutions which can help enhance the coordination of eHIS to improve the situation include:

i. Mapping all partners and updating the list on regular basis i.e. semiannual.
ii. Continue to strengthen M&E and eHIS Technical working groups.
iii. Developing guidelines and frameworks for eHIS.

4.2.8 EHIS interoperability standards and guidelines adoption and enforcement

There are efforts to develop the eHIS interoperability standards and guidelines. In these efforts, the Baobab inbuilt module for data transfer into DHIS2 is being used as a proof of concept of the possibility of such data transfers, and as a potential learning point of issues to be considered in developing these Standard Operating Procedures. The data standards subgroup of the M&E TWG has been tasked to do this under the direction of CMED. The efforts are in line with the HIS strategic plan for 2011 -2016, which has one of its objectives as: to design and implement an integrated national HIS which includes health sector data from all sources (not limited to health service delivery) (Ministry of Health Malawi, 2010). This has the focus on interoperability of eHIS and one of the two strategic activities involved is "To develop, adopt and implement guidelines for interoperability of all HIS systems", further divided into smaller activities spread across the first four years of the five year strategic plan. In the last year of implementation of the HSSP 2011-2016, most of the activities outlined under this objective had not been tackled. Below is an extract of the strategic action under objective 6 of the HIS strategic plan.



Strategies for Implementing the Strategic Plan

Strategy	Major Activities	Timeframe for Implementation						Responsible Office	External Resources Required
		2011	2012	2013	2014	2015	2016		
Objective 6: To design and implement an integrated national HIS which includes health sector data from all sources (not limited to health service delivery)									
6.1 Develop, adopt and implement guidelines for interoperability of all HIS subsystems.	Review and assess existing HIS components and subsystems.							CMED	TA
	Develop draft interoperability standards, guidelines and requirements for HIS components and subsystems.							CMED	TA
	Disseminate guidelines to stakeholders for feedback and input.							CMED	TA and budget for meetings and consultations
	Finalise standards, guidelines and requirements for interoperability of HIS components and subsystems.							CMED	TA
	Disseminate standards, guidelines and requirements for interoperability of HIS components and subsystems.							CMED	Budget for dissemination

Figure 4.13: The eHIS interoperability strategic plan section: Source: HIS strategic plan (MoH) 2011-2016

4.3 Analysis and discussion

In this section, I present the analysis and discussion of the findings, with respect to eHIS interoperability. The discussion is aligned to address the set objectives and research questions of this study.

4.3.1 Degree of similarity in the Baobab health system reports to the DHIS2 reports

The first objective was to check the degree of conformity of the Baobab health system reports to those of DHIS2. The Ministry of Health through CMED and the eHIS Technical Working Groups have made tremendous strides in eliminating parallel reporting which was evident in many health programs (Ministry of Health, 2016). Over 80% of the reporting of health services now report using the standard MoH reporting

forms and through the DHIS2 system (Ibid). The removal of parallel reporting and enforcement of reporting through standard reports in DHIS2 has led to an improvement in the number of reports submitted into DHIS2 from the various health programs. At the point of writing this document, there were over 40 different reporting forms in DHIS2, covering a wide range of health programs from the primary, secondary and tertiary health care services. The number of DHIS2 reporting forms is expected to increase with the adoption of more health program reports in DHIS2. There are now efforts to integrate reports from specific health programs, which will in turn reduce the number of reports in DHIS2, while making sure that all required health services data is captured and reported through DHIS2. This is a very commendable development as it provides a specific focus in HIS reporting. There is however the need to align the various reports coming out of the various eHIS to those in DHIS2.

Unifying and standardizing reports is a very important stage in the ability to exchange data across systems. Similarity in content and format of the electronic reports will make it possible for both syntactical and semantic interoperability (Adebesin, 2013; Foster, Kotzé & Van Greunen, 2013). From the analysis of the four representative samples of reports extracted from DHIS2, Baobab health system and Afyapro system, it was observed that there is a high degree of conformity in these reports in both content of data elements and format of the reports. In addition to the four reports which were used in this study, Baobab health has and continues to make efforts to unify other program reports that the system produces to match those in DHIS2.

The fact that 50% of the selected and analyzed reports have all the data elements and indicators required by DHIS2 corresponding reports is encouraging and commendable,

showing a positive direction in the steps towards eHIS interoperability with DHIS2, the main MoH eHIS. For the reports with a 100% match, it is encouraging to note that the match is in all aspects of the data elements and indicators i.e. the data element number, data element name and position in the reports. At a functional level, the data types of these data elements in the sampled reports are the same i.e. where numerical elements are expected, the format is the same in the corresponding reports. This is good as it would ensure compliance to data integrity and quality enforced by the checks and balances at the data entry level with the specified data types in DHIS2.

While the 100% adherence to the content and format of the two reports is of great value, the presence of the additional data elements and indicators in the ANC and the HIV/ART reports from the Baobab health system reports was a concern. In as much as these additional data elements have a meaning and value in these reports, their presence defeats the presence of a 100% adherence to syntactic and semantic interoperability with DHIS2 corresponding report. The study found that at the point of this observation, HIV/ART had not fully transitioned into DHIS2 reporting. There was still some parallel reporting in HIV/ART program, raising the chances of multiple versions of the reporting format. In addition, the missing of aggregate calculators in the ANC and HIV/ART reports of the Baobab health system did not give a good picture to the adherence of the standardized HMIS reports. The HMIS-15 report from Afyapro had a whole section of human resources information which is not present in the HMIS-15 report from DHIS2. It would be much better if the human resources information were reported under a separate relevant reporting form, there by maintaining the standard and uniformity on the HMIS-15 report. The observed conformity to reporting standards in DHIS2 is a great step towards realizing eHIS interoperability. However, there is need

to work on all reports produced by other eHIS to ensure and certify that there is a 100% conformity to DHIS2 reports.

4.3.2 Data transfer protocols and standards between DHIS2 and Baobab health system

A key element in eHIS interoperability is the capacity of the systems to talk to each other and effectively exchange the data – technical interoperability. With technical interoperability, the focus is the ability to move data from one system to the other, regardless of the content and format of the data. This is where the discussion on data exchange protocols and standards come in. Data exchange protocols is a means by which the systems can talk to each other and understand the transactions (Heard, 2007). The data exchange protocol is a language of communication to enable the process of data exchange between systems. The number and types of data exchange protocols that a system has determines how flexible it is to talk to other systems in both directions i.e. to send and receive information (Gebase et al., 2008). A system using more and widely used data exchange protocols has a higher chance of exchanging data with other systems.

DHIS2 supports multiple data formats and data exchange protocols including: Excel, XML, CSV, JSON, PDF, PNG, JSONP and SDMX-HD (Braa & Sahay, 2012; DHIS2 Documentation, 2014). These formats enable the presentation of data in text, numbers, tables, images, maps and charts while the protocols allow for flexible data exchange with many other systems. This is very important in the health domain whose data and information needs are so vast and needed in different formats. The Baobab health system also supports various data formats including text, CSV, image, table or chart form, all of which are supported by DHIS2 as well. This means information

presentation in the two systems can be easily handled, in a way that the exchanged information can be used for various purposes and analysis. It is also worth mentioning that DHIS2 is platform independent and can thus be installed on a windows or linux platform (DHIS2 Documentation, 2014). DHIS2 is compatible with multiple databases systems so long as they support Hibernate database abstraction such as Postgre SQL, My SQL, MS SQL server and others (Ibid). This provides for more flexibility for other systems to exchange data with DHIS2. The Baobab health system runs on a platform called Ruby on rails and SQL database.

The diverse nature of data exchange protocols in DHIS2 makes it easy and possible for other systems to interact with DHIS2. In the test setup for data exchange between Baobab health system and DHIS2, the JSON data exchange protocol was used and worked perfectly. Data was sent from the Baobab health system to DHIS2 and its format and content were preserved. This was a great milestone in the interoperability of the two systems. Complete system reports were sent from the Baobab health system to DHIS2 in the test environment, confirming the presence of technical interoperability in this test environment. The reports transferred into the DHIS2 maintained the same format and outlook entailing that syntactic interoperability was achieved. The transferred reports into DHIS2 were as complete as sent from the Baobab health system from where they were sent. As such, the reports were usable in the DHIS2 environment with the same meaning, confirming the presence of semantic interoperability. While the use of the JSON protocol worked in the test environment of the data exchange between the two systems, it would be of interest to explore the use of the SDMX-HD standard and its associated protocols to leverage the advantages and flexibility it has in relation to data exchange as discussed in literature review. Practical success stories exist of

DHIS2 interoperability that used the SDMX-HD standard to enable data exchange with Open MRS and IHRIS for instance (Braa & Sahay, 2012).

The modified TYCOON framework used in this study puts forward five types of cooperation between transferred information. These were noted as transfer, complementarity, equivalence, redundancy and specialization. In the test environment of the Baobab health system and DHIS2, whole reports were transferrable from Baobab health system into DHIS2. The transferrable reports were available in full without needing further operation in the DHIS2 system. This means the cooperation incurred in this exercise was 'transfer'. A broader view of the two systems highlights that at a larger operational interoperability scale, the other cooperation types will have to be considered. This is the case because other reports, which were not sampled as they were not part of the test interoperability, may require merging of reports from other system modules. For instance, HMIS-15, which was not part of the test reports in the Baobab health system, requires compilation of data from many departments such as OPD, ANC, family planning, Under-five children services and others. There is need to do more testing with each of the reports produced by the Baobab health system and required by DHIS2 beyond the sampled reports which were tested in the test environment, which was meant to test and prove possibility of interoperability between the two systems.

4.3.3 Degree of data transfer between Baobab health system and DHIS2

The high degree of conformity in the corresponding reports in Baobab health and DHIS2 systems may give the impression that there is data exchange across the systems. Data exchange however goes beyond the content and format conformity of the reports. Transfer protocols and transfer medium are also required in data exchange across

systems. The export of data from Baobab Health system into DHIS2 was tested with several sampled reports namely the ANC, IDSR and HIV/ART. The data exchange was successful in the test environment of the Baobab health system and DHIS2. Baobab health trust took an extra step to include the data transfer functionality into DHIS2 in the live version of the Baobab health system, in preparation for live implementation of data transfer. This functionality exist in the live deployments of Baobab health system but it had not been activated at the time of conducting the study. Plans are underway to integrate all departmental data from the different sub systems of the Baobab health system so as to be able to pull all the reports from the various system modules. Implementation of data exchange between the two systems in a live set up will need to consider several issues including:

1. Complete adjustment of the reports in Baobab health system to fully conform to the corresponding standard DHIS2 reports in content and format.

2. The actual process of transferring the data from the Baobab health system into DHIS2: Will it be an automatic pre-set transmission at a set time or will it involve someone to trigger the push into DHIS2?

3. Verification and validation of the Baobab health system reports before being transferred to DHIS2. Currently, before the data is keyed into DHIS2, the paper based report is verified and validated by the program coordinator or the HMIS officer. Within the electronic transmission, verification and validation would still need to be carried out to maintain quality and integrity of the data.

4. Mode of transmission. DHIS2 is web based and centralized national wide and as such data transfer over a network will have to be decided and resources provided.

5. Consolidation of HMIS-15 report in the Baobab Health system. For reports that take summaries from various departments i.e. HMIS-15, the Baobab health system will have to be linked across departments at a facility to enable consolidation of the data and then retrieval of the respective data elements required in the HMIS-15 report.

The process of ensuring and implementing interoperability and data exchange between the two systems needs a step wise approach with a few selected reports exchanged in a particular phase. For each step, the implementation could be monitored and evaluated, addressing issues along the way, and lessons learned to improve the next phase.

4.3.4 Coordination of eHIS in Malawi

Key to eHIS interoperability is the coordination of the eHIS in a country. The Malawi MoH HIS policy gives CMED the responsibility of coordinating HMIS functions which include reporting by eHIS in Malawi (Ministry of Health, 2015). During the interviews with CMED, it was clear that the eHIS in Malawi were loosely coordinated.

> "The eHIS are not strongly coordinated as we would wish. Some of the implementing partners do not go through CMED to introduce and update their eHIS implementation, and some are projects which are not aligned to MoH policies and strategies. An additional challenge to eHIS coordination is that we don't have minimum guiding principles or standards for eHIS implementation, except generic HIS policy". CMED Official.

Various organizations implement specific eHIS based on their needs and their financial muscle, a common occurrence in many countries (Galimoto 2007; Ministry of Medical services Kenya, 2011; Department of Health, South Africa, 2012; Chan, 2012; Ministry of Health, 2013; Gray & Vawda, 2016). What makes a difference is how well coordinated these systems are to align with the country's health information needs. For instance, a country may set the minimum hardware and software requirements for eHIS

to adhere to, and so ensuring a minimum standard for systems to comply with in achieving the national HIS needs. In some countries, it is a requirement that before an eHIS system is implemented, it is first presented to the Ministry of Health and a committee of experts evaluates and analyses its fitness to serve the health care needs and HIS needs of the country (WHO, 2010; Department of Health, South Africa, 2012; Gray & Vawda, 2016). This in turn makes the implementation of eHIS interoperability relatively easy and relevant to the needs of the country. In such instances, hardware and the software specifications would already be accommodative to incoming eHIS interoperability. In addition to hardware and software specifications, a country could also set standards for eHIS interoperability to ensure cross platform sharing of data across systems. For established eHIS, the MoH could be carrying out periodic reviews to check adherence of changing policies and requirements for eHIS. The above suggested actions are part of the eHIS coordination that enhance eHIS interoperability. In additional to the above, the MOH would also establish and coordinate eHIS Technical working groups which bring together all stakeholders in eHIS for discussions on processes, procedures and adjustments required in being up to standard with requirements and move forward.

The Ministry of Health in Malawi has made great advancement and improvements in the establishment, coordination and sustenance of eHIS TWGs, which bring together various stakeholders in eHIS to advance the various agenda in eHIS. The M&E TWG has been a very good vehicle for moving HIS policies, strategies and implementing actions recommended by the group as well as checking on performance of HIS and issues pertaining to the operations of the eHIS in Malawi. While the MoH has been good in the coordination of the TWGs, there is still much to be done on the issue of standards and guidelines for eHIS implementation in general and eHIS interoperability

as a specific need. There are no standards and specifications to guide the implementation of eHIS including the interoperability of the same. The lack of these standards and specifications has contributed to the lack of interoperability across eHIS in Malawi. The Baobab health system for instance awaits the release of the Standard Operating procedures for eHIS interoperability in order to effect the interoperability functionality in the live system already deployed.

4.3.5 EHIS interoperability in Malawi

The interoperability of eHIS in Malawi can be described as very minimal, with only few systems exchanging data not in a formally organized and standardized way. DHIS2 tracker and DHIS2 mobile are two systems that are able to feed data into the main DHIS2. One can argue that these two systems are by themselves subsystems of DHIS2. While that argument holds, the two systems are developed further for specific purpose which is patient level data and in very different geographical positions and hence there is a process of data aggregation from the patient level and then the data exchange of the aggregated data into DHIS2 main system. This is interoperability that involves transfer of equivalent modules or reports from the DHIS2 mobile or DHIS2 tracker into DHIS2 main system.

A few other undocumented instances of data exchange exist with data moving from one system to the other in CSV or XML files using export and import functionalities of the databases. This is mainly driven by different organizational needs. For example the quarterly HIV/ART reports from Baobab health system are pushed into an independent HIV/ART system at the HIV unit of the Ministry of Health. The desire for Ministry of Health is to have systems interoperability beyond these individual few systems.

> "When we talk about eHIS interoperability, the desire of the Ministry is to have each and every established EMR or eHIS system talk to each other beyond DHIS2. This is important for continuum of care of the clients as well as the general HIS performance" CMED Technical advisor.

The MoH's desire to have all eHIS talk to each other beyond DHIS2 is an excellent one, which needs to be pursued. The subject of eHIS interoperability is at the centre of attention by many multicounty entities as well as individual countries. The European Commission for instance is championing a harmonized approach to interoperability for European countries (Rossing, 2010). It is on record that some of the countries have advanced with development and implementation of eHIS interoperability strategies which include the setting and enforcing of interoperability standards (Rossing, 2010; Hammond, 2008; eHGI, 2012). This means there are starting points to learn from and work on to achieve eHIS interoperability.

4.3.6 EHIS infrastructural status in Malawi

To be able to exchange data cross geographical boundaries, there is need to boost the infrastructure to support eHIS interoperability. Key elements are the cost and availability of electricity and internet connectivity across the country. The cost of internet in Malawi is rated to be one of the highest in the Southern Africa, leading to low penetration of internet services (ITU, 2013). The penetration of electricity is also on the low end, rated at 9.8% in 2014 (Hivos, 2014). These infrastructural challenges are prohibitive to eHIS interoperability.

4.3.7 EHIS interoperability opportunities in Malawi

Despite the challenges to eHIS interoperability in Malawi, there exists opportunities which can be utilized to spearhead the interoperability of eHIS. First on the list is the

presence of the vibrant eHIS TWGs, which are an ideal platform for the development of the eHIS interoperability standards and operating procedures. The TWGs meet once every quarter to discuss progress of scheduled activities and review plans. The much spoken about pending eHIS interoperability standards and guidelines can be developed if the TWGs are allocated monetary and time resources.

The second opportunity is the use of DHIS2 as a national wide reporting system as adopted and enforced by the MoH in Malawi. International development partners and many other players in the eHIS have embraced this concept, increasing the chances that interoperability of other systems to DHIS2 can be encouraged and in some instances funded. It is also very encouraging to note that the MoH has taken an active role in policy and strategy to address the issue of eHIS interoperability and introduction and use of eHIS across Malawi as captured in the HIS policy statement below:

> "In order to ensure interoperability and data integrity, all systems used for data collection and/or management (electronic- and paper-based) including Electronic Medical Records Systems (EMRS) shall be designed and managed in compliance with approved national standards and guidelines on health data management. Electronic Medical Records system shall be gradually introduced in all health facilities nationwide. When a fully functional EMR is introduced at a health facility, this shall be the primary data source". (Ministry of Health, 2015).

The eHIS strategy also has a complete section of the foundations work stream whose core focus areas are in line with eHIS interoperability namely: national eHIS information standards, computing infrastructure, national connectivity services, identification and authentication, reliable power supply and information protection.

In summary, eHIS interoperability in Malawi is very minimal and unstructured due to several challenges including: (1) lack of eHIS interoperability specifications, standards and guidelines; (2) Poor and expensive ICT and power infrastructure, and (3) inadequate coordination in eHIS implementation leading to low commitment of organizations to invest in eHIS interoperability. There also exist opportunities that could be leveraged to enhance eHIS interoperability in Malawi.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

I conclude the study by highlighting the research summary, status of eHIS interoperability in Malawi in relation to literature, summary of findings and their direct conclusions, the recommendations from the study and finally the study contributions as well as propositions for further research areas.

5.1 Research summary

The study, which falls in the Health Information Systems domain originates from the observation that despite the existence of eHIS capable of producing aggregate reports, the reporting of the aggregate reports into DHIS2 is done by manual entry from paper based reports. The existence of the eHIS is an opportunity for electronic information sharing with DHIS2, thereby improving health information availability for decision making at different points in the health care system. The study therefore set out to find out the technical and organizational issues surrounding interoperability between other eHIS and DHIS2 where such implementations would be expected. The study was motivated by many benefits that would be realized if eHIS interoperability with DHIS2 was achieved. Such benefits include cost effectiveness in the reporting system, improved accuracy and completeness of reports, real-time reporting and the ease of level of effort to the health facilities staff involved in reporting. The gaps being experienced in the above highlighted benefits are the current major challenges of the

health system reporting in Malawi. Within the study, I took significant time to understand and document the context of health care services in Malawi with a particular focus on eHIS including DHIS2 in Malawi. This provided a good foundation of further explanations and findings within the study.

To practically analyze the status of eHIS interoperability and the associated issues on the ground, two systems, Baobab health system and DHIS2, were taken as a case systems for study. Baobab health system is the most widely implemented eHIS in Malawi with electronic reporting capability while DHIS2 is the national wide reporting system as per MoH reporting requirements. The specific objectives for the study and the research questions were set as presented in Chapter 1 of the study. The Modified TYCOON theoretical framework was used to guide the study. The modified TYCOON framework used the concepts of software modules interactions to achieve specific goals with the aid the SDMX-HD standard for data transfer between other eHIS and DHIS2. Literature review, MoH and the respective systems' documents analysis, interviews with eHIS specialists, coordinators and district HMIS officers, observation of the two systems were used to inform the study.

5.2 EHIS Prerequisites –Malawi's status

The study established that there are seven key elements, discussed in chapter 3 as drivers of eHIS interoperability that facilitate the interoperability of eHIS systems. These elements provide a conducive environment to implement and enforce eHIS interoperability and are collectively known as drivers of interoperability (Chan, 2012; Adebesin et al., 2013). From these seven elements, the study established that services & Applications, Infrastructure, Standards & Interoperability and the workforce have a very direct influence on technical interoperability for eHIS. Each one of these

determines the availability and cost of capacity to configure systems for interoperability and provide the medium for the transfer of the information across systems. The study concluded that many countries in Africa have achieved very little levels of these elements leading to low levels of eHIS interoperability in Africa in general. The study specifically found that Malawi is challenged with infrastructure, with very expensive and intermittent power supply as well as internet connectivity. The study also concluded that Malawi does not have a set of minimum standards and procedures for implementation of eHIS, let alone standards and guidelines to guide and enforce implementation eHIS interoperability. In addition, there are also low levels of skilled workforce to implement eHIS interoperability. The study concluded that the lack of the necessary cost effective ICT infrastructure, standards and guidelines for eHIS are the main challenges hindering eHIS interoperability in Malawi.

In addition to these challenges, there also exist gaps in the leadership and governance, strategy and investment as well as legislation and policy with regards to the implementation and enforcement of eHIS interoperability. While there has been the development of the eHIS strategy, eHIS policy and the inclusion of eHIS issues in the Health Sector Strategic Plan (HSSP) in 2011-2016, the implementation of the strategies and enforcement of the policies have not been to the desired standard. Some of the key thematic areas of the strategies were not implemented and eventually missed their deadlines. The study concluded that these tools have not been optimally effective to influence the eHIS interoperability in Malawi.

5.3 Barriers to eHIS interoperability in Malawi

In general the technical issues that involve eHIS interoperability range from conformity of reporting formats, the data exchange protocols used in the various systems, availability and cost of infrastructure and the workforce needed to implement and sustain interoperable systems. In this study, I focused on the conformity of the reporting formats and the data exchange protocols, as well as the presence of standards and guidelines of eHIS interoperability. As part of the interviews, questions about infrastructure status and the workforce status were also tackled to get an insight on the capacity of these drivers and how they are affecting eHIS interoperability in Malawi.

The study examined four selected reports from Baobab health system to check their conformity to DHIS2 corresponding reports. Conformity of the information being transferred is of paramount importance in achieving semantic interoperability discussed in Chapter 2. Two out of the four reports (50%) from eHIS other than DHIS2, were found to be with high conformity (100%) with DHIS2 reports. These two reports from Baobab and Afyapro eHIS had all the data elements expected on the DHIS2 reports and a few additional elements. The other two reports had some missing data elements and had a conformity of 94% and 84% respectively. The study concluded that there is a high conformity of the Baobab health system reports to those of DHIS2. There is room to improve on the other reports which do not achieve a 100% report conformity to DHIS2 reports. The current status is encouraging and provides a great opportunity for the implementation of eHIS interoperability, beginning with the reports with a 100% conformity, while improving the conformity of the remaining reports.

The study also looked into data exchange protocols of the two systems as this is an important element in technical interoperability. The study established that DHIS2

accommodates many data exchange protocols such as HTTP, HTML, JSON, JSONP, SDMX-HD and others. The study also established that the Baobab health system supports multiple data exchange protocols such as JSON, HTTP, CSV among others. The study concluded that these two systems have the necessary data exchange protocols to enable data exchange between them. In fact, the study established that such data exchange had been tested before using the JSON data exchange protocols. Data was transferred from the Baobab health system to DHIS2 in the test environment using selected reports. The data exchange protocols used by the Baobab health system were compatible with those used by DHIS2 hence the possibility of data transfer across the systems.

Another element of focus in this study was the availability of standards to enhance eHIS interoperability. Out of the many standards of eHIS interoperability, literature review showed that the SDMX-HD is the most preferable standard in eHIS interoperability with DHIS2 at an aggregate data sharing level. The study found that Malawi does not have a prescribed standard for eHIS interoperability. The Ministry of Health through CMED was in the process of developing standards and guidelines also known as Standard Operating Procedures, to guide the implementation of eHIS interoperability. For the Baobab health system and other systems, the SOPs are the key missing piece to allow for national wide implementation of interoperability with DHIS2. The study concluded that there is interest and effort to implement eHIS interoperability with DHIS2. There is however slow progress with the process of developing the SOPs for eHIS interoperability.

The MoH showed commitment in developing these standards in the soonest possible time after missing the previous deadline of 2014. CMED continues to provide the

leadership and governance of HIS which includes eHIS interoperability as demonstrated by including eHIS activities and policy statements in the eHIS strategy, HIS policy and the HIS strategic plan. The investment in the eHIS interoperability plan and activities is however insufficient leading to failure to implement some of the activities planned such as the development of the interoperability of SOPs. The study recommends prioritization of the development of the eHIS interoperability SOPs to leverage the efforts already made by stakeholders such as the Baobab health system to implement the interoperability with DHIS2 thereby realizing the benefits that come with the eHIS interoperability.

5.4 Recommendations

Having gone through a rigorous mixed methods approach and analyzed the findings, the study makes the following recommendations:

1. **Adoption of the eHIS interoperability drivers**

   The study recommends the consideration by MoH in looking into the drivers of eHIS interoperability, making efforts in improving those within MoH's capacity such as strategy and investments, leadership and governance, workforce, legislation, policy and compliance to standards and interoperability, while discussing with other Ministries on how to improve the other aspects such as ICT connectivity infrastructure and power supply. The MoH can leverage the TWGs where partners implementing eHIS can contribute to these efforts and provide some investments to the same.

2. **Enforce conformity of eHIS reports to those in DHIS2**

As part of the eHIS coordination efforts by CMED, there is need for a systematic exercise of checking conformity of eHIS reports and enforcing their conformity to the corresponding reports in DHIS2, where such is not the case. This is one way of ensuring functional and semantic interoperability.

3. **Develop eHIS interoperability standards and guidelines**

The study recommends that the Ministry of Health adopts and enforce usage of data exchange protocols along with the SDMX-HD standard for data transfer which offers additional flexibility and advantages to the data transfer process as discussed in Chapter 2. The study also recommends further effort by the Ministry of Health in determining and recommending optimum data standards and protocols that enable data exchange by all eHIS with DHIS2. This will ensure new systems coming into place will have to be checked for these protocols and thus making the interoperability implementation a feasible and easier processes. The lack of eHIS interoperability SOPs was found to be a key element contributing to lack of eHIS interoperability. The SOPs are the bench mark and guiding framework to eHIS interoperability. These therefore need to be developed and enforced to realize eHIS interoperability in practice. The development, enforcement and monitoring the use of these SOPs has to be a continuous process to be part of the MoH policies and strategies. Government should lead in this process and allocate and or mobilize resources required for the monitoring of eHIS interoperability.

4. **Develop minimum software and hardware requirements and data exchange protocols for eHIS**

   One of the challenges to eHIS interoperability is the presence of legacy systems which by design are incapable of exchanging data with other systems. With no specifications on hardware and software requirements for an eHIS, it is inevitable to have systems which are incapable of exchanging data. Malawi does not have any requirements for minimum hardware and software for eHIS. It is thus recommended to have such standards and guidelines for compliance to eHIS interoperability protocols. Again, it is the responsibility of the Ministry of health through CMED to develop and enforce these standards across eHIS implementation in Malawi

5. **Strengthen coordination of eHIS**

   An overarching driver to eHIS interoperability is leadership and governance, which ensures that eHIS initiatives are in line with national health priorities and get sufficient human and financial resources. As observed, the coordination eHIS in Malawi is not very strong. There is need for CMED to strengthen coordination of eHIS in Malawi. In addition, the MoH should also consider developing a long term phased plan to implementation of eHIS interoperability in Malawi. This should take into account the drivers of eHIS interoperability discussed in literature review.

6. **Advocate for better and cost effective power and connectivity infrastructure**

   The connectivity and power infrastructure in Malawi is prohibitive to eHIS interoperability. Connectivity and power is expensive, erratic and not available in some places in Malawi. The health sector is lowly funded and operating on a not for profit basis hence unable to afford the cost. The MoH needs to lobby for availability and affordability of power and connectivity services to provide a suitable and capacitating environment for eHIS interoperability.

5.5 Theoretical contributions of the study

The study has added more literature to the area of eHIS interoperability. Several aspects of eHIS interoperability have been discussed in this study. In addition to the literature on eHIS interoperability and eHIS standards, the study has also significantly contributed to the theory of eHIS interoperability by bringing in a modified theoretical framework which was derived from the TYCOON framework. This modified framework focuses on Types and Goals of COOperatioN between modalities with the use eHIS standards. The modalities in this study were the electronic reports in the two systems whose goal is to conform to the reporting standards as stipulated by MoH, so as to be used for decision making within the health sector. The cooperation between the system reports is the various transfer concepts aimed at achieving specific desirable qualities of data availability, quality and usability. The modified framework incorporated the SDMX-HD standards and data exchange protocols to explain the types and goals of cooperation.

5.6 Practical contributions of the study

The first contribution has been the assessment and discovery that not all of the HIS reports from the eHIS have a 100% match to the corresponding reports in DHIS2. This means MoH can take an extra steps to have a thorough look at the reporting forms from the eHIS and enforce conformity to DHIS2 reports. Secondly, through this study gaps and opportunities in eHIS interoperability have been brought out. This gives an opportunity for MoH and stakeholders to address these issues which were collected with anonymity. Thirdly, the study has made various practical recommendations which will enhance the discussion and implementation of eHIS interoperability in Malawi.

5.7 Further research

While the study has unveiled the technical and organizational issues affecting eHIS interoperability, several other aspects calling for further research have also been identified in the process. These can also be categorized within the two domains of technical or administrative issues.

1. Another emerging issue in interoperability is the issue of privacy, security and confidentiality of health data. Patient/client data is required to be upheld with all the ultimate privacy and confidentiality. EHIS interoperability potentially brings a threat to this aspect if not well handled. What are the issues to consider to ensure patient data privacy and confidentiality while achieving interoperability and integration?
2. EHIS are poorly coordinated with no standards for minimum software and hardware requirement for eHIS implementation. What are the various ways/approaches to eHIS coordination? What factors should be considered?

3. Lastly, an action research to help develop the eHIS interoperability standards and guidelines for Malawi would make a better research area.

The above possible research areas can enrich theoretical and practical knowledge in the field of eHIS as from the information collected from this study.

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APPENDICES

Appendix A: Support letters from school and study sites

Letter of support from school

ACTING PRINCIPAL
Richard Tambulasi, B.A (Pub Admin), BPA (Hons), MPA, Ph.D

CHANCELLOR COLLEGE
P.O. Box 280, Zomba, Malawi
Telephone: (265) 524 222
Fax: (265) 524 046
E-mail: principal@cc.ac.mw

5th September, 2014

NHSRC

Dear Sir/Madam,

CHRISTOPHER KULANGA – MSC/INF/10/11

This is to confirm that **Mr. Christopher Kulanga** is one of our Msc. in Informatics students here at Chancellor College. His title of his study is **'Investigating the Interoperability of HMIS Systems. A case of DHIS2.0 and Afypro'.**

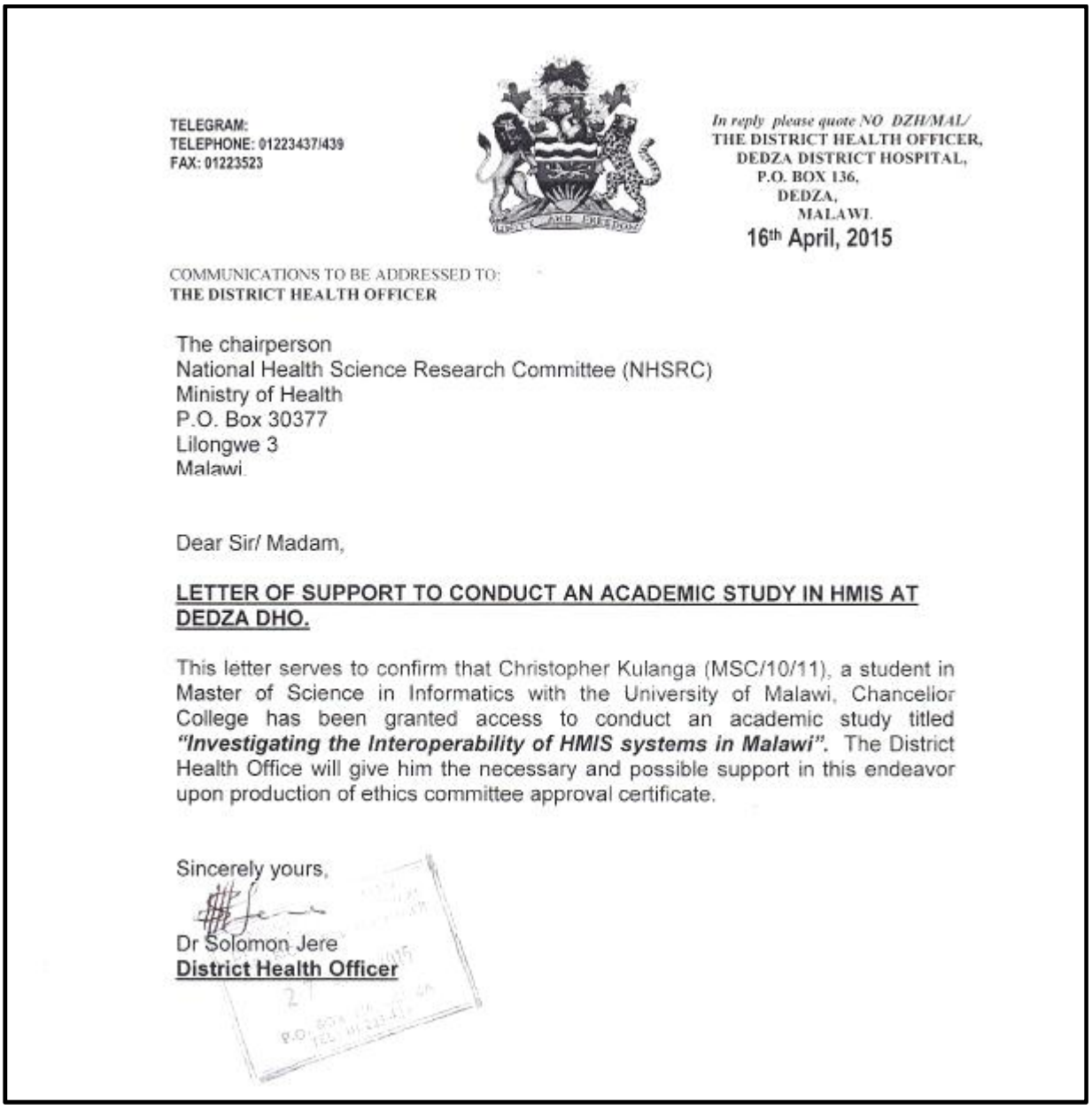
Any assistance rendered to him will be appreciated.

Yours sincerely,

Tiwonge D. Manda
Lecturer, Computer Science Department

UNIVERSITY OF MALAWI
CHANCELLOR COLLEGE
DEPT OF COMPUTER SCIENCE
2014 -09- 05
P.O. BOX 280
ZOMBA

Letter of support from Dedza DHO



TELEGRAM:
TELEPHONE: 01223437/439
FAX: 01223523

In reply please quote NO DZH/MAL/
THE DISTRICT HEALTH OFFICER,
DEDZA DISTRICT HOSPITAL,
P.O. BOX 136,
DEDZA,
MALAWI.
16th April, 2015

COMMUNICATIONS TO BE ADDRESSED TO:
THE DISTRICT HEALTH OFFICER

The chairperson
National Health Science Research Committee (NHSRC)
Ministry of Health
P.O. Box 30377
Lilongwe 3
Malawi

Dear Sir/ Madam,

LETTER OF SUPPORT TO CONDUCT AN ACADEMIC STUDY IN HMIS AT DEDZA DHO.

This letter serves to confirm that Christopher Kulanga (MSC/10/11), a student in Master of Science in Informatics with the University of Malawi, Chancelior College has been granted access to conduct an academic study titled ***"Investigating the Interoperability of HMIS systems in Malawi".*** The District Health Office will give him the necessary and possible support in this endeavor upon production of ethics committee approval certificate.

Sincerely yours,

Dr Solomon Jere
District Health Officer

Letter of support from Dowa DHO

Telephone : 282 222
Fax: 282 200
All communications should be addressed to:
The District Health Officer

In reply please quote No: .....
Ministry of Health
Dowa District Hospital
P.O. Box 25
DOWA
MALAWI

22nd April, 2015

The chairperson
National Health Science Research Committee (NHSRC)
Ministry of Health
P.O. Box 30377
Lilongwe 3
Malawi.

Dear Sir/ Madam,

LETTER OF SUPPORT TO CONDUCT AN ACADEMIC STUDY IN HMIS AT DOWA DISTRICT HOSPITAL.

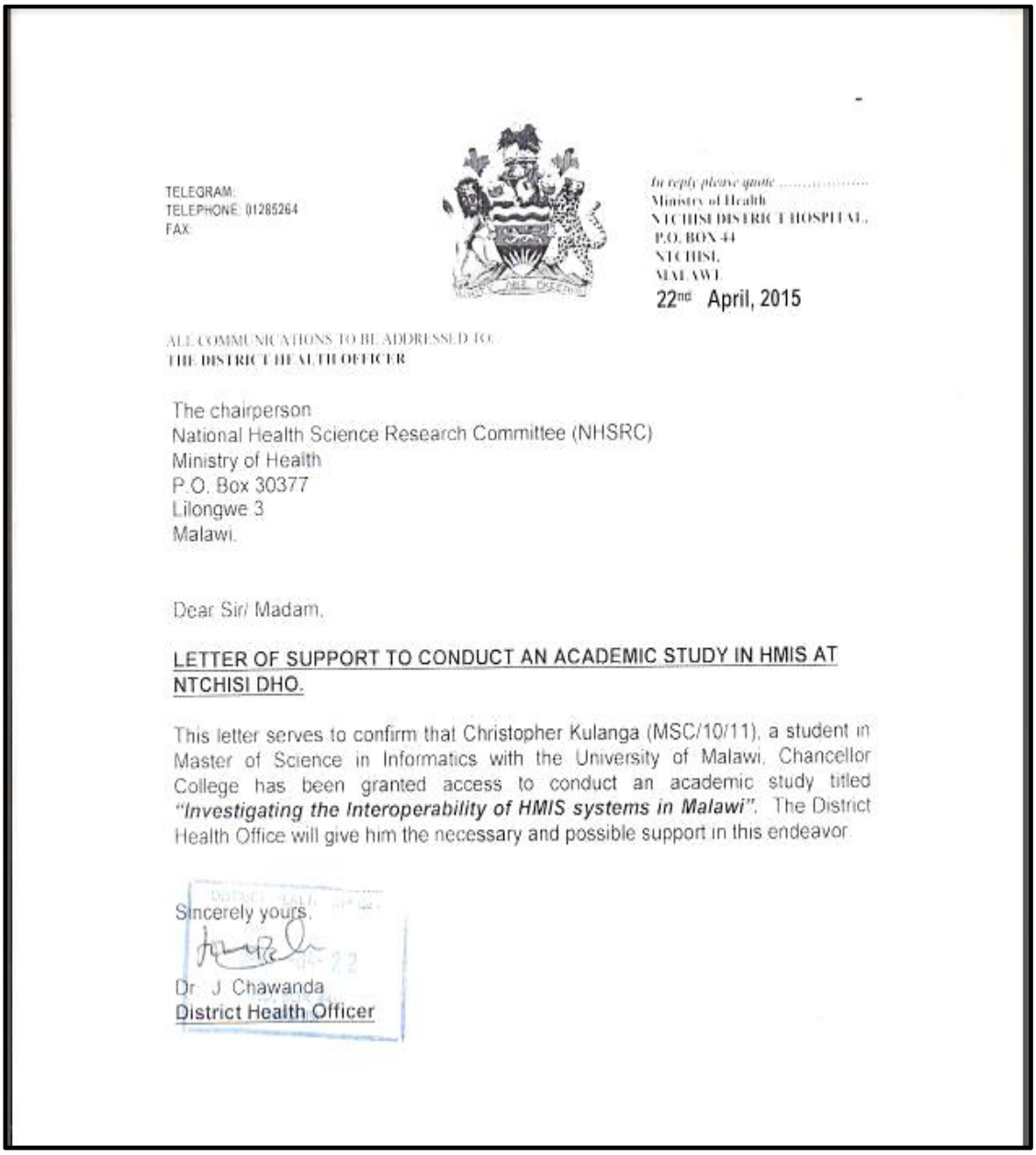
This letter serves to confirm that Christopher Kulanga (MSC/10/11), a student in Master of Science in Informatics with the University of Malawi, Chancellor College has been granted access to conduct an academic study titled ***"Investigating the Interoperability of HMIS systems in Malawi".*** The District Health Office will give him the necessary and possible support in this endeavor.

Sincerely yours,

DOWA DISTRICT HEALTH OFFICER
22 APR 2015
P.O. BOX 25, DOWA
MALAWI

E.J. Bakali
DISTRICT HEALTH OFFICER

Letter of support from Ntchisi DHO



TELEGRAM:
TELEPHONE: 01285264
FAX:

In reply please quote .....
Ministry of Health
NTCHISI DISTRICT HOSPITAL
P.O. BOX 44
NTCHISI
MALAWI

22nd April, 2015

ALL COMMUNICATIONS TO BE ADDRESSED TO
THE DISTRICT HEALTH OFFICER

The chairperson
National Health Science Research Committee (NHSRC)
Ministry of Health
P.O. Box 30377
Lilongwe 3
Malawi.

Dear Sir/ Madam,

LETTER OF SUPPORT TO CONDUCT AN ACADEMIC STUDY IN HMIS AT NTCHISI DHO.

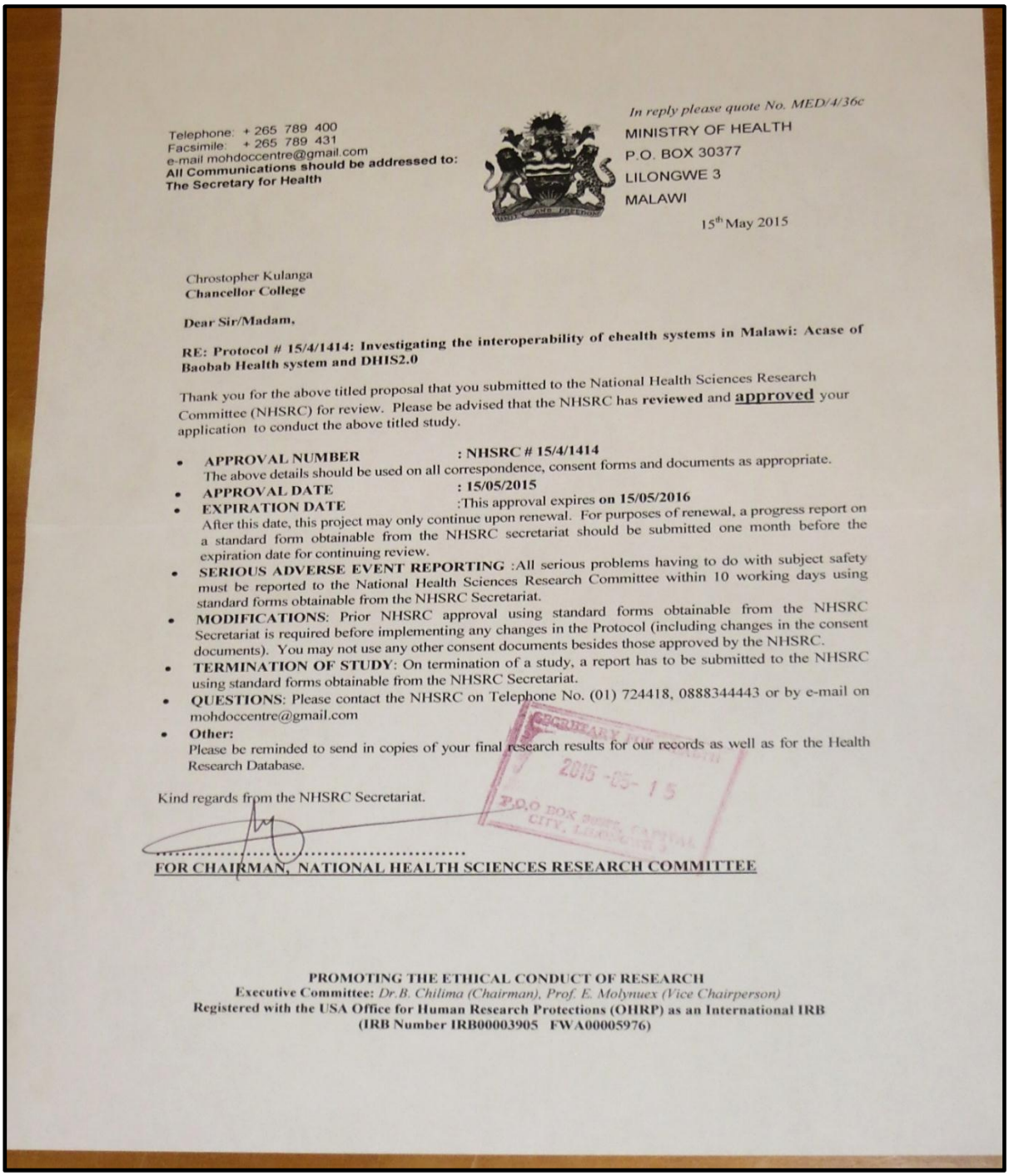
This letter serves to confirm that Christopher Kulanga (MSC/10/11), a student in Master of Science in Informatics with the University of Malawi, Chancellor College has been granted access to conduct an academic study titled ***"Investigating the Interoperability of HMIS systems in Malawi"***. The District Health Office will give him the necessary and possible support in this endeavor.

Sincerely yours,

Dr J Chawanda
District Health Officer

Appendix B: Ethical clearance from NHSRC

Letter of Approval from NHSRC



Telephone: + 265 789 400
Facsimile: + 265 789 431
e-mail mohdoccentre@gmail.com
All Communications should be addressed to:
The Secretary for Health

In reply please quote No. MED/4/36c
MINISTRY OF HEALTH
P.O. BOX 30377
LILONGWE 3
MALAWI

15th May 2015

Chrostopher Kulanga
Chancellor College

Dear Sir/Madam,

RE: Protocol # 15/4/1414: Investigating the interoperability of ehealth systems in Malawi: Acase of Baobab Health system and DHIS2.0

Thank you for the above titled proposal that you submitted to the National Health Sciences Research Committee (NHSRC) for review. Please be advised that the NHSRC has **reviewed** and **approved** your application to conduct the above titled study.

- **APPROVAL NUMBER** : **NHSRC # 15/4/1414**
  The above details should be used on all correspondence, consent forms and documents as appropriate.
- **APPROVAL DATE** : **15/05/2015**
- **EXPIRATION DATE** :This approval expires **on 15/05/2016**
  After this date, this project may only continue upon renewal. For purposes of renewal, a progress report on a standard form obtainable from the NHSRC secretariat should be submitted one month before the expiration date for continuing review.
- **SERIOUS ADVERSE EVENT REPORTING** :All serious problems having to do with subject safety must be reported to the National Health Sciences Research Committee within 10 working days using standard forms obtainable from the NHSRC Secretariat.
- **MODIFICATIONS**: Prior NHSRC approval using standard forms obtainable from the NHSRC Secretariat is required before implementing any changes in the Protocol (including changes in the consent documents). You may not use any other consent documents besides those approved by the NHSRC.
- **TERMINATION OF STUDY**: On termination of a study, a report has to be submitted to the NHSRC using standard forms obtainable from the NHSRC Secretariat.
- **QUESTIONS**: Please contact the NHSRC on Telephone No. (01) 724418, 0888344443 or by e-mail on mohdoccentre@gmail.com
- **Other:**
  Please be reminded to send in copies of your final research results for our records as well as for the Health Research Database.

Kind regards from the NHSRC Secretariat.

.....
FOR CHAIRMAN, NATIONAL HEALTH SCIENCES RESEARCH COMMITTEE

PROMOTING THE ETHICAL CONDUCT OF RESEARCH
Executive Committee: *Dr.B. Chilima (Chairman), Prof. E. Molynuex (Vice Chairperson)*
Registered with the USA Office for Human Research Protections (OHRP) as an International IRB
(IRB Number IRB00003905 FWA00005976)

Appendix C: Study consent

Study participant's consent form.

Study title: Barriers to the interoperability of eHIS in Malawi.

Name and contact of investigator:

Christopher Kulanga

P.O. Box 30137

Lilongwe

Cell: 0999 119 672/0888 708 574

Email: chriskulanga@gmail.com

NHSRC contacts.

The chairperson

National Health Science Research Committee (NHSRC)

Ministry of Health

P.O. Box 30377

Lilongwe 3

Introduction.

Dear Sir/Madam.

My name is Christopher Kulanga, a student of the University of Malawi studying Master of Science in Informatics. I am currently conducting a study as part of my academic work. My study focuses on Interoperability of eHIS systems with DHIS2. I would like to request for your

participation in the study. You have been selected to participate in the study because of one or more of the following:

1. You are involved in compiling and sending health program reports.
2. You are a regular user of DHIS2.
3. You are a regular user of the patient level eHIS at this hospital
4. You are part of the team that maintains and manages DHIS2.
5. You receive and analyze reports from various health facilities and districts.
6. You are part of the coordination team in HIS at national level.
7. You develop or support one of the eHIS in use in Malawi.

Purpose:

The study looks at the issues surrounding data exchange between other eHIS and DHIS2 in Malawi.

Procedure.

Our interaction will be in a form of an interview which will be guided by a guide developed for this study. Please feel comfortable to give more information relevant to the study. No audio recordings will be taken.

Benefits.

Participation in this study is purely voluntary. Your participation and input in the study will help shape the future of interoperability of eHIS in Malawi there by optimizing the functionalities of eHIS in Malawi and enhancing timely availability of health information leading to better health service delivery.

Risks.

There are no anticipated risks to you in this study.

Privacy and confidentiality.

Please note that your personal details will be captured for the sake of this consent only and will not at any point be disclosed or discussed in the study. All the discussions pertaining this study will be treated with utmost confidentiality and will only be used for the purposes of this study. Your participation in this study is highly recommended and appreciated but voluntary.

Should you chose to participate in the study and have questions, worries, fears or reservations along the way, please do let me know and we will together address them.

Study approval.

The study has been approved by the National Health Sciences Research Committee (NHSRC) and can be contacted on the address provided above.

Consent and signature.

Do you agree to participate in the study? Yes _____ No_____

I have read and understand the consent and the context of the study and agree to participate. I understand that my participation in the study is voluntary and that by participating in the study, I am not giving up any of my rights as a study participant.

Name: _____ Position/role: _____

Signature: _____ Date: _____

Study sites: Dedza DHO, Dowa DHO, Ntchisi DHO, CMED (Lilongwe), Baobab health system officers (Lilongwe).

Appendix D: Interview guides

Barriers to the interoperability of eHIS in Malawi.

1. District HMIS officers and program coordinators interview guide

1. Do you have eHIS in place at your institution?

   _____

2. If yes, which one and in which specific areas is it in use?
   a. System name:_____
   b. Areas in use:
      i. _____
      ii. _____
3. Do you get the electronic reports from these systems?

   _____

4. If yes what reports do you get?
   a. _____
   b. _____
5. Do these reports match the reporting forms that you have to compile and report to central level?

   _____

   __

6. If yes, is it an exact match or a partial match?

   _____

7. How would you quantify the partial match?
   a. Less than half
   b. Half
   c. Between half and ¾
   d. Above ¾

e. 100% match

8. Have you been trained to use DHIS2?

_____

9. Do you use DHIS2 for reporting?

_____

10. If yes, how often?

_____

11. Which reports do you report using DHIS2?

a. _____

when:_____

b. _____

when: _____

12. What challenges do you encounter sending reports using DHIS2?

a. _____

b. _____

13. If you have eHIS, do these systems or part of them exchange data with DHIS2?

_____

14. If not, what do you think are the reasons?

a. _____

_

b. _____

15. Do you feel it would help if these two systems were able to exchange data/information?

_____

16. What do you think would be the benefits?

a. _____

b. _____

17. How else do you use DHIS2?

    _____

18. Apart from the HMIS officer, who else is trained in DHIS2?

    _____

19. How much technical support do you get in using:

    a. eHIS at your institution?

       _____

    b. DHIS2?

       _____

20. Are you aware of any eHIS standards that the eHIS system used here complies to?

    _____

21. What would you like to see change in the current way of compiling and submitting reports?

    _____

2. CMED coordination Officers Interview guide

Barriers to the interoperability of eHIS in Malawi.

Section 1. HMIS reports.

1. What are the core health services reports from health facilities?

    a. _____

    b. _____

2. Who compiles these reports?

    a. _____

    b. _____

3. How do these reports get to the district and the central level?

   _____

4. How often do these reports have to be submitted?

   a. _____

   b. _____

5. What is the current level of reporting for HMIS-15 per district?

   _____

6. What are some of the challenges encountered in compiling and submitting reports?

   a. Compiling:

      i. _____

      ii. _____

   b. Submitting:

      i. _____

      ii. _____

7. What are some of the suggested solutions to the challenges raised above:

   a. Compiling:

      i. _____

      ii. _____

   b. Submitting:

      i. _____

      ii. _____

Section 2. Electronic HMIS/eHIS.

1. What are some of the eHIS solutions implemented and known by Ministry of Health?
    a. _____ place: _____

       Implementer:_____

    b. _____ place: _____

       Implementer:_____

2. Does CMED have a landscape or mapping of eHIS in the districts?

   _____

3. What reports do these systems produce?
    a. _____ Report: _____
    b. _____ Report: _____

4. Are these reports directly fed into DHIS2?

   Yes/No

5. If yes, which reports are directly fed into DHIS2?
    a. _____
    b. _____

6. Does Malawi have a well-defined data dictionary to reference in the implementation of eHIS?

   _____

7. Does Malawi have a well-defined data set for Health to guide the implementation of eHIS services?

_____

__

8. Does Malawi have a defined core (minimum) set of indicators for core reporting in DHIS2?

_____

9. Does Malawi have a strategy or policy to guide the implementation of eHIS?

_____

   a. If Yes, over which period does the strategy span?

10. What are the major themes of the eHIS strategy?

_____

11. Which of those themes have already been achieved?

_____

12. Does the strategy or any reinforcement document specify the minimum software and hardware minimum requirements for a system to be rolled out?

_____

13. Are there specific minimum software and hardware requirements for an eHIS system?

_____

14. If yes, what are the minimum requirements and eHIS system must satisfy to be rolled out?

    a._____

    b._____

15. How does Ministry of Health enforce the eHIS strategy or policy?

_____

_

16. Is it the Ministry of Health's responsibility to coordinate the deployment of eHIS in Malawi?

_____

a. If yes, how well coordinated are the eHIS in Malawi?

_____

17. What are some of the challenges faced in coordinating eHIS in Malawi?

    a. _____

    b. _____

18. What measures have been taken to deal with these challenges?

    a. _____

    b. _____

Section 3. eHIS interoperability

1. What's the big picture in eHIS interoperability with DHIS2 in Malawi?

   _____

2. Is there a road map or policy to ensure eHIS interoperability with DHIS2?

   _____

3. If there is a road map, does the roadmap have legal framework to ensure security, privacy and confidentiality of patient data?

   _____

4. What steps is government taking in ensuring interoperability of eHIS with DHIS2?

   _____

5. Are there deliberate efforts/mechanisms to ensure eHIS interoperability adherence by stakeholders?

   _____

6. Do stakeholders in eHIS have the adequate workforce to ensure eHIS interoperability?

   _____

7. What are the challenges to eHIS interoperability from the Ministry of Health Point of view?

   a. _____

b. _____

8. What are the opportunities available to ensure eHIS interoperability with DHIS2?
    a. _____
    b. _____

9. Do public universities or other institutions offer opportunities for eHIS solutions including eHIS interoperability?

    _____

10. If yes, are there gaps in the services provided in such institutions as related to the subject of eHIS interoperability?

    _____

11. Is there collaboration between such tertiary providers and government and other eHIS stakeholders on the tertiary services provided?

    _____

19. Does Malawi have the necessary infrastructure for eHIS interoperability?
    c. Computers:

        _____

    d. Computer networks:

        _____

    e. Internet:

        _____

    f. Electricity/power:

        _____

20. Any information you would like to share relating to HMIS interoperability with DHIS2?

_____

Section 4. eHIS standards

1. Does Malawi have membership and participation to any health standards development organization?
    a. If yes, which ones?
        i. _____
    b. If not, what are the barriers to achieving this?
        i. _____
        ii. _____
2. What eHIS standards has Malawi adopted and used in eHIS solutions?
    a. _____
3. Do other eHIS stakeholders/institutions also use these adopted standards?

    _____

4. Does Malawi have a regulatory unit to check the use of standards in eHIS?

    _____

5. Does Malawi have policies for eHIS standards adoption?

    _____

6. Does Malawi have personnel with enough skills in eHIS standards development and implementation?

    _____

3. DHIS2 developers' interview guide.

Barriers to the interoperability of eHIS in Malawi.

DHIS2 developers' interview guide

1. Briefly describe your role in DHIS2?

    _____

2. Describe the reporting capabilities of DHIS2?

   _____

3. What are the core reports fed into DHIS2 from facilities or district?

   a. _____

   b. _____

4. How do these reports get into DHIS2?

   _____

5. What are the core reports that DHIS2 produces?

   _____

   What are the data elements expected of a system into DHIS2?

   _____

   What are the indicators to be reported on into DHIS2 from health facilities?

   _____

6. Does DHIS2 conform to any eHIS standards?

   _____

7. If yes, which ones?

   _____

8. How long have these standards been adopted by DHIS2?

   _____

9. What data transfer protocols exist in DHIS2?

   _____

10. Do other eHIS transfer data directly into DHIS2?

    _____

11. What are the organizational challenges to data exchange between these systems?

    a. _____

    b. _____

12. What are the technical challenges to the data transfer between these systems?
    a. _____
    b. _____
13. What organizational challenges have a direct influence on the technical challenges?
    a. _____
    b. _____
14. What do you think are the solutions to some of these challenges?
    a. _____
    b. _____
15. Are there any changes that need to be made to facilitate data exchange between DHIS2 and other eHIS?
    a. _____
    b. _____
16. What steps do other eHIS providers have to take to achieve interoperability with DHIS2?
    a. _____
    b. _____
17. Does Ministry of Health need to do anything to ensure eHIS interoperability of other HMIS systems with DHIS2?
    a. _____
    b. _____
18. What are the perceived opportunities to HMIS interoperability with DHIS2?
    a. _____
19. Any information you may want to share in relation to HMIS interoperability with DHIS2?

    _____

4. eHIS developers interview guide

Barriers to the interoperability of HMIS systems: A case of Baobab Health system and DHIS2.

Baobab Health system developers'/Systems admin interview guide

1. Briefly describe your role in Baobab Health system?

   _____

2. Describe the reporting capabilities of Baobab Health system?

   _____

3. What are the core reports that Baobab Health system produces?

   _____

4. What are the data elements embedded in Baobab Health system?

   _____

5. What indicators are reported from Baobab Health system?

   _____

6. Does Baobab Health system conform to any eHIS standards?

   _____

7. If yes, which ones?

   _____

8. How long have these standards been adopted by Baobab Health system?

   _____

9. What data transfer protocols exist in Baobab Health system?

   _____

10. How much similarity is there between the data exchange protocols for Baobab Health system and DHIS2?

    a. Less than half

    b. Half

c. Between half and ¾

d. Over ¾

e. 100%

11. Does Baobab Health system have the data elements expected by DHIS2?

_____

12. If yes, which data elements?

a. _____

b. _____

c. _____

13. To what extent are these data elements in Baobab Health system similar to those expected by DHIS2?

a. Less than half

b. Half

c. Between half and ¾

d. Over ¾

e. 100%

14. What are some of the core indicators reported by Baobab Health system?

a. _____

b. _____

15. What indicators calculated by Baobab Health system are also expected in DHIS2?

a. _____

b. _____

16. To what extent are these indicators in Baobab Health system similar to those expected by DHIS2?

a. Less than half

b. Half

c. Between half and ¾

d. Over ¾

e. 100%

17. Does Baobab Health system exchange data with DHIS2?

    _____

18. If yes, which specific reports/data is transferred from Baobab Health system into DHIS2?

    a. _____

    b. _____

19. What are the organizational challenges to data exchange between Baobab Health system?

    a. _____

    b. _____

20. What are the technical challenges to the data transfer between Baobab Health system and DHIS2?

    a. _____

    b. _____

21. What organizational challenges have a direct influence on the technical challenges?

    a. _____

    b. _____

22. What do you think are the solutions to some of these challenges?

    a. _____

    b. _____

23. Are there any changes that need to be made to facilitate data exchange between Baobab Health system and DHIS2?

    _____

24. What steps does Baobab Health system have to take to achieve interoperability with DHIS2?
    a. _____
    b. _____
25. Does Ministry of Health need to do anything to ensure eHIS interoperability of Baobab Health system systems with DHIS2?
    a. _____
    b. _____
26. What are the opportunities (perceived or existing) to Baobab Health system interoperability with DHIS2?
    a. _____
    b. _____
27. Any information you may want to share in relation to Baobab Health system interoperability with DHIS2?

    _____

Appendix E: Sample reporting forms used in the study.

1. HMIS-15 from DHIS2.

Maternal services	
39	Number of pregnant women starting antenatal care during their first trimester
40	Total number of new antenatal attendees
40	Total antenatal visits
41	Number of deliveries attended by skilled health personnel
42	Number of women obstetric complications treated at obstretric care facility
43	Number of caesarean sections
44	Total number of live births
44	Number of babies born with weight less than 2500g
45	Number of abortion complications treated
46	Number of eclampsia cases treated
47	Number of postpartum haemorrhage (PPH) cases treated
48	Number of sepsis cases treated
49	Number of pregnant women treated for severe anaemia
51	Number of newborn treated for complications
52	Number of postpartum care within 2 weeks of delivery
Family Planning	
53a	Number of persons reciving 3 months supply of condoms
b	Number of persons recieving 3 months of oral pills
c	Number of persons recieving Depo-Provera
d	Number of persons recieving Norplant
e	Number of persons recieving IUCD
f	Number of persons recieving sterilisation method of FP
Child Health	
55	Number of fully immunised under 1 children

56	Number of under 1 children given BCG
56	Number of under 1 children given pentavalent – III
56	Number of under 1 children given polio – III
56	Number of under 1 children given measles 1st doses at 9M
57	Number of Vitamin A doses given to 6 - 59 M population
62	Number of under-weight in under fives attending clinic
Attendance	
30	Num of 15 - 49 years recieving volunteer & confidential testing and serostatus
31	Number of 15 - 49 age group tested HIV positive
32	Number of HIV positive persons recieving ARV treatment
34	Number of pregnant women recieving VCT and serostatus results
35	Number of pregnant women tested HIV positive
36	Number of HIV positive women treated for PMTCT
62	Total number of children attending under - five clinic
108	Number of OPD attendance
Tuberculosis	
65	Number of confirmed TB new cases
66	Num of smear negative and extra-pulmonary cases completed treatment
67	Num of new smear sputum positive cases proved smear -ve at the end of treatment
Supplies	
23	Was there any stock outs of SP for more than a week at a time?
23	Was there any stock outs of ORS for more than a week at a time?
23	Was there any stock outs of contrimaxazole for more than a week at a time?
23	Was there any stock outs of SP , ORS and Contrimaxazole for more than a week?
24	Number of functioning ambulances
76	Number of insecticide treated nets distributed
Community Health Activities	
25	Number of households with access to safe drinking water
26	Number of households atleast a sanplat latrine

38	Num of HBC patents follow-up and provided treatment
Physical Facilities	
17	Do you have functioning water supply systems??
17	Do you have functioning Communication systems??
17	Do you have functioning Electricity??
17	Do you have functioning water supply,Electricity and Communication systems??
Management and Supervision	
13	Is the health center committee functional?
15	Were you supervised by DHMT members using the intergrated supervision checklist?
New Cases (OPD plus inpatient)	
27	Sexually transmitted infections-new cases
29	Syphilis in pregnancy
31	HIV confirmed positive (15-19 years) new cases
37	Opportunistic infection - new cases
58	Acute respiratory infections - new cases (U5)
60	Diarrhoea non - bloody -new cases (under5)
64	Malnutrition - nwe case (under 5)
69	Malaria - new cases (under 5)
70	Malaria - new cases (5 & over)
78	Neonatal tetanus - confirmed new cases
79	Cholera - confirmed new cases
81	Measles - confirmed new cases
82	Acute Flaccid paralysis -confirmed new cases
83	Ebola - confirmed new cases
84	Meningococal meningitis - confimed new cases
85	Plague - confirmed new cases
86	Rabies - confirmed new cases
87	Yellow fever - confirmed new cases
88	Dysentery - new cases

90	Eye infections - new cases
91	Ear infections - new cases
92	Skin infections - new cases
93	Oral conditions
94	Schistosomiasis - new cases
95	Leprosy - new cases
96	Common injuries and woulds (except RTA)
98	Number of road traffic accidents
Admissions	
20a	Bed capacity
b	Total number of admissions (includin maternity)
c	Total number of discharges
d	Total inpatient days
Inpatient Deaths (Including Maternity)	
102	Total number of inpatient deaths from all causes (excluding maternity)
50	Number of direct obstetric deaths in facility
59	Acute respiratory infections - inpatient deaths (U5)
61	Diarrhoea non -bloody (under 5) - inpatient deaths
64	Malnutrition - inpatient deaths (under 5)
68	TB - inpatient deaths
69	Malaria - inpatient deaths under 5
74	Malaria - inpatient deaths (5 & over)
80	Cholera - inpatients deaths
89	Dysentery- inpatients deaths
98	No . of road traffic accidents - inpatient deaths

2. HMIS-15 from Afyapro system (was taken as an alternative system to Baobab since HMIS-15 was not available in the Baobab health system).

Fiscal Year: **HMIS - 15**

Health Management Information

To

Monthly Report

Facility Code:

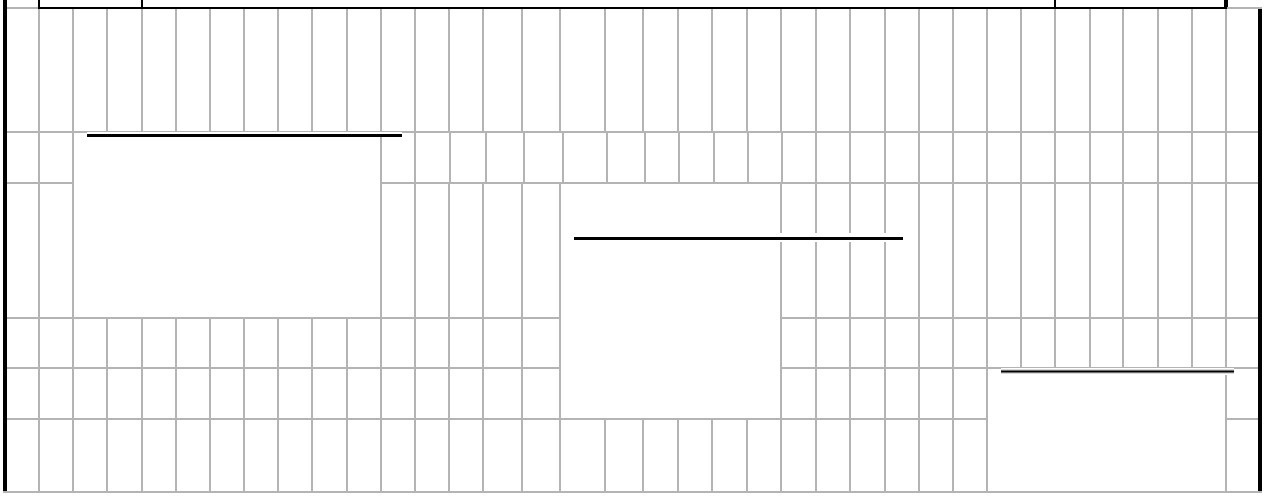
Indic. No	Data Element (DE)	Month
39	Number of pregnant women starting antenatal care during their first trimester	
40	Total number of new antenatal attendances	
40	Total antenatal visits	
41	Number of deliveries attended by skilled health personnel	
42	Number of women with obstetric complications treated at obstetric care facility	
43	Number of caesarean sections	
44	Total number of live births	
44	Number of babies born with weight less than 2500g	
45	Number of abortion complications treated	
46	Number of eclampsia cases treated	
47	Number of postpartum haemorrhage (PPH) cases	
48	Number of sepsis cases treated	
49	Number of pregnant women treated for severe anaemia	
51	Number of new born treated for complications	
52	Number of postpartum care within 2 weeks of delivery	
Family Planning		
53 a	Number of persons receiving three months supply of condoms	

	B	Number of persons receiving three months supply of oral pills	
	C	Number of persons receiving Depo-provera	
	D	Number of persons receiving Norplan	
	E	Number of persons receiving IUCD	
	F	Number of persons receiving sterilization method of FP	
	Child Health		
	55	Number of full immunized uder 1 children	
	56	Number of under one children given BCG	
	56	Number of under one children given pentavalent -III	
	56	Number of under one children given polio - III	
	56	Number of under one children given measles first doses at 9 months	
	57	Number of vitamin A doses given to 6 - 59 months population	
	62	Number of under-weights in under-fives attending clinic	
	Attendance		
	30	Number of 15-49 years receiving volunteer and confidential testsing and serostatus result	
	31	Number of 15-49 age group tested HIV Positive	
	32	Number of HIV positive persons receiving ARV treatment	
	34	Number of pregnant women receiving VCT and serostatus result	
	35	Number of pregnant women tested HIV positive	
	36	Number of HIV positive women treated for PMCT	
	62	Total number of children attending under-five clinic	
	103	Number of OPD attendance	
	Tuberculosis		
	65	Number of confirmed TB new cases	
	66	Number of smear negative and extra-pulmonary cases completed treatment	
	67	Number of new sputum positive cases proved smear nagative at the end of treatment	
	Supplies		
	23	Was there any stock outs of SP for more than a week at a time? (Y/N)	
	23	Was there any stock outs of ORS for more than a week at a time (Y/N)	
	23	Was there any stock outs of contrimoxazole or more a week at a time (Y/N)	
	23	Was there any stock outs of SP, ORS contrimoxazolen for more than a week at a time? (Y/N)	
	24	Number of functioning ambulances	

	76	Number of insecticide treated nets distributed	
	Community Health Activities		
	25	Number of households with access to safe drinking water	
	26	Number of households with at least a sanplat latrine	
	38	Number of HBC patients followed-up and provided treatment	
	Human Resources Currently at work		
		Clinical officer	
		Doctors	
		Dental surgeon	
		Dermatologist	
		Medical Officer	
		Obstetric/Gynacologist	
		Ophthalmologist	
		Paediatrician	
		Pathologist	
		Physician	
		Surgeon	
		Environment Health Officer	
		Health Surveilance Assistant	
		Medical Assistant	
		Nurses	
		Registered	
		Enrolled/Midwife	
		Community	
		Pharmacist	
		Physiotherapist	
		Radiologist	
		Technicians	
		Laboratory	
		Pharmacy	
		Radiography	
		All other positions	

		Total personnel currently at work	
	Finance		
	56	Total income from cost sharing	
	Physical facilities		
	17	Do you have functioning water supply system? (Y/N)	
	17	Do you have functioning electricity (Y/N)	
	17	Do you have functioning communication system (Y/N)	
	17	Do you have functioning water supply, electricity and communication system (Y/N)	
	Management and Supervision		
	13	Is the health centre committee functioning? (Y/N)	
	15	Were you supervised by DHMT members using the integrated supervision checklist	
	New case (OPD plus Inpatient)		
	27	Sexually transmitted infections - new cases	
	29	Syphillis in pregnancy	
	31	HIV confirmed positive (15 - 49 years) new cases	
	37	Opportunistic infections - new cases	
	58	Acute respiratory infections - new cases (under 5)	
	60	Diarrhoea non-bloody - new cases (under 50	
	64	Malnutrition - new vases (under 5)	
	69	Malaria - new cases (under 5)	
	70	Malaria - new cases (5 & over)	
	78	Neonatal tetanus - confirmed new cases	
	79	Cholera - confirmed new cases	
	81	Measles - confirmed new cases	
	82	Accute flaccid paralysis - confirmed new cases	
	83	Ebola - confirmed new cases	
	84	Meningococal meningitis - confirmed new cases	
	85	Plague - confirmed new cases	
	86	Rabies - confirmed new cases	
	87	Yellow fever - confirmed new cases	
	88	Dysentery - new cases	
	90	Eye infection - new cases	

91	Ear infection - new cases	
92	Skin infections - new cases	
93	Oral conditions (including dental decay) - new cases	
94	Schistosomiasis - new cases	
95	Leprosy - new cases	
96	Common injuries and wounds (except RTA)	
98	Number of road traffc accidents	
Admissions		
20a	Bed capacity	
B	Total number of admissions (including maternity)	
C	Total number of discharges	
D	Total inpatient days	
Inpatient Deaths (Including maternity deaths)		
102	Total number of inpatient deaths from all causes (excluding maternity)	
50	Number of direct obstetric deaths in the facility	
59	Acute respiratory infections - inpatient deaths (under 5)	
61	Diarrhoea non-bloody (under 5) inpatient deaths	
64	Malnutrition - inpatient deaths (under 5)	
68	TB - inpatient deaths	
69	Malaria - inpatient deaths (under 5)	
74	Malaria - inpatient deaths (5 and over)	
80	Cholera - inpatient deaths	
89	Dysentery - inpatient deaths	
98	Number of road traffic accidents - inpatient deaths	



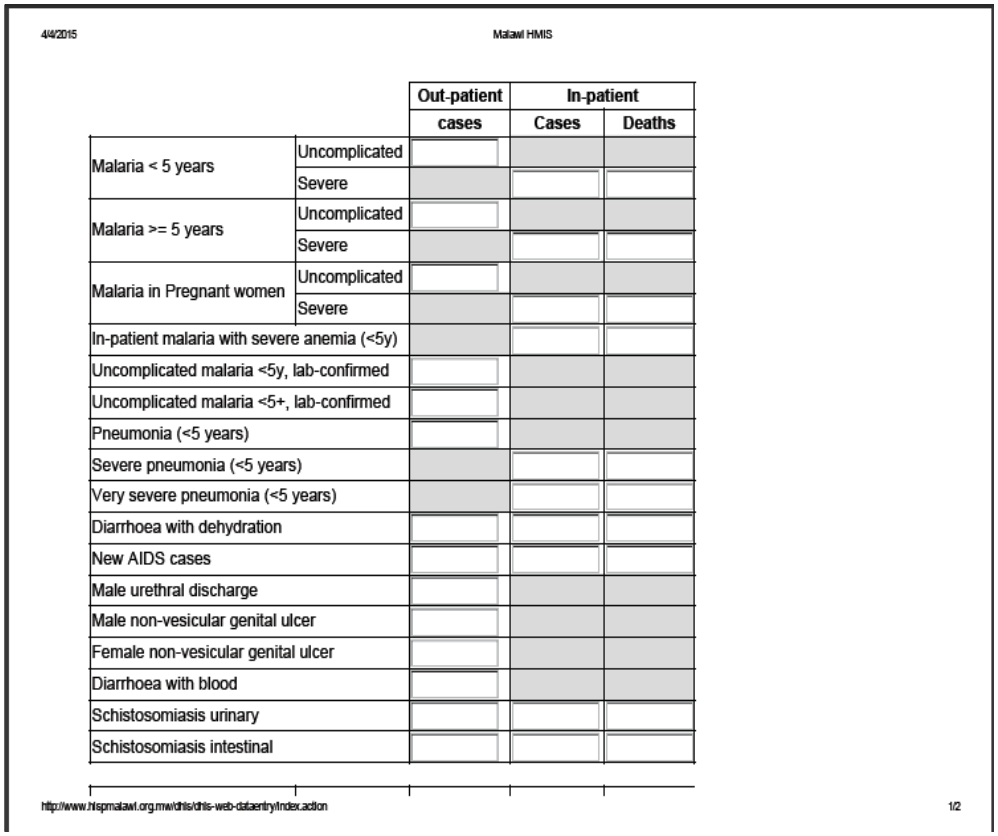
Report prepared by	Signature	Date
Report verified by	Signature	Date
Report approved by	Signature	Date

Instructions: 1. HMIS - 15 has to be completed before transcribing data onto this form

2. Management team has to analyse data and provide feedback to its staff before sending report to DHO

3. This monthly report is due on 5th of each month

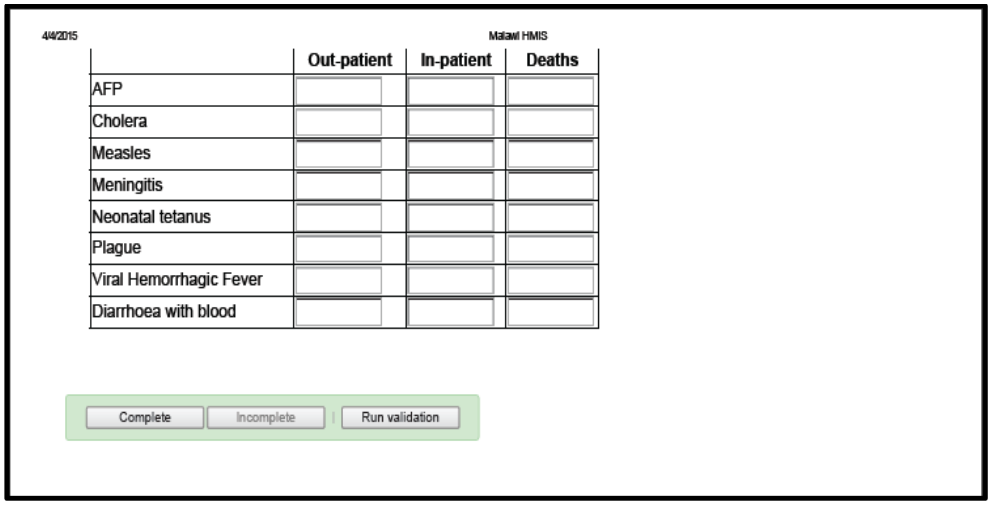
3. IDSR from DHIS2



4/4/2015 Malawi HMIS

		Out-patient cases	In-patient Cases	In-patient Deaths
Malaria < 5 years	Uncomplicated			
	Severe			
Malaria >= 5 years	Uncomplicated			
	Severe			
Malaria in Pregnant women	Uncomplicated			
	Severe			
In-patient malaria with severe anemia (<5y)				
Uncomplicated malaria <5y, lab-confirmed				
Uncomplicated malaria <5+, lab-confirmed				
Pneumonia (<5 years)				
Severe pneumonia (<5 years)				
Very severe pneumonia (<5 years)				
Diarrhoea with dehydration				
New AIDS cases				
Male urethral discharge				
Male non-vesicular genital ulcer				
Female non-vesicular genital ulcer				
Diarrhoea with blood				
Schistosomiasis urinary				
Schistosomiasis intestinal				

http://www.hispmalawi.org.mw/dhis/dhis-web-dataentry/index.action 1/2

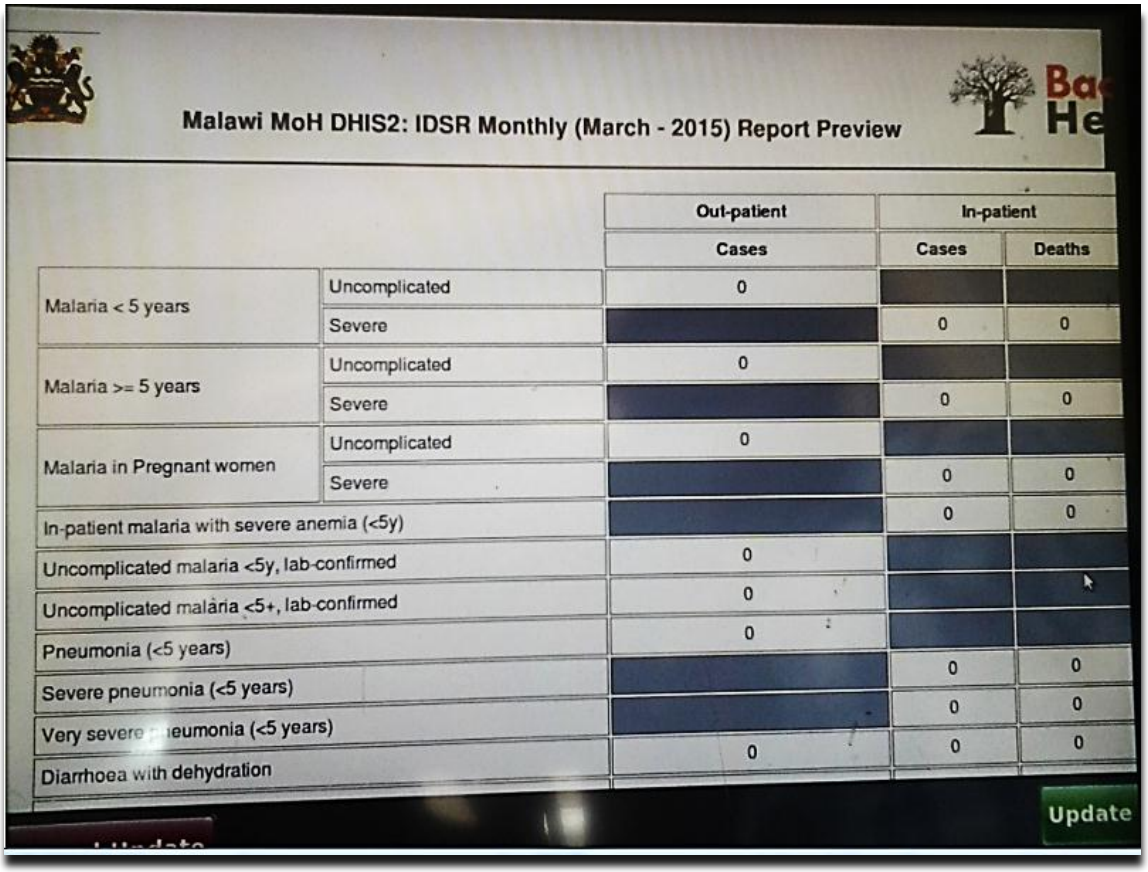


4/4/2015 Malawi HMIS

	Out-patient	In-patient	Deaths
AFP			
Cholera			
Measles			
Meningitis			
Neonatal tetanus			
Plague			
Viral Hemorrhagic Fever			
Diarrhoea with blood			

Complete | Incomplete | Run validation

4. IDSR from Baobab health system

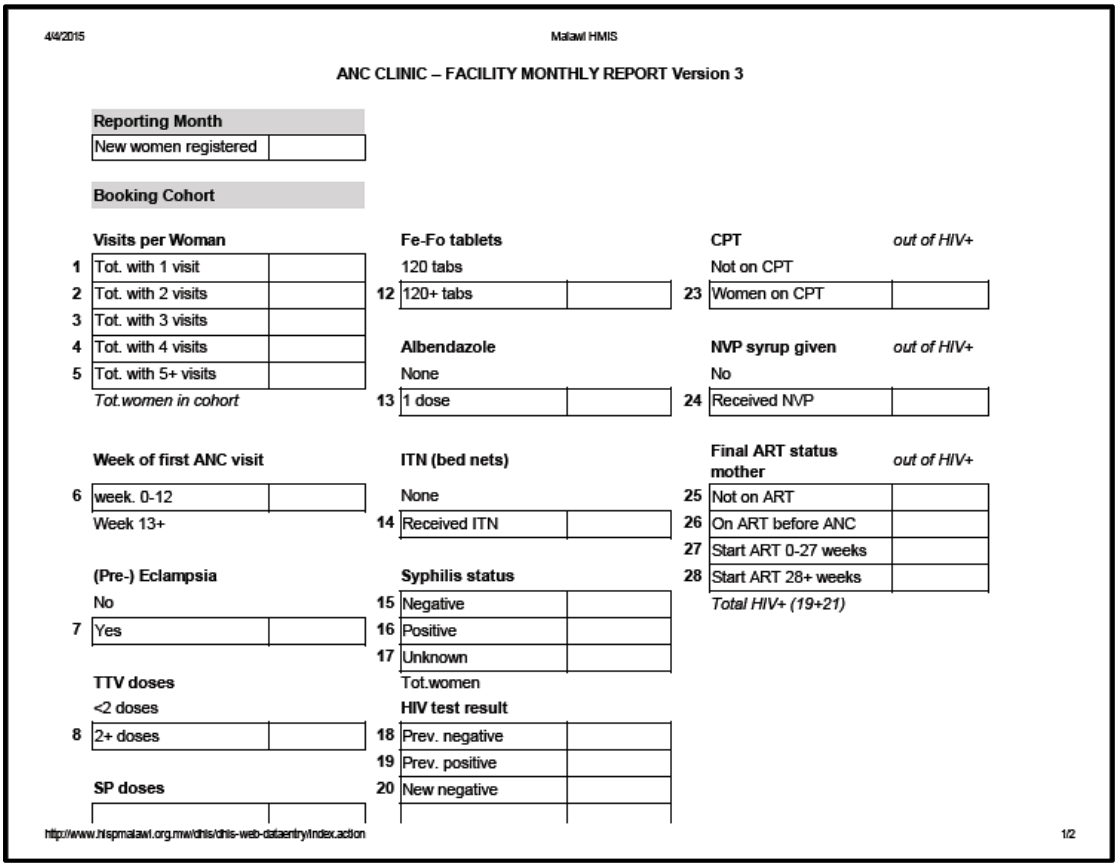


Malawi MoH DHIS2: IDSR Monthly (March - 2015) Report Preview

		Out-patient	In-patient	
		Cases	Cases	Deaths
Malaria < 5 years	Uncomplicated	0		
	Severe		0	0
Malaria >= 5 years	Uncomplicated	0		
	Severe		0	0
Malaria in Pregnant women	Uncomplicated	0		
	Severe		0	0
In-patient malaria with severe anemia (<5y)			0	0
Uncomplicated malaria <5y, lab-confirmed		0		
Uncomplicated malaria <5+, lab-confirmed		0		
Pneumonia (<5 years)		0		
Severe pneumonia (<5 years)			0	0
Very severe pneumonia (<5 years)			0	0
Diarrhoea with dehydration		0	0	0

Update

5. ANC report from DHIS2



4/4/2015 Malawi HMIS

ANC CLINIC – FACILITY MONTHLY REPORT Version 3

Reporting Month	
New women registered	

Booking Cohort

	Visits per Woman	
1	Tot. with 1 visit	
2	Tot. with 2 visits	
3	Tot. with 3 visits	
4	Tot. with 4 visits	
5	Tot. with 5+ visits	
	Tot.women in cohort	

	Week of first ANC visit	
6	week. 0-12	
	Week 13+	

	(Pre-) Eclampsia	
	No	
7	Yes	

	TTV doses	
	<2 doses	
8	2+ doses	

	SP doses	

	Fe-Fo tablets		out of HIV+
	120 tabs		
12	120+ tabs		

	Albendazole		out of HIV+
	None		
13	1 dose		

	ITN (bed nets)		out of HIV+
	None		
14	Received ITN		

	Syphilis status		out of HIV+
15	Negative		
16	Positive		
17	Unknown		
	Tot.women		

	HIV test result		out of HIV+
18	Prev. negative		
19	Prev. positive		
20	New negative		
21	New positive		
22	Not done		
	Tot.women		
	Total HIV+ (19+21)		

	CPT	out of HIV+
	Not on CPT	
23	Women on CPT	

	NVP syrup given	out of HIV+
	No	
24	Received NVP	

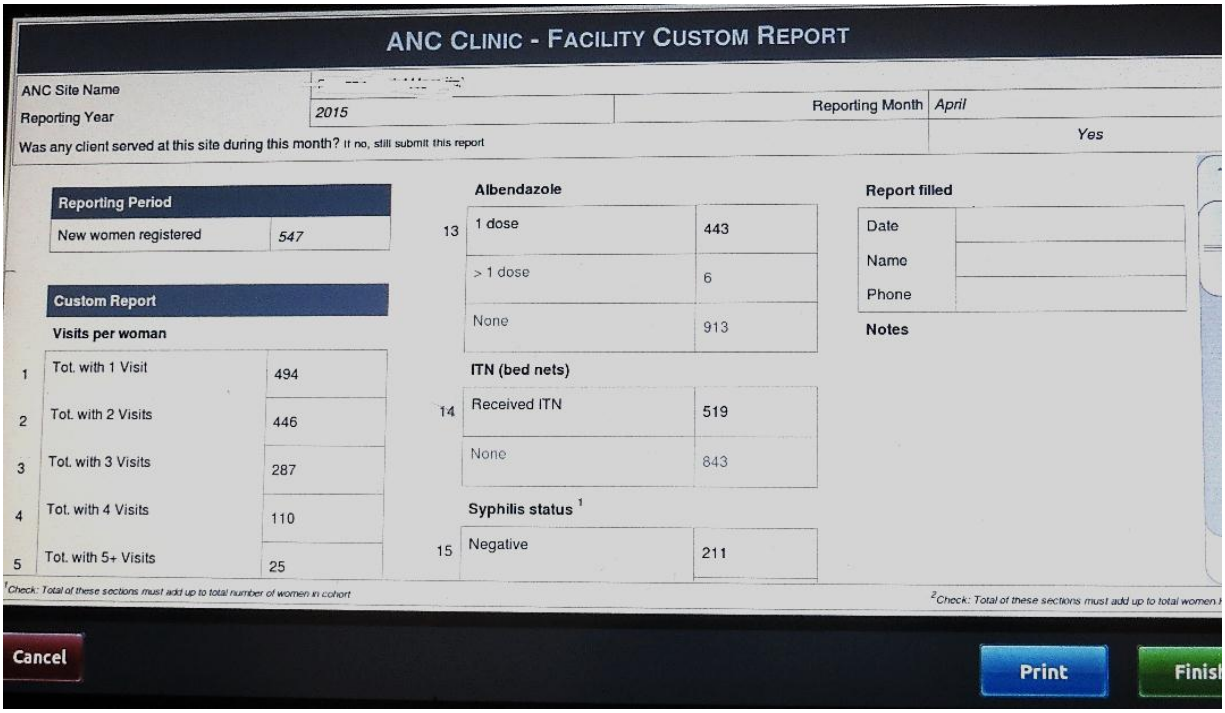
	Final ART status mother	out of HIV+
25	Not on ART	
26	On ART before ANC	
27	Start ART 0-27 weeks	
28	Start ART 28+ weeks	
	Total HIV+ (19+21)	

Complete | Incomplete | Run validation

Completed by: lysonmasuko at: 2015-02-20 See details

http://www.hispmalawi.org.mw/dhis/dhis-web-dataentry/index.action 1/2

6. ANC report from Baobab Health System



ANC CLINIC - FACILITY CUSTOM REPORT

ANC Site Name

Reporting Year: 2015 | Reporting Month: April

Was any client served at this site during this month? If no, still submit this report: Yes

Reporting Period

New women registered	547

Custom Report

Visits per woman

1	Tot. with 1 Visit	494
2	Tot. with 2 Visits	446
3	Tot. with 3 Visits	287
4	Tot. with 4 Visits	110
5	Tot. with 5+ Visits	25

[1] Check: Total of these sections must add up to total number of women in cohort

Albendazole

13	1 dose	443
	> 1 dose	6
	None	913

ITN (bed nets)

14	Received ITN	519
	None	843

Syphilis status [1]

15	Negative	211

[2] Check: Total of these sections must add up to total women

Report filled

Date	
Name	
Phone	

Notes

Cancel | Print | Finish