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Strengthening health systems through eHealth: Two mixed-methods case studies at 10 facilities in Malawi

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Declaration

This thesis represents my original work and has not been submitted for any other degree or professional qualification.

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Executive Summary

Background

International agencies such as the World Health Organisation have highlighted the potential of digital information and communications technologies to strengthen *health systems*, which are underpinned by the 'building blocks' of information, human resources, finances, commodities, leadership and governance, and service delivery. In high income countries, evidence of the positive impacts of 'eHealth' innovations on the cost-effectiveness of healthcare is growing and many governments are now providing incentives for their adoption. In contrast, the use of eHealth in developing countries has remained low and efforts to introduce these new approaches have experienced high failure rates. There is even scepticism regarding the feasibility of eHealth in low-resource settings, which may be hindered by high costs, indeterminate returns on investment, technical problems and socio-organisational barriers.

More research is needed to document both the *value* of eHealth for strengthening resource-limited health systems and the *challenges* involved in their implementation and adoption, so that insights from such research may be used to inform future initiatives. While many studies of eHealth for patient care in low- and middle-income countries (LMIC) are taking place, evidence of its role in improving administrative processes such as financial management is lacking, despite the importance of 'good governance' (transparency and accountability) for ensuring strong and resilient health systems.

The overall objective of this PhD was to elucidate the enablers, inhibitors and outcomes characterising the implementation and adoption of a modular eHealth system in a group of healthcare facilities in rural Malawi. The system included both clinical and billing modules. The specific objectives were (i) to understand the socio-technical, organisational and change management factors facilitating or hindering the implementation and adoption of the eHealth system, (ii) to assess the quality of data captured by the eHealth system compared with conventional paper-based records, and (iii) to understand how information within the eHealth system was used for service delivery, reporting and

financial management. A further aim was to contribute to the corpus of mixed-methods case studies exploring eHealth system implementation processes and outcomes (including data quality) in LMIC. As described in the following chapters, the research also gave rise to unanticipated and serendipitous findings, which led to new lines of enquiry and influenced the theoretical perspectives from which the analysis drew.

Methods

Mixed-methods case study was used for the research, taking a 'soft-positivist' approach to analysis, which encompasses both inductive and deductive forms of enquiry. Two case studies were undertaken in rural Malawi: one at a 300-bed fee-for-service hospital, and the other at nine primary care health centres that surround the hospital. At the outset of the research, the 'logic model' underpinning the eHealth system implementation programme was mapped, based on formative scoping to articulate the goals and intentions of those commissioning and supplying the eHealth system, along with literature-informed theory. This provided a framework against which to evaluate the processes and outcomes of eHealth system implementation at the ten facilities.

For the hospital case study (Case Study 1), a *retrospective* single-case embedded design was employed, with outpatient and inpatient departments being the two units of analysis. Qualitative data included document review and in-depth key informant interviews, while quantitative data was obtained from the web-based District Health Information System (DHIS2), patient files and the hospital's finance records. For the study of primary health centres (Case Study 2), a single-case embedded design was also used, with the rollout project as the case and the three units of analysis being 3 Early Adopter Facilities, 4 Late Majority facilities and 2 Laggard facilities. This case study used a *prospective* design, with data being collected 7 months and 24 months after implementation of the eHealth system due to a mismatch between the independent eHealth implementation project and the PhD research. Data sources included documentation screened against the criteria listed in the Performance of Routine Information System Management (PRISM) tools, information extracted from the eHealth system, health indicators drawn from DHIS2 and qualitative data from focus group discussions. In both case studies, framework analysis was used for

qualitative data, while quantitative data was analysed by calculating data completeness, accuracy and agreement. Descriptive statistics and the Mann-Whitney U-test were used for analysing finance data in Case Study 1. Content analysis was also used to gain insights from Case Study 2.

Results

Based on the initial logic model, staff-, service delivery- and management-level outcomes were moderated through the organisational change management and socio-technical factors described below.

Key organisational and process factors influencing system implementation

Change management processes: Organisational strategies aimed at facilitating the introduction of the eHealth system included training clinical and clerical staff in the *computer skills* required to use it (see below) and adapting *work processes* to accommodate and optimise adoption. At the three health facilities where the billing module was implemented, the latter included introducing new procedures for providing electronic receipts to clients and service providers. At Madalo Hospital this also involved the creation of a new category of administrative staff with responsibility for managing the appropriate capture, entry and exchange of data using the system. However, such data clerks were only introduced within the inpatient department, whilst already over-burdened clinical staff in the outpatient department were expected to integrate the eHealth system into their existing work routines. Outpatient departments at the health centres resorted to task-shifting patient data entry roles from clinicians to lower-educated allied staff such as janitors and security guards.

Infrastructure and security issues: Organisational enablers were infrastructural and policy interventions aimed at securing equipment and patient data. These included installations of locks and burglar-proof bars, enhanced engagement of security guards and frequent backup of data. An organisational intervention undertaken at the health centres was the introduction of backup batteries and solar power, aimed at providing a continuous

electricity supply. However, problems with battery depletion, frequent connectivity interruptions between the client computers and the server and electricity fluctuations and outages, affected both the efficiency of the batteries and the practical utility of the eHealth system. Highly efficient nano-computing units were later introduced, to reduce electricity demands and improve the consistency of available power for the purposes of using the system.

Socio-technical issues arising during the implementation process

Technical/software problems: There were 24 problems identified with the eHealth system, encompassing its design flaws, security protocols, and hardware and database limitations. For instance, entry of patient data was in multiple windows needing to be minimised, passwords expired with no one at the facilities with rights to issue new passwords, there were frequent disconnections between the client computers and the server, and lists of drugs and indicators for reporting in its database were limited. Although health centre staff used the system for backup storage and retrieval of data, only Early Adopters reported use of the eHealth system's search function.

Socio-technical issues: The technical problems outlined above resulted in a heavy reliance on paper records by the health centres, although centres varied in their attitude towards and persistence with eHealth system implementation, with Early Adopter sites overcoming most challenges. At the hospital, the eHealth system was subjected to such inappropriate use by staff that even establishing rules and an IT centre to regulate usage were ineffective, leading to a system crash in 2012 due to viruses and other malware. Such inappropriate use included staff depleting hospital server space by storing personal files (videos, music, pictures, games), being on Facebook instead of attending to patients, sharing of login credentials and not always logging off their account after use, and removal of cables from the computers.

Leadership: At the hospital, there was strong management support for the eHealth system. In contrast, there were strong opinions from staff at Late Majority and Laggard facilities

about the ineffective engagement of health facility "in-charges". Further, many system champions were senior staff and thus busier and more mobile, most often leaving the junior staff at the health centres, who were not formally trained, to be using the eHealth system.

Training: Limitations in the scope and number of staff formally trained was perceived to be a barrier to eHealth system adoption at the health centres, particularly lack of training in basic troubleshooting and maintenance. Even peer training lacked follow-up formal training. At the hospital, developing an appropriately skilled cadre of system users was hindered by high staff turnover and departmental rotations, which required frequent rounds of basic training. Staff at the hospital and health centres were nevertheless happy about the computer knowledge they had gained as a result of the implementation programme, although most expressed a lack of confidence in using the eHealth system.

Technical support: For reasons including those already outlined, staff requested support for a range of hardware and software problems, not all of which it was possible to fulfil in a timely way, due to lack of sufficient IT personnel. Lack of in-country technical support for the software was also a considerable barrier to progress, particularly for the IT team based at the hospital, requiring requests for changes to be passed to the parent company. In one attempt to address this, the rights to a partial version of the software was passed to a local foundation for onward management, however the software developers were unwilling to release the source code so that further enhancements and customisation could be made. Efforts to recruit more hospital IT workers and reorganising responsibilities were frustrated by high staff turnover among the IT team. As a result, response to calls from health centres for technical support by the IT team was said to be slow and ineffective (except at Late Majority Facilities), and there was no transfer of basic troubleshooting and minor repair skills from the IT team to the health facility staff.

Perceived outcomes: Despite the challenges described above, some tracer outcomes of the eHealth system were detectable from the qualitative and numerical results, relating to data quality, service delivery, reporting and decision-making, and financial management.

Perceived and measured outcomes of eHealth system implementation

Documentation and associated workload: In both case studies, implementation of the eHealth system illuminated the dysfunctional paper-based system, particularly loss of documents. At the health centres (Case Study 2), only Early Adopters reported reduced administrative and patient care workload following eHealth implementation, while the other adopter groups reported increased workload due to dual use of paper and electronic systems, as well as staff shortage and high patient load.

Data quality: Both case studies reported poor data quality in the eHealth system, mainly due to the dual use of the paper-based and electronic systems, and staff defaulting to using the paper-based system only. This was aggravated by infrastructure and leadership problems at the health centres. Across the health centres, completeness of outpatient registration data in the eHealth system was 82.4%, as compared to DHIS2 (100.0% for Early Adopters, 73.9% for Late Majority), equivalent to an average monthly omission of 1,271 clients. When compared to DHIS2 data at Madalo Hospital, outpatient registration data in the eHealth system was 76.0% complete, under-reporting by an average 577 clients per month. Compared with the hospital's paper-based records, inpatient registration and diagnosis data in the eHealth system, as entered by ward clerks, was 93.6% complete and 68.9% accurate.

Service delivery (efficiency and patient experience): At Madalo Hospital, the eHealth system was reported to have made retrieval of patients' paper files faster, as the implementation project had also led to changes in the hospital's filing system. This new filing system also facilitated retrieval of data for patients with lost paper records, and allowed linking of patients' outpatient and inpatient records. Reported service delivery improvements at the health centres included enhanced ability for tracing patients, treatment continuity, identifying the correct patient, ensuring patient confidentiality, keeping health workers alert and available, following clinical protocols, identifying the need to change prescription for (or refer) a recurrent patient, and reportedly showing the patient that the

provider was paying attention. Improvements in patient experience were perceived to be through avoiding the need for patient details to be re-entered at subsequent visits, better management of queues, and patients feeling more understood by the service provider and having more confidence in the services. Perceived negative patient experiences were associated with staff members' slow typing skills and unfamiliarity with the eHealth system, dual entry of patient information into both the electronic and paper systems, extra steps added to the patient journey through the care process, and disrupted patient-provider interaction.

Efficiency of reporting: After its implementation at the hospital site, the eHealth system had become routinely used to generate data for measuring quality of care, and partly for national reporting purposes (HMIS). Customised reports for the hospital were created and used for decisions such as allocation of wards, advocacy and funding applications. In contrast, all the primary healthcare facilities were still using paper registers to compile HMIS reports, a few in combination with the eHealth system, because of lack of knowledge of the reporting module, poor design of the system's reports, and disruptions in electricity and network connections to the server.

Management of finances: Financial management was reported to have improved at Madalo Hospital due to better-quality data capture and tracking of service charges, separation of billing and receiving roles by recruiting ward clerks, enhanced oversight by management, and fraud prevention through greater transparency and accountability. Although median monthly revenue was significantly higher after eHealth system implementation (P=0.024), micro- and macro-contextual factors confounded this effect, and the descriptive and qualitative data revealed that genuine improvement only came about after recruitment of ward clerks towards the end of the study period. At the health centres, the eHealth system reportedly helped staff in the accounts department with billing, the facility in-charges with financial oversight, and clients with more trust in printed receipts.

Conclusion

Converging the results of these two case studies illustrates the potential of eHealth to

strengthen LMIC health systems through developing human resource capacity (skills, staff roles), facilitating service delivery, and improving financial management and governance. However, realising such improvements is dependent upon understanding the socio-technical interactions mediating the integration of new systems into organisational processes and work practices, and implementing appropriate change management interventions. The results of this study suggest that, for effective implementation and adoption of eHealth systems, healthcare leaders should (1) recruit data entry clerks to relieve clinical staff, improve workflow and avoid data fraud, (2) facilitate appropriate data use among system users and an information culture at the facilities, and (3) strengthen knowledge and skills transfer from eHealth system developers to local implementers and system champions, to optimise responsiveness and ensure sustainability. Further interdisciplinary research is needed to obtain additional insights into factors affecting the quality of eHealth data and its use in the management of LMIC health systems, including the role of social, professional and technological influences on financial good-governance.

Lay Summary

This thesis examines the challenges and benefits associated with implementing computer-based health information systems (eHealth) in low- and middle-income country (LMIC) healthcare settings, using case studies from rural Malawi. It aimed to provide insights to help answer the following broad questions:

Question 1: How do eHealth implementation processes take place in LMIC settings and how do technological, organisational and social factors affect their success?

Question 2: How does introducing eHealth systems affect the capture, quality and use of data for decision making and how do such changes come about? Why do some expected changes not happen?

A review of previous studies on eHealth adoption and implementation revealed that most have taken place in high income countries, emphasising the need for further research in LMIC. Also reviewed were theories about how information technologies and human beings jointly influence the success of IT implementation projects, and about different approaches to evaluation, which together influenced the research strategy.

Two case studies were undertaken. The first looked historically at how a modular eHealth system had been introduced in one large hospital in Malawi, while the second analysed a live project that was rolling-out a version of the system in nine rural health centres.

Both examined the ease or difficulty of the implementation process, including how change was managed and any unanticipated challenges, how the system influenced administrative and healthcare processes and efficiencies, and what effects it had on information quality, clinical or managerial decision making or financial governance.

The case studies used mixed-methods, including analysis of historical documents from

management meetings, hospital records on cases and billing, comparisons with national data collection initiatives, and interviews with people involved in the project at different levels.

Findings from the study fell into several categories, associated with the processes or outcomes of eHealth implementation:

Organisational and process factors influencing eHealth system implementation

Change management processes

The results illustrate how organisational changes were needed to accommodate use of the eHealth system, including training and IT support, changes to filing systems and new staff roles, as described below. A key change was the introduction of dedicated ward clerks in some hospital departments, which relieved clinical staff from entering patient data and improved data quality and accuracy. These new staff were not available in the health centres and often data entry jobs were delegated to low-skilled workers, leading to problems.

Infrastructural and security issues

A key threat for the health centres was theft of equipment, which meant that security measures had to be increased. Inconsistent power supply also caused problems, including staff having to default to paper-based systems. This was addressed through introducing solar panels and low-power computers.

Sociotechnical issues

Problems with the eHealth system's software reduced satisfaction with and use of the system, including fields not being available for data entry, frequent password re-sets and poor connectivity between the computer units and the server. Part of the problem was traced to staff using the computers for personal activities such as storing games or videos, or using Facebook, which depleted server space and diverted staff from patient care.

Leadership

Leaders and 'system champions' influenced the willingness of sites to implement the eHealth system and the efficiency with which they did so. Ineffective engagement of these "in-charges" was mentioned as a barrier to adoption in some health facilities, with junior staff being left to use the system without support.

Training

Lack of consistent training and high staff turnover meant that staff unfamiliar with the system entered information into both paper and electronic forms, adding to rather than reducing workload. It also left health facilities unable to deal with software or hardware problems without specialist support.

Technical support

IT support was difficult for the health centres to obtain and, as noted above, lack of training meant that centres could not become self-sufficient. Problems with software could not always be addressed by local IT support professionals, due to their inability to access the source code owned by the vendor. This also prevented them from adapting the system to suit local requirements.

Outcomes of the system

Several outcomes of the eHealth implementation project were also seen in the data or described by the interview participants. These included:

Documentation / workload

Where the system was implemented effectively, reductions in administrative workload were seen. As noted, however, training and technical limitations meant that data was often entered on paper forms, which increased workload or resulted in tasks being shifted to unqualified staff.

Data quality

The same barriers resulted in markedly fewer outpatients being recorded on the eHealth system, in both the hospital and the health centres, compared with existing paper-based systems. However, in wards where trained data clerks were employed, the completeness of inpatient registration and the accuracy of diagnosis data on the system were higher than elsewhere.

Service delivery (efficiency and patient experience)

The eHealth implementation project also triggered organisational changes which improved efficiencies, notably changes to the hospital's paper filing system, which had eased retrieval of patients' files and made it easier to link outpatient and inpatient records. Health centre staff reported that using the system made it easier to identify and trace patients, support continuing care, ensure patient confidentiality, follow clinical protocols, identify the need to change prescriptions or activate referrals, and keep health workers alert and available. Patient experience was perceived to have improved through avoiding the need for information to be re-entered at subsequent visits, managing queues more efficiently, and making patients feel more understood by their service provider and more confident with services. In contrast, staff members' slow typing skills, unfamiliarity with the eHealth system, dual entry of patient information into electronic and paper systems, and additional steps in patient journey, were thought to decrease patient satisfaction.

Efficiency of reporting

After its implementation at the hospital site, the eHealth system was routinely used to generate data for measuring quality of care, and partly for national reporting purposes (HMIS). Customised reports were also created and used for internal decisions such as allocation of wards. In contrast, the primary healthcare facilities were still reliant on paper registers to compile HMIS reports, sometimes in combination with the eHealth system, because of lack of knowledge of the reporting module, poor design of the system's reports, and disruptions in electricity and network connections.

Management of finances

Interviewees felt that financial management had improved at the hospital due to better capture and tracking of service charges and making information more accessible for decision making. However, rises in revenue during eHealth implementation and adoption were confounded by inflation. After correcting for this, it was found that reliable improvements in revenue only came about after ward clerks were employed to manage billing processes and communicate with the accounting department, which increased transparency and thus helped to avoid illicit practices such as under-the-counter payments. At the health centres, the eHealth system reportedly helped staff in the accounts department with billing, the facility in-charges with financial oversight, and clients with more trust in printed receipts.

Conclusion

These case studies illustrate the potential of eHealth to strengthen LMIC health systems through developing human resource capacity, aiding service delivery, and improving financial management and governance. However, realising such improvements is dependent upon socio-technical factors, which mediate the integration of new systems into organisational processes and work practices. These findings suggest that, for effective implementation and adoption of eHealth systems, healthcare leaders should recruit data entry clerks to decrease clinical workload and avoid fraud; facilitate the use of systems by appropriate staff members but recognise that paper may still be necessary in the face of infrastructural barriers; strengthen the transfer of knowledge and skills from vendors to local IT support teams to enable better customisation and maintenance, and train health facility staff to deal with problems themselves. Further interdisciplinary research is needed to obtain additional insights into factors affecting the quality of eHealth data and its use in the management of LMIC health systems, including the role of social, professional and technological influences on financial governance. The research is important for several reasons: It helps to fill a gap in the body of written evidence about the implementation of eHealth in LMIC; it shows how technologies can act as a force for good provided the right people are in place; and it illustrates the complexity involved in

implementing and sustaining technology projects in LMIC healthcare and the challenges involved in making best use of these systems to harness their potential benefits.

Structure of the Thesis

Chapter 1 provides the background to the research, summarising the state of current knowledge, outstanding research questions for the field and the theoretical and methodological foundations of the study. It opens with an overview of the role of electronic health information systems (henceforth referred to as eHealth) both in the management of information within healthcare organisations and as a set of enabling technologies for global health. This is followed by a review of research literature on factors affecting the implementation and adoption of eHealth systems, and their effects on the quality of data for use in financial management. Thereafter, the theoretical and interdisciplinary underpinnings of the thesis are described, followed by a broad overview of the methodologies, focussing on a theoretical and literary overview of the methods. It closes with a description of the processes undertaken to ensure ethical considerations for the study.

Chapter 2 describes the context in which the study took place. It starts by profiling the socio-economic situation in Malawi. Thereafter, health systems strengthening policies, strategies and interventions and their outcomes in Malawi are depicted, including efforts to implement eHealth for improving health information management in the region. The bespoke eHealth system and implementation programme on which the PhD case study is based, is then described, including its components and logic model for the study.

Chapter 3 presents findings for the retrospective case study of system implementation in the large referral hospital serving the 9 health centres. Case Study 1 is an in-depth biographical analysis of the planning and implementation of the eHealth system over a period of almost a decade, beginning with the vision and goals articulated by the hospital executives commissioning the platform. It analyses the formal processes, as described in written project documentation, as well as the socio-technical dynamics characterising the technology customisation and implementation process as it unfolded over time in a complex, multi-stakeholder organisation. It also sought to establish the effects of the eHealth system on quality and use of data for service delivery, reporting and financial

management, and to understand the cultural and behavioural factors influencing acceptance, use and effectiveness of the system in context.

Chapter 4 presents the findings from the prospective case study of a recent eHealth system implementation project in nine rural health centres (Case Study 2). It outlines the contextual, socio-technical, change management and organisational enablers and inhibitors to implementation, as well as the effects of the system on the quality of data available for service delivery, reporting and financial management. Health centres are stratified as Early Adopter facilities, Late Majority facilities and Laggard facilities, and differences and similarities between these levels of adoption are presented.

Chapter 5 integrates and discusses the key findings from the two case studies in the context of existing empirical and theoretical literature, and new insights are isolated. Enablers and inhibitors to eHealth implementation and adoption are first discussed, which cover complex change management, technological, organizational and social interactions. Effects of the system on quality and use of data for service delivery are then portrayed, followed by discussion of the complex and interdependent relationship between technology and people when seeking to improve financial management. It also considers the transferability of these findings to other sectors in LMIC.

Chapter 6 draws out the limitations and key conclusions from the study, summarises the main learning points and makes recommendations for policymakers and organisations seeking to implement administrative eHealth systems in LMIC health organisations. It calls for new research exploring how similar systems are being implemented and adopted and how they can be optimised to improve the quality of data for managing health facilities, patients and finances. It also recommends that models of health system strengthening through eHealth acknowledge that benefits may accrue from influences on good-governance in addition to better use of information provision.

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Abbreviations, Acronyms and Concepts

CHAM	Christian Health Association of Malawi, having a membership of some faith-based health facilities in Malawi
DHIS	District Health Information System, a web-based database for health data in some developing countries
GVH	Group Village Head, overseer of a group of villages
Health Passport	A patient-held, longitudinal paper-based health record
HIV	Human Immunodeficiency Virus, which causes AIDS
HSA	Health Surveillance Assistants, government-paid community health workers
HSSP	Health Sector Strategic Plan of Malawi Government's Ministry of Health
MDHS	Malawi Demographic and Health Survey, reported by NSO roughly every 4 years
NSO	National Statistical Office of Malawi
SLA	Service Level Agreement between government and CHAM facilities to exempt maternal, neonatal and child health services
TA	Traditional Authority, overseer of a group of GVH areas

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CHAPTER 1 INTRODUCTION

Chapter Aims

- Analyse the role of eHealth in global health systems and health systems strengthening
- Review published research on eHealth implementation and adoption factors and their effects on data quality and use, particularly (although not exclusively) focusing on LMIC and financial management
- Examine and compare theoretical and interdisciplinary perspectives that have been brought to bear in studying similar complex research problems
- Articulate the high-level research questions, aims and objectives addressed by this research
- Critique a range of potentially applicable research methodologies and analytical perspectives, and outline the high-level approach taken

1.1 eHealth in the Context of Global Health Systems

This section defines eHealth and its role in strengthening global health systems, comparing advances in eHealth systems adoption in high income countries and their state of adoption in middle- and low-income countries, and the perceived and reported effects of these eHealth systems. This will tell us whether this thesis, and the case studies portrayed in it, are relevant to global health.

Timely access to high quality information has been recognized as an important building block of health systems, which also include financial resources, human resources, medical supplies, service delivery, and leadership and governance (World Health Organization 2010a; USAID 2012). Strengthening health information systems has been postulated as leading to strengthening of all the other building blocks of health systems (Labrique et al. 2013; Nutley 2012). However, others have argued that

quality of data capture and continuous use of information for decision making particularly focus on the service delivery and resource management building blocks of health systems (Aqil et al. 2009).

eHealth is a term that has been used for over two decades, with numerous definitions in the literature, depending on the context in which it is used. Though they all mention specifically health and technology, health has not been defined as an outcome, but rather as a process (Oh et al. 2005). For instance, the World Health Organization defines eHealth as *"the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research"* (World Health Organisation 2004). One of the earliest definitions of eHealth used widely in academic literature was by Gunther Eysenbach, which stated that:

> *"e-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology."* (Eysenbach 2001)

This definition has been used ever since (Boogerd et al. 2015), with some modifications, e.g. (Pagliari et al. 2005), because not only does it take into account the various purposes of technologies for healthcare and users, it also defines their value to society (Catwell & Sheikh 2009), and no other consensus has been reached on its definition (Showell & Nøhr 2012). Use of the term 'eHealth' or 'eHealth system' in this thesis includes technological systems that capture and manage both individual patient's administrative and health data, including the process of implementing them. It excludes electronic systems that capture either type of data exclusively, for

instance electronic patient records (EPR) or cash register-type billing systems. It also excludes embedded sub-systems such as decision support systems (DSS), telemedicine/telehealth, and wider electronic applications in health such as mobile phones (mHealth). At several instances, the generic term information and communication technologies (ICT) will be used for the same meaning as eHealth systems.

Key administrative data include patient registration and billing, while health data was encompassed in HIMSS's definition of the electronic health record (EHR) component of an eHealth system, as being:

> *"… a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. Included in this information are patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data and radiology reports. The EHR automates and streamlines the clinician's workflow. The EHR has the ability to generate a complete record of a clinical patient encounter - as well as supporting other care-related activities directly or indirectly via interface - including evidence-based decision support, quality management, and outcomes reporting."* (Healthcare and Information Management Systems Society 2017)

eHealth has been reported to be a key field of medical informatics (Qureshi et al. 2012), increasingly being used to strengthen health systems (Akanbi et al. 2012). There has been growing interest globally in taking advantage of electronic solutions to improve the quality and safety of health care (Black et al. 2011). eHealth systems have been advocated to have great potential to improve health in both developed and developing countries, by enhancing access to health information, making health services more efficient, contributing to improved quality of services and reducing their cost (World Health Organization 2012).

In advocating for the expansion of eHealth systems, early researchers argued that

paper-based methods of medical record keeping were prone to error and loss, impeding health providers' ability to offer continuity of patient care (Mostert-Phipps et al. 2010). This was thought to be more acute in developing countries suffering from shortages of facilities, funds and trained staff to provide healthcare (Lueddeke 2015).

As a result, health systems worldwide started investing in eHealth in order to improve the administrative and clinical accessibility of patient records (Williams & Boren 2008). In the context of global health, these technologies were even advocated as a means of strengthening developing country health systems, to enable more equitable, accessible and safe health systems (Yogeswaran & Wright 2010). However, their ability to fulfil these goals has been mixed, as will be discussed later in this chapter.

Physicians and hospitals started implementing eHealth systems with the general expectation that such systems would improve the quality, safety and efficiency of healthcare services (Noblin et al. 2013), with adoption of eHealth more than doubling over a decade (Boland et al. 2013; Patel et al. 2013), mainly in the US due to the "carrot and stick" of the Health Information Technology for Economic and Clinical Health Act of 2009 (HITECH) (Nambisan et al. 2013; Kruse et al. 2016), with both early eHealth users and nonusers reportedly rating eHealth features as having the most value to their practices (Chiang et al. 2008).

In settings where eHealth systems were successfully implemented, they started producing early results such as significant reduction in antibiotic consumption and an improvement in rational antibiotic use (Li et al. 2013) and improved maternal and child care (Jimoh et al. 2012), and were associated with high quality primary health care (Lau et al. 2013; Miller & West 2007) and paediatric care (Soares et al. 2012). eHealth was seen to have earned its place as a valuable source of information for delivery of health services, population health and policy development (Kamadjeu et al. 2005; Teviu et al. 2012), and was expected to strengthen health systems as one of

the prime movers of globalization (Idowu et al. 2006).

While eHealth was being reported to improve the efficacy of healthcare service delivery in high income countries, with governments providing incentives for adoption of these technologies (Blumenthal 2009; Abraham & Junglas 2011), they were yet to be widely deployed in the developing world, where ironically more than 90% of the global disease burden existed (Douglas 2009). Even though the benefits of using electronic methods of record keeping were widely documented, use of this technology in developing countries remained low (Yoon et al. 2012), with the majority of healthcare practitioners in these countries still using paper-based methods (Mostert-Phipps et al. 2010). When eHealth systems started being implemented in sub-Saharan Africa, they were largely driven by vertical disease programmes, such as HIV (Castelnuovo et al. 2012; Gadabu et al. 2011; Fraser et al. 2007) and later chronic diseases (Tchuitcheu & Rienhoff 2011). Yet even the penetration of these systems was very low (Akanbi et al. 2012). Early implementers in this region were OpenMRS (Waters et al. 2010; Oza et al. 2017) for patient-level data and District Health Information System (Braa et al. 2004; Braa et al. 2012; Monawe et al. 2015) for aggregate data.

Some authors expressed scepticism regarding the feasibility of eHealth in low-resource settings (Douglas 2009), particularly hindered by significant start-up and ongoing maintenance costs, uncertain returns on investment and the myriad technological problems that pester eHealth systems (Devkota & Devkota 2014). Successfully implementing eHealth systems in healthcare organizations was a difficult task (Berg 2001; Lluch 2011), and across the world efforts to introduce eHealth systems experienced high failure rates (Yogeswaran & Wright 2010; Noblin et al. 2013; Greenhalgh et al. 2017). Due to limited resources in developing countries, it was even more imperative to ensure that introducing new eHealth systems avoided failure (Kahouei et al. 2015). In particular, there was need for studies and interventions to optimise adoption of eHealth systems by healthcare staff (Lewis et

al. 2012). As a result, some implementation processes focussing on user resistance were developed, and they were reported to reduce implementation costs with minimal wastage of resources (Jimoh et al. 2012).

However, there was insufficient evidence available on the inhibitors to adoption of eHealth in low-income health systems (Mostert-Phipps et al. 2010). This study, therefore, sought to depict some of these barriers and facilitators to implementation and adoption of an eHealth system in a limited resource setting. It sought to further show their effects on quality and use of eHealth data for strengthening health systems' human resources, service delivery and financial management building blocks.

1.2 State of Knowledge on eHealth and Unanswered Questions

Literature review is presented in this section. Although most of the other sections also cite various sources, this section involved a scoping review, presented as a narrative expert overview, using key search words. Firstly, the search strategy is described below, followed by a portrayal of systematic reviews detailing known facilitators and barriers to eHealth system implementation and adoption. Thereafter, documented effects of eHealth systems on quality and use of data for financial management are portrayed.

1.2.1 Search Strategy

Published literature was searched from MEDLINE, Web of Science, Google Scholar, the University of Edinburgh online library, Cochrane Library and several specific publications such as the Journal of International Medical Informatics Association and the Journal of Medical Internet Research. Exemplar keywords used in the Medline, Google Scholar, Web of Science and Scopus searches are in Appendix 1. Subscriptions were also made to publishing houses throughout the study for email notifications about relevant Tables of Contents or latest online publications. Requests to authors for full text articles were made. Snowballing from the references in the papers downloaded also revealed additional papers.

Discussions held early in the study with stakeholders in eHealth systems development and implementation consistently indicated that questions in the field were around developers' claims that their systems improve quality and use of data for decision making during patient care, reporting and financial management. Studies on these outcomes are presented below, but first literature on factors affecting eHealth system implementation and adoption are portrayed.

1.2.2 Enablers and Inhibitors of eHealth Implementation and Adoption

There are ten systematic reviews depicted in this section, published between 2013 and 2016. Out of the 724 papers included in the systematic reviews, only 115 were from developing countries, representing 16% of the studies reviewed. Elements extracted from each paper were author names and publication date, title of the study, its focus and scope (objectives, technologies, framework used to analyse the papers), original study types reviewed, databases searched, inclusion and exclusion criteria presented, countries where the original studies took place, number of studies included, and how many of them from developing countries, and the enablers and inhibitors to eHealth implementation and adoption found. A table summarising these elements is presented in the appendices.

Early evaluations of eHealth implementation and adoption factors used quantitative methods, particularly using the Information Systems Success Model developed by William DeLone and Ephraim McLean (DeLone & McLean 2003). Finding other quantitative instruments to measure factors that affect implementation and adoption of eHealth systems has since been difficult. A recent systematic review aimed to find instruments that would measure provider-, innovation-, patient-, organisational- and structural-level factors affecting implementation of eHealth systems (Chaudoir et al. 2013). After reviewing 125 articles published up to August 2012, they found that only the Barriers and Facilitators Instrument from Holland was designed to measure each of these factors.

Realising the value qualitative insights could add to the quantitative measures, researchers started using mixed-methods.

More research was still needed to document the challenges involved in eHealth implementation and how these challenges might be addressed (Buntin et al. 2011). Realising the value qualitative insights could add to the quantitative measures, researchers started using mixed-methods. For example, a systematic review of 101

mixed-methods studies drew out factors that could facilitate or hinder implementation of eHealth systems and their adoption among health workers (Gagnon et al. 2012). They used a mix of theoretical frameworks to analyse the literature, some of which will be discussed later in this chapter, such as the Technology Acceptance Model (Davis 1989) and its modification (Yarbrough & Smith 2007), a framework for physician knowledge, attitudes and behaviour towards clinical guidelines (Cabana et al. 1999), and the Diffusion of Innovations model (Rogers 2003). They developed a grid of adoption factors similar to the Contextual Implementation Model (Callen et al. 2008), which included the organisational context, the clinical unit context and the individual context. Technology Acceptance Model's system usefulness and ease of use were the most common facilitators to eHealth adoption. Common barriers to implementation and adoption were time constraints and increased workload, mostly due to low computer competency among the staff, as well as poor design of the software, and lack of alignment of the eHealth system with facility workflows, practices and culture, including assignment of staff roles. Training was perceived as both a facilitator, if well done, or as a barrier if inadequate.

It was then realised that these factors were not stand-alone issues – they interacted with each other, requiring holistic multidisciplinary approaches (Lluch 2011). For instance, the introduction of patient records in the US at the beginning of the twentieth century necessitated changes in hospital workflow and the emergence of a new profession of medical record managers (Berg 1999; Pagliari 2012). Likewise, it was increasingly acknowledged that introducing information technologies could disrupt existing work processes and thus required additional change management and service redesign efforts, making it hard for evaluators to disentangle the effects of the technology from the human and organizational processes that surrounded it (McLean et al. 2013; Pagliari 2012). For these reasons, evaluations of complex programmes that focus solely on assessing clinical and cost indicators had limited generalizability beyond the setting in which the research was undertaken, and sociotechnical evaluations became more useful for uncovering unanticipated

influences and effects (Cresswell & Sheikh 2014; Gomez & Pather 2012). Implementing ICT in the context of global development projects added an additional layer of complexity, leading some researchers to argue that quantifying hard outcomes may be less important than understanding ICT as an enabler of socio-economic development (Gomez & Pather 2012).

Further, eHealth systems implemented needed to be adopted by health workers for them to be useful, and organisation theories have also been used to explore factors that enable or inhibit eHealth system adoption among health workers. In that regard, 31 databases and sources from the disciplines of management, business, health, information systems and social policy were searched for articles published from 1995 up to 2011, describing barriers to eHealth adoption by health workers (Lluch 2011). She categorised the barriers using the Five-Star model that Jay Galbraith had developed and modified (Galbraith 2002), and analysed and discussed them using an organisational management perspective, applying it to healthcare organisational systems. Under the Structure of Healthcare Organisation System category were hierarchy (to leverage Generation Y leaders and shifts in control), cooperation and teamwork across the different tiers in the organisation, and ensuring autonomy of health workers. Another category was Tasks, which comprised changes in workflow and routine (including changing from process-oriented to patient-oriented approach), and depersonalization due to loss of face-to-face care provision. A third category was People Policy, and this covered training and IT skills and competence; support from IT technicians, management and policy makers; trust for the system and its outputs among staff, and issues of liability; legal frameworks related to liability; accountability to patients, employers and other colleagues; and the balance between shifts in power relations and practitioner autonomy. Fourth was the Incentives category, which discussed reward systems, life-work balance, and pay-for-performance or pay-for-use incentives. Finally, the Information and Decision Processes category identified internal communication and increases in workload resulting from changes in workflow, and sharing of eHealth records with other

professionals, as inhibitors to eHealth adoption.

Another systematic review identified and synthesized factors that influence health workers' acceptance of eHealth systems (Li et al. 2013). Using the Unified Theory of Acceptance and Use of Technology (UTAUT (Venkatesh et al. 2003; Maillet et al. 2015)), ninety-three papers were reviewed, and influential factors were categorised into seven clusters:

(1) Health care provider characteristics,

(2) Health facility characteristics,

(3) Voluntariness of use,

(4) Performance expectancy,

(5) Effort expectancy,

(6) Social influence, and

(7) Facilitating or inhibiting conditions.

More researchers then saw that eHealth system implementation also involved changes in the organisational culture and workflow, and organisational theories started being used.

Health workers' behaviour intention was strongly influenced by perceived usefulness, which was further influenced by perceived ease of use, alignment of the eHealth system with facility processes, IT knowledge and competence among the health workers, commitment and support to change by management, changes in patient-provider relationship, and involvement of the health workers in the design and implementation processes.

More researchers then saw that eHealth system implementation was not merely installing a technology, but rather also involved changes in the organisational culture and workflow, and organisational theories started being used to explore enablers and inhibitors to eHealth system implementation and adoption. In a systematic review of implementation and adoption factors in rural communities (Hage et al. 2013), they used the Classic Model of Strategic Management of Change developed by Andrew Pettigrew and Richard Whipp (Pettigrew & Whipp 1991). In the 51 papers published up to 31st May 2011, seven from developing countries, contextual factors that were found to enable eHealth adoption included being in a geographically isolated

location, younger, having more income, family status (being married or with children), not having local social ties, having more experience with ICT and other technologies, higher community involvement, lack of alternative sources of information or services, and the need for anonymity, self-reliance, helping others with eHealth issues and access to information and services. Antonyms of these factors hindered eHealth system adoption, as well as social inequalities and third party factors such as poor relationships with them, being competitive, and access to services without the need for eHealth. Process factors facilitating eHealth adoption were identified as having implementation teams that were locally based, skilled and motivated; implementation practices that included training and user involvement; bottom-up strategies that considered local leaders; and top-down strategies that involved organisational leaders. Process factors that hindered eHealth adoption included insufficient resources, potential for conflict, and personality and organizational issues. Finally, eHealth content was another factor that was seen to promote adoption, which included the design of the project, the design of the eHealth system software, and sustainability through stakeholder contractual arrangements.

Similarly, an interpretive review of systematic review of publications between 1997 and 2010 found eleven articles on organisational factors affecting implementation and adoption of eHealth (Cresswell & Sheikh 2013). Using an adapted Critical Appraisal Skills Programme (CASP) approach (Singh 2013), these articles presented technological factors that affected implementation and adoption, including speed of the eHealth system, benefits that could be demonstrated soon after implementation, costs, interoperability with existing systems and organisational processes, perceived ease of use, and eHealth systems that could be easily adapted. Social factors affecting eHealth implementation and adoption included users' IT knowledge and competency; attitudes of users, their colleagues and their clients towards the technology; role of the eHealth system in supporting inter-professional roles and relationships; and the costs of the system. Lastly, organisational factors identified were size and complexity of the health facility, where the larger and more complex,

the more receptive of the eHealth system; presence of user champions to lead and support the implementation and adoption process; and strength of the management and leadership in the organisation. However, a study of an eHealth implementation in rural Australia in the review found that the isolated and small health facilities disconnected from the complexity of urban areas were seen to be an advantage to eHealth implementation and adoption (Cripps & Standing 2011).

Some studies have focussed only on enablers to eHealth implementation and adoption. For instance, a systematic review of the success of eHealth implementation in low-income settings from studies published between 1999 and 2013 identified 47 articles with 381 success criteria having 229 measurements (Fritz et al. 2015). Using Brender et al's Delphi study (Brender et al. 2006), these success criteria were arranged into seven categories. Nearly a third of the success criteria (29.0%) were in the Functionality category, which comprised the need for extra features, usability of the eHealth system, and the need for functionalities for data aggregation and reporting. About 23.5% of the criteria were grouped under the Organisation category, and included human resources issues such as staff computer competence, project management and managerial commitment and staff attitude to the eHealth system, and local stakeholder involvement. Another 21.5% of the success criteria focussed on the Technical category, comprising infrastructure such as power, network and internet access, as well as the eHealth software characteristics, issues of security and privacy, and standards. Training category comprised 10.0% of the success criteria, and included their availability, and computer knowledge and background of staff. In the Political category (6.0%) were nation-wide politics, trust, attitude to change, political will, and health system's infrastructure location and presence of ICT. Ethical issues (5.5%) dealt with how the eHealth system would be sustained, including issues of privacy and security. Availability of resources, particularly human resources, and costs criteria were

Several theoretical and conceptual frameworks have since been developed from these enablers and inhibitors to eHealth system implementation and adoption.

grouped under the Financial category, comprising 4.5% of the success criteria.

On the other hand, other studies have focussed only on inhibitors to eHealth implementation and adoption. For instance, a systematic review of literature published between 2001 and 2011 described problems associated with eHealth implementation (Nguyen et al. 2014). Using the DeLone's and McLean's revised framework (Delone & Mclean 2003) with Van der Meijden et al.'s contingent factors (van der Meijden et al. 2003) as the conceptual frameworks to review 98 articles, three from developing countries, they found that eHealth system adoption was hindered by project plans that were unclear and lack of standards and guidelines that were uniform. Further, limited inclusion in user training programmes of how the eHealth system could improve quality of care, particularly to facilitators, champions and project leaders, led to low eHealth system adoption. Other inhibiting factors found were lack of interoperability of the eHealth system with other existing systems, and limited time allocated to building and configuring the eHealth system. There were also organisational inhibiting factors identified, particularly organisational culture of anxiety and change management, readiness to adopt the system, leadership, internal communication and decision making, and funding.

Several theoretical and conceptual frameworks have since been developed from these enablers and inhibitors to eHealth system implementation and adoption. For instance, a recent systematic review of 44 studies from developed countries used the Consolidated Framework for Implementation Research (CFIR (Damschroder et al. 2009)) to categorise enablers and inhibitors to eHealth implementation and adoption (Ross et al. 2016). Studies in the systematic review were published until 1 January 2014, mainly from North America and Europe, while three studies were from developing countries. This framework categorised enablers and inhibitors to eHealth implementation and adoption into Innovation, Outer Setting, Inner Setting, Individual and Process factors. Innovation factors for successful implementation included eHealth systems that were adaptable and interoperable, easy to use (fast,

minimal downtime, simple, optimal connectivity), and were of low cost. Outer Setting factors were legislation, incentives, standards and liability concerns. Inner Setting factors were the alignment between the eHealth system and the organisation's workflow and practices, the way leadership was engaged, availability of resources (infrastructure and time), and training that included information about benefits of the system, and availability of IT support. Individual factors comprised knowledge, attitude and IT competence among users. Process factors covered strategic planning for the implementation, engagement of champions and key stakeholders, and reflexive evaluation.

Many of the enablers and inhibitors to eHealth implementation and adoption were common across developed and developing countries. A non-systematic review examined challenges to sustainable eHealth implementation across 46 developing and 24 developed countries (Luna et al. 2014). They found key implementation challenges to be difficulties in interoperability with developed countries, issues of security and privacy, lack of medical informatics professionals, difficulties with regional integration, lack of national eHealth agenda and inadequate infrastructure.

However, conceptual frameworks for eHealth system implementation enablers and inhibitors have also been developed specifically for low-income countries. For instance, a recent systematic review identified 32 articles on benefits of and challenges to implementing eHealth systems in low-income settings (Jawhari et al. 2016). They then developed a conceptual framework that identified systemic, human, process, product and outcome factors of the benefits and challenges. Systemic factors were infrastructure such as reliability of power, network and connectivity. Human factors were socio-technical interactions between facility staff, IT staff, patients and the technology. These human barriers included lack of IT support, inadequate computer competency, and high staff turnover. Process factors recognised that eHealth systems often brought to attention dysfunctional processes and workflows, requiring a variety of mitigating interventions, ranging from engagement of users and their leaders to

providing ID cards to patients. Poor performing digital products with bugs and missing features were also barriers to successful eHealth implementation in low-income countries. Common product challenges included difficulties for staff to login due to complex security features, backup rules that were time-consuming, or reporting requirements that were too complex. eHealth system outcomes varied from simply providing unique patient identifiers, to complex clinical decision support.

This section has looked at the transition in research about enablers and inhibitors to eHealth system implementation and adoption. Starting from the use of quantitative tools, this section has shown that more research was then needed to document implementation challenges and how to address them. Upon realising the value of qualitative methods in eHealth implementation and adoption research, they then started being used to complement quantitative studies. After identifying implementation factors, focus was then on adoption factors among health workers. Organisational theories started being employed to understand enablers and inhibitors to adoption. Currently, frameworks exist for research specifically in developed country settings and others specifically for developing country settings. This thesis, set in a low-resource country, used mixed methods to explore socio-technological and organisational enablers and inhibitors to eHealth system implementation and adoption. These factors were analysed using the framework developed by Badeia Jawhari and colleagues (Jawhari et al. 2016) specifically for such low-resource settings, and comprised systemic, human, process, product and outcome factors.

1.2.3 eHealth and Health Data Quality

Changes in quality of patient data from 2004 to 2014, when this study began, are portrayed in this section, along with the development and role of eHealth systems in these changes. Studies were sourced from Sub-Saharan African countries, with case studies depicted from Rwanda, Ghana, Zambia, Tanzania, Kenya, Mozambique,

South Africa and Malawi.

Timely access to high quality information has been recognized as a critical resource underpinning continuity of care (Gulliford et al. 2006) and an important building block of health systems, which also include financial resources, human resources, medical supplies, service delivery, and leadership and governance (World Health Organization 2010a; Nutley 2012). Quality of data capture and continuous use of information for decision making particularly focus on the service delivery and resource management building blocks of health systems (Aqil et al. 2009). Strengthening health information systems has also been reported to contribute toward organizational transformation by fostering changes in learning, coordination and culture across the organization (Abraham & Junglas 2011b). However, this has been constrained by poor data quality and insufficient capacity among health personnel to analyze and use data for decision making (Mutale et al. 2013). Dimensions of data quality most commonly measured are completeness and accuracy (Weiskopf & Weng 2013), where completeness means the presence of the data element in the record, and accuracy means the data element is correct.

Early quality assessments of paper-based records were for vertical disease programmes. For instance, an analysis of the quality of routine malaria data performed in selected districts in Southern Mozambique assessed source data completeness and accuracy, and how they changed across reporting levels (Chilundo et al. 2004). This was a strongly qualitative study, with no quantitative assessment of data completeness or accuracy. However, qualitative interviews with health workers, including statistical officers and managers, revealed that primary data was of poor quality, and they further explored factors that led to poor data quality. These factors included presence of numerous uncoordinated reporting systems that resulted in redundancies and wastage of resources. Also, at some health facilities, data were made up by the health workers to fulfil reporting requirements, such that malaria incidence and indicators in the country's malaria strategic plan could not be correctly

calculated, thus not fulfilling the information needs of health managers.

One of the earlier quantitative analyses of paper-based data quality was an assessment of completeness and accuracy of maternal mortality civil registration data in the Greater Accra region of Ghana (Yakubu Zakariah et al. 2006). They compared civil registration records of maternal deaths with maternal deaths recorded by four referral hospitals in the region over the same period. Hospitals yielded a maternal mortality ratio that was more than six times that reported by the civil registry, with completeness of 43% for the civil registry. By searching both sources, 27 new cases were identified, representing an under-registration of 18%, or an accuracy of 72%, in the civil registry.

Later, HIV was another vertical disease programme that became interested in measuring whether the quality of paper-based data could adequately provide useful information for HIV prevention, treatment and care. For instance, data quality assessment of paper-based records compared aggregated paper-based data from HIV clinics at 89 public facilities in Malawi, to independently-compiled reports from paper-based primary data sources at the facilities, so they could determine how many of the clinics had complete and accurate data (Makombe et al. 2008). Although 70% of the sites had complete data for patient registration and 80% for HIV outcomes, only 40% of them had accurate patient registration data and 72% had accurate HIV outcome data. Factors associated with improved data quality were higher HIV client numbers, presence of dedicated data entry clerks, being supervised, geographic location, longer established HIV services and not being a rural hospital or health centre. As the number of HIV patients and treatment sites continued to grow in Malawi, the paper-based system was overwhelmed, and eHealth systems were seen as the solution to maintain and improve data quality and reporting to enhance patient care (Lowrance et al. 2007).

Implementation of eHealth systems to maintain and improve data quality and use thus became a priority (Lowrance et al. 2007). Paper-based systems started being used sequentially with eHealth systems, where paper-based data collected at the facilities was entered into an eHealth system at district level. When eHealth systems started being implemented in sub-Saharan Africa, they were largely driven by vertical disease programmes, such as HIV (Castelnuovo et al. 2012; Gadabu et al. 2011; Fraser et al. 2007) and later included chronic diseases (Tchuitcheu & Rienhoff 2011) and later infectious diseases (Jazayeri et al. 2015). Yet even the penetration of these systems was very low (Akanbi et al. 2012). Flagship implementers in the Sub-Saharan region were OpenMRS (Waters et al. 2010; Jazayeri et al. 2015) for patient-level data and District Health Information System (Braa et al. 2012; Monawe et al. 2015) for aggregate data.

Without improving the information culture of data quality and use from the point of collection, eHealth systems such as the DHIS were feared to have limited impact.

District Health Information System (DHIS) was used in Malawi, Rwanda, Tanzania, Zambia, Kenya, Ghana, South Africa and Latin America (Health Information System Programme 2017), developed by the Health Information System Programme (HISP) led by the University of Oslo. DHIS was first developed as Excel sheets, then later as Microsoft Access files, and then web-based (DHIS2). When it was implemented at ten rural South African health facilities, it was found that it had data quality of 97.5% completeness and 75.0% accuracy (Garrib et al. 2008). In-depth interviews revealed that lack of an information culture, as depicted by health personnel not finding the data useful, hindered data quality.

Without improving the information culture of data quality and use from the point of collection, eHealth systems such as the DHIS were feared to have limited impact (Piette et al. 2012). As such, eHealth systems that not only focused on data capture, but also wider organisational changes, started being implemented. One of the

pioneers of these systems in Africa was Partners in Health (PIH), who implemented OpenMRS in Rwanda in 2005 to support and improve HIV and TB patient care (Amoroso et al. 2010). Apart from reported improvements in data quality at technological level, early organisational benefits of this open source point-of-care system were reported to be improvements in data feedback and use, and strengthening health information management.

Not all eHealth implementations reported such enthusiastic results, as will be discussed later in Chapter 6 of the thesis. For instance, the Baobab Health Trust's eHealth system in Malawi showed limited differences between the eHealth system and paper-based data collected retrospectively by a researcher (Douglas 2009). The same eHealth system's data was later again compared to paper-based data, this time with the electronic data as the benchmark (Gadabu et al. 2011). They found that completeness of the paper-based system was 89%, inadequate to be reliably used in case of eHealth system failure. Another study in rural southern Tanzania showed that completeness of data in an eHealth system only improved to 54% (Maokola et al. 2011).

Further, in Kenya, completeness and accuracy of primary and secondary antenatal data was assessed at two private hospitals with eHealth systems, and a public hospital using only the paper-based system (Hahn et al. 2013). In qualitative interviews, staff at the private facilities rated the quality of data higher than staff at the public facility. However, quantitative analysis found that completeness was higher at the public facility that was using paper registers (96.7%) than at the private facilities with eHealth systems (71.7% and 77.8%, respectively). Accuracy was also found to be higher at the public hospital (95.7%) than at the private facilities (90.2% and 89.8%, respectively), despite implementation of eHealth systems at the private facilities.

Penetration of eHealth systems was very low in many low- and middle-income countries (Akanbi et al. 2012), and they found it difficult to ensure quality and use of paper-based health information systems (Ledikwe et al. 2014), which was in most use. During that time, a cross-sectional, cluster sample study conducted at 22 hospitals in Kenya (Kihuba et al. 2014) found completeness of paper-based data to vary between 90.3% , 75.8% and 58.2% in the maternal and child health clinics, maternity wards and paediatric wards, respectively. Accuracy was 68.9% for fresh stillbirth and 71.8% for neonatal deaths. Improved recording of such maternal and neonatal health data may have been a result of that component of health services being better-resourced, and studies were needed to determine whether data in other health services were of similar quality, as done in this thesis.

Implementing HIS strengthening is reported to also contribute to organizational transformation by nurturing changes in coordination, culture and learning across the organization.

Factors associated with poor quality data in resource constrained settings included not only ineffective data collection tools and training for data collectors in health facilities (Piette et al. 2012), but also due to insufficient capacity to analyze and use data for decision making (Mutale et al. 2013). Not only have eHealth systems been implemented to improve data quality, but also to improve its use for decision making. For instance, a set of interventions to improve the use of data for decision making were implemented in four African countries (Mutale et al. 2013), where Ghana and Tanzania implemented social and organisational interventions only, while Rwanda and Zambia added technological interventions. Of these technological interventions, Rwanda implemented OpenMRS to capture HIV, TB and chronic diseases data, and endeavoured to improve data quality and use by initial and continuous training as well as effective access to the IT team by the system users. Zambia implemented the Electronic Data Capture System (EDCS), and clinical quality improvement teams mentored other staff to improve data quality and use by using the system's reports of predetermined healthcare quality indicators. That paper only described the social,

organisational and technological interventions implemented, but did not report their effects on data quality or use in decision making, which this thesis went further to do.

Implementing health information system strengthening is reported to also contribute to organizational transformation by nurturing changes in coordination, culture and learning across the organization (Abraham & Junglas 2011b). Strengthening of health information system was thought to lead to facilities developing an information culture, where data would be used because of good quality, and quality of the data would be good because of their use (Braa et al. 2012). Health facilities are the entry point for health information systems, playing a vital role in the generation of data and its use for patient care and service management (Hahn et al. 2013). As such, transforming health facilities into information culture was vital.

As in many developing countries, strengthening health information systems in Malawi began around 1999 when grossly unreliable and non-use of paper-based systems were realised to be obstructing health services planning and management (Chaulagai et al. 2005). Development of the Malawi health management information system (HMIS) was a multi-stakeholder process that first defined a minimum dataset, incorporated from vertical disease programmes' indicators, designed for planning, management and service improvement. Organisational interventions included training of support personnel to capture data. Social interventions included incorporating information management into pre-service training and instituting it into job descriptions for health workers, including support staff. Quarterly feedback and supportive supervision were also planned as organisational and social interventions. There was no technological intervention planned by 2005.

From around 2007, the Health Information System Programme (HISP) introduced the District Health Information System (DHIS) that had been used in Ghana, Kenya, Malawi, Rwanda, South Africa, Tanzania, Zambia and Latin America (Health Information System Programme 2017), developed by the Health Information System

Programme (HISP) led by the University of Oslo. DHIS in Malawi first came as Microsoft Excel sheets, then Microsoft Access database and then web-based. While primary data was collected at health facilities using paper registers and submitted as aggregated data to the district office, District Statisticians converted these aggregated data into digital form on the web-based DHIS2, used for planning. OpenMRS was modified in Malawi by Baobab Health Trust to capture patient-level HIV and TB data (Waters et al. 2010), and some years later chronic diseases and primary care. However, most health facilities in Malawi still used paper based health information systems for management and service improvement.

Having profiled the transition of data quality assessment over the past decade, it has been shown that, although effects of eHealth systems on data quality are mixed, there were reported improvements in the organisational cultures of information use. This thesis aimed to not only quantify data quality, but to also explore qualitative socio-technological and organisational factors that affected data quality.

1.2.4 eHealth Systems and Financial Management

eHealth systems have been thought to be a core feature of modern healthcare organizations, enabling clinical and administrative data to be captured and mobilized to support the delivery of patient care, operational and business processes, public health activities and research (Black et al. 2011). As such, eHealth systems have been characterized as essential technologies for health systems strengthening (World Health Organization 2010). This section depicts the financial governance outcomes after implementation of eHealth systems. Case studies from North America, Middle East, Asia and Malawi are portrayed.

As strong health systems relied on effective governance (Mugo 2013; Joshi et al. 2015), eHealth systems offered an important route towards achieving this (Lewis 2006), not least through aiding the management of finances (McReavy et al. 2009; Giniat 2011).

"Governance" is used in this context to define a complex construct that included management and good governance, and particularly regulatory compliance of finances. This term did not refer to organizational governance, but the broader good governance concept about transparency and accountability (Holeman et al. 2016). While over time there have been robust arguments for investing in eHealth to improve the efficiency, quality and safety of care (Agrawal 2002; Wang et al. 2003; Hillestad et al. 2005; Silow-Carroll 2012), relatively little was known about their effects on financial governance in healthcare organizations (Holeman et al. 2016).

Organizational decision makers and sponsors of eHealth investments required evidence of the early impacts of eHealth systems in order to maintain their commitment (Piette et al. 2012). Researchers therefore started estimating that efficiency gains resulting from eHealth adoption may amount to over $77 billion per year once 90% rates of adoption have been realized nationally (Hillestad et al. 2005), due to faster, more accurate communication and streamlined processes (Silow-Carroll et al. 2012). They further estimated that health providers would get returns of approximately $86,400 per provider over a 5-year period (Wang et al. 2003; Sidorov 2006). These benefits were projected to derive mainly from more efficient usage of drugs, better capture of patient charges and state incentive payments, decreased billing errors, and reduced length of patients' hospital stay. It was estimated that despite the high initial and ongoing maintenance costs of eHealth implementation, a net financial gain could be realized by the third year of operation (Driessen et al. 2013).

Other estimates reported a less optimistic outlook of the utility of eHealth in improving revenue. Some facilities started reporting loss of revenue, particularly in the early years of eHealth adoption.

Other estimates, however, reported a less optimistic outlook of the utility of eHealth in improving revenue. For instance, a paper from the Massachusetts eHealth Collaborative projected a $43,743 loss for an average practice over a five-year period

after adoption of eHealth, while only 27% of practices would achieve a positive return on investment (ROI) (Adler-Milstein et al. 2013). Practices that would achieve this positive ROI were thought to be those whose revenue increased by increasing the number of patients seen per day as a result of improved efficiency, and improved charge capture and billing that led to reduced rejection of insurance claims. Although this study was limited by its focus on only small-to-medium sized primary care facilities in a developed country, the present thesis sought insights from a large secondary care facilities in a rural setting of a developing country.

As it turned out, some medical facilities started reporting loss of revenue, particularly in the early years of eHealth adoption (Menachemi et al. 2011). Indeed, financial losses in facilities implementing eHealth systems were unintended consequences, such as those in some organizations implementing eHealth for the first time (Miller & West 2007). This was commonly due to disruptions in access to patient data and interference with staff productivity, and such fears led to low adoption of eHealth (Police et al. 2011). These losses of revenue needed to be added to the financial plans for eHealth implementation, which also included additional personnel and utilities (electricity and internet) costs (Gleason & Farish-Hunt 2014). Indeed, the financial impact of eHealth interventions depended largely on non-IT costs, including non-IT labour and capital, and time (Ko & Osei-Bryson 2008).

Then researchers started investigating the amount of time it took for health facilities to recover from this initial loss of revenue. An interrupted time series study of a network of fee-for-service outpatient health facilities reported financial outcomes of an eHealth system implemented over thirty months from June 2006, evaluating changes in revenue at 1 to 6, 7 to 12, and over 12 months post-implementation (Fleming et al. 2014). It was found that net revenue initially decreased, but after twelve months it recovered to pre-

Other studies started demonstrating improved revenue derived from improvements in collecting outstanding receivables, staff productivity, cost-effectiveness and liquidity.

implementation levels, despite insignificant changes in patient volumes, although eHealth implementation was accompanied by increases in staffing and other related expenses of 3% and 6%, respectively. However, the study did not examine longer term effects of the eHealth implementation, while the present thesis investigated changes in revenue four years after implementation.

Similarly, there was no significant change in revenue four years after implementation of an eHealth system at the UC Davis Health System Eye Centre and its satellite offices of Davis Medical Centre at the University of California (Lim et al. 2015). Even charge capture and patient levels remained stable. Although this study was limited to a single academic institution within an integrated, high-income health system, the present thesis aimed to compare findings of these studies to a diverse, low-income health system. Another evaluation of an eHealth system implemented at the eye department of the Oregon Health and Science University (Chiang et al. 2013) found non-significant effect on revenue and patient volumes, three and four years after eHealth implementation, respectively.

Other studies, however, started demonstrating improved health facility revenue following implementation of eHealth (Bardhan & Thouin 2013). For instance, a study at Samsung Medical Centre in Korea measured the costs and benefits of an eHealth system during an 8-year period after its adoption (Choi et al. 2013). They found that, despite an overall increase in administrative costs, the cumulative net present value was $3,617, with a modest benefit-cost ratio of 1.23, despite a relatively long discounted payback period of 6.18 years. However, qualitative benefits of the eHealth were not included in this study, a limitation that the current thesis overcomes. At Sentara Healthcare in the USA, financial returns, though not their initial motivation for embarking on eHealth implementation, was reported to have exceeded their expectations within five years through cost savings and revenue generation by improving process efficiencies and quality improvements (Abraham & Junglas 2011b).

These financial benefits derived from improvements in collecting outstanding receivables, staff productivity, cost-effectiveness and liquidity (Smith et al. 2013). Robust eHealth systems were reported to be streamlining collection and processing of revenue, enabling fees to be entered immediately to reduce loss or omission of charges (Ellis Jr 2013). For instance, administrative and clinical leaders at facilities in Colorado, USA were motivated to adopt eHealth by anticipating efficiency gains, though they did not expect actual monetary gains (Ross et al. 2010).

Apart from eHealth systems being reported to be helping hospitals strengthen revenue management through improved efficiency and management of billing practices, revenue gains were also being found to derive from wider financial management and oversight functions of eHealth systems, particularly to reduce and eliminate fraudulent practices (McReavy et al. 2009). These practices were in the form of illegal informal, under-the-table payments to health workers (Lewis 2007) and theft of revenue from user fees (Vian 2008).

Evidence about wider use of ICT to improve financial governance and eliminate fraud, particularly in e-government, mounted (Bertot et al. 2010), with principles that started to be applied to eHealth systems. Some of them were computer-based analytical techniques to identify fraudulent financial behaviour in health practices (Pejic-Bach 2010), especially related to insurance claims (Ngai et al. 2011). One of these methods was the Knowledge Discovery in Database (KDD) technique, which used health facility expenditure patterns to cluster health facilities into segments, thus shortlisting facilities needing further investigation (Lin et al. 2008). This method, also known as data mining, was being used to show fraudulent behaviour involving collusion between health practitioners and pharmacies in Iran (Joudaki et al. 2016). It was also shown to detect 77.4% of prescription fraud among medical practices in Turkey (Aral et al. 2012). However, a later literature review found that most studies on data mining and KDD were limited in that they did not focus on detection of fraud

during provision of health services (Joudaki et al. 2015). Further, these methods focussed on fraud across institutions, while the present thesis investigated use of eHealth to detect and prevent fraudulent practices within a hospital.

At the same time, a UK government-funded practice paper addressed corruption in the health sector (Hussmann 2011) and noted that to mitigate fraudulent billing of services, accounting and transparency in billing for services needed to be strengthened, which, in addition to increasing internal transparency, also mitigated theft of formal user fees. Use of ICT was presented in the report as an essential mitigating strategy to increase transparency and accountability. As such, eHealth systems went on to being reported to improve financial governance at health facilities through automation and providing audit trails of transactions, as well as enabling electronic billing to avoid bribery and informal payments (Holeman et al. 2016). However, eHealth systems were also known to increase occurrence of fraud in some instances (Bowman 2013), such as through informal payments (Clifford et al. 2008) and inappropriate "cloning" of health records (Marbury 2014), where diagnosis and treatment codes were copied-and-pasted across medical records of different persons. There was still very limited evidence on use of eHealth systems to improve financial management and reduce fraudulent practices in the health sector (Holeman et al. 2016), a gap this study aimed to help fill.

Apart from eHealth helping hospitals strengthen efficiency and management of billing practices, revenue gains were also being derived from reduction and elimination fraudulent practices.

In lower income country health systems, the need to optimise efficiency and financial governance was particularly acute, given the limited human and financial resources and the high burden of disease. eHealth systems were gradually being introduced as a means of addressing these challenges (Scheffler et al. 2009; Blaya et al. 2010). Health

There were few studies on financial outcomes of eHealth systems implemented in low-income countries, since health services in such settings are typically free at public facilities.

systems in lower income countries were often further weakened by ingrained inefficiencies, corruption, social norms that discouraged optimum work practices, and ineffective governance, all of which combined to compromise their ability to provide safe and equitable patient care (Muula & Maseko 2006). Although eHealth systems had potential to better these barriers through improving documentation and enabling greater transparency and accountability, relatively little was known about whether these benefits were being realised nor, indeed, about how social and contextual factors influenced the governance of eHealth projects within the organisations attempting to deliver them. One area in which these difficulties were often manifested was in the handling of patient billing and fee recovery, which created financial incentives that may have resulted in significant leakage of resources (Lewis 2006).

There were few studies on financial outcomes of eHealth systems implemented in low-income countries, since health services in such settings are typically free at public facilities, paid by taxes. However, financial outcomes could be estimated through models that translate efficiency gains into monetary values. For instance, a study done in Malawi modelled the financial effects of implementing the Baobab Health Trust eHealth system in a tertiary, free, public facility (Driessen et al. 2013), and found that a 10.5% reduction in length of patients' hospital stay would save $128,645 per year in food and personnel costs. Further, a 28% reduction in transcription time would have an annual value of $64,563, and a $91,187 annual saving for reductions in duplication of laboratory samples and tests.

This section has described how eHealth systems have attempted to strengthen the financial resources pillar of health systems over the past two decades. Early estimates of potential financial gains and losses have been depicted, and financial losses in the early stages of implementation have been portrayed. Researchers then started to observe the amount of time it took for facilities to recover from this early dip in finances, then reports of improved revenue began to be published. These gains were

mainly from improved efficiency and billing data quality, as well as detection and prevention of fraud. Evidence on use of eHealth systems to improve financial management and reduce fraudulent practices in the health sector was, however, limited, especially from developing countries. This thesis added evidence to the global literature on effects of eHealth system implementation on revenue, fraud prevention and financial management in a resource-limited setting.

1.3 Objectives, Research Questions and Specific Aims

While the potential of eHealth to strengthen health systems in low- and middle-income countries is widely acknowledged, there has remained little high quality evidence to substantiate this (Piette et al. 2012; Driessen et al. 2013; Wang et al. 2003), which hinders informed policy-making and practice. This study investigated the implementation and effects of a bespoke eHealth system at ten facilities (one hospital and nine health centres) in rural Malawi, with a view to informing eHealth researchers, developers and implementers on implementation and adoption dynamics affecting eHealth system outcomes for strengthening limited-resource health systems. This evaluation used mixed methods case study design to depict the process and influences of the rollout of the eHealth system by making use of data captured using the electronic system to assess 'hard' effects on finances and data quality. It also employed qualitative methods to portray its implementation and assess 'soft' impacts on perceived quality and use of data in decision making during patient care and financial management.

This study had the broad objective of portraying the implementation of a bespoke eHealth system at ten linked facilities in rural Malawi, and any enablers, inhibitors and outcomes of its adoption.

It aimed at providing insights to help answer two broad questions for eHealth in LMIC:

Question 1: What general and unique features characterise eHealth implementation processes in LMIC settings? How do complex interactions between technological, organisational and social factors affect the ease of implementation and the success of adoption?

Question 2: How does introducing eHealth systems affect the quality and use of data for clinical and managerial decision making? How do such changes come about? Why do some expected changes not happen?

The specific aims of the study were:

Specific Aim 1: To describe the socio-technical and organisational facilitators, barriers and consequences of implementation and adoption of the eHealth system.

Specific Aim 2: To assess the quality of data captured in the eHealth system and its use in patient care, reporting and financial management.

1.4 Theoretical Perspectives

Many theoretical perspectives have been brought to bear in the study of eHealth. These include theories about the value of different forms of evidence and frameworks which can guide the analysis and interpretation of study findings. Diverse epistemological propositions are reviewed in this section, followed by theoretical lenses through which information systems may be evaluated. Different methodological approaches, including mixed-methods case studies, are then described.

1.4.1 Epistemological Propositions

In seeking to gather and interpret evidence, understanding philosophical perspectives on the nature of scientific truth is worthwhile. In this section, positivist or realist perspectives are compared with interpretive and soft-positivist ones, and the advantages and disadvantages of each epistemological proposition are discussed.

Although positivist and realist philosophies assume that there are realities that are stable and can be known, such realities being distinct from our personal values and understanding (Green & Thorogood 2014), in reality, people make sense of their place in the world, hold personal views about the researchers studying them, and conduct themselves in manners that are not determined in law-like ways. There is a significant body of literature on information systems that reflects the positivist approach, which attempted to validate or extend theories of information system success based on empirical studies (Hanmer et al. 2011), or in quasi-experimental studies, where the researcher does not have direct control over the technology being implemented (Cresswell & Sheikh 2014).

Interpretive epistemology, on the other hand, postulates that the importance of any variable is the meaning that each individual gives to that variable, which are

subjective creations built through interactions with others (Heeks & Bailur 2007), without invalidating the material existence of physical objects. An interpretive approach has been found to be more appropriate for socio-technical studies of eHealth systems (Ramaiah et al. 2012; Høstgaard et al. 2011; Boulus & Bjorn 2007), particularly in middle- and low-income country health systems (Mostert-Phipps et al. 2010; Moens et al. 2010; Scholl et al. 2011). An interpretive philosophy puts more importance on questions not about the 'reality' of the world, but about how people interpret it (Green & Thorogood 2014). Interpretive studies aim to construe the data that has been produced by developing categories of concepts whose assumptions are supported or challenged (Zaidah & Zainal 2007).

However, interpretive approaches have a limitation in that, assuming phenomena are nothing but social constructs and not categories of the natural world as posited by the positivist epistemologies, then we can only derive knowledge about them through similarly socially constituted categories (Green & Thorogood 2014), which is not helpful for scientific progress in, say, development of drugs or health technologies. Guidelines for undertaking an interpretive approach in information systems research were provided by Michael Myers and Heinz Klein (Myers & Klein 1999). They presented principles for interpretive field research. First was the fundamental principle of the hermeneutic circle, which achieved human understanding by an iterative process between contemplating the interdependent meaning of categories on one hand, and the whole that they form on the other. Second was the principle of contextualization, where the social and historical background of the research setting were critically reflected so that the way the current phenomenon being investigated emerged could be seen. Third was the principle of interaction between the researcher and the subjects, which showed how the interaction between the researcher and participants socially constructed the data. Fourthly, there was also the principle of dialogical reasoning,

Over the years, the strong boundaries between positivist and interpretivist stances were moderated and several views evolved spanning between these two extremes.

which required thoughtfulness to possible contradictions between the assumptions in the theory guiding the research design and actual findings, and revisions of the theoretical preconceptions. Included was also the fifth principle, multiple interpretations, which took into account differences in interpretations of the same events under study among the research participants. Sixth was the principle of suspicion, which cautioned interpretive researchers to be sensitive to participants who may possibly give biased or systematically distorted accounts of events.

Many researchers consider qualitative studies synonymous with interpretive approaches and quantitative methods with positivist approaches, which is erroneous (Conboy et al. 2012). On the other hand, one approach does not have to be exclusive from the other. In fact, over the years, the strong boundaries between positivist and interpretivist stances were moderated and several views evolved spanning between these two extremes (Nöhren 2016). Other researchers have used both positivist and interpretive approaches in a single study. For example, an interpretive approach to identify and examine the factors that affected the success or failure of an eHealth system was used in combination with a positivist survey of the same organisations to explore similarities and differences in their experiences implementing the eHealth system (Hanmer et al. 2011). Such an approach is often referred to as soft-positivism, which uses an established framework from theoretical literature conflated with qualitative data analysis based on multi-level stakeholders' views (Abraham & Junglas 2011b). Soft positivism assumes that research is fundamentally a process of uncovering or discerning pre-existing phenomena and how they are related (Madill et al. 2000). From a positivist standpoint, soft positivism approach brings prior expectations to the data analysis, while at the same time allows some unexpected findings and explanations to emerge from the data, an interpretive standpoint (Leidner et al. 2009; Ravishankar et al. 2011), as illustrated in Figure 1.

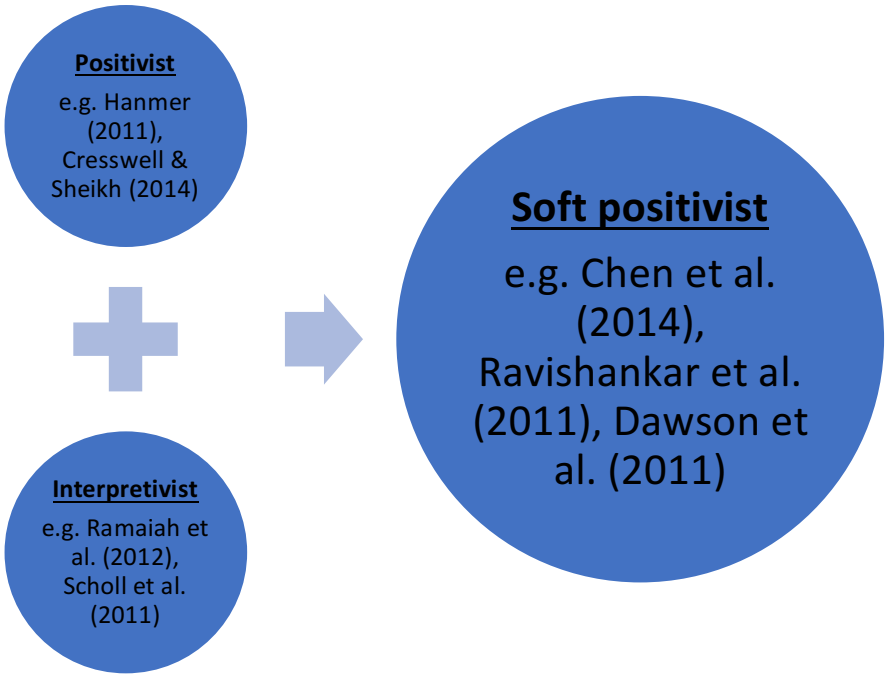

Figure 1 Epistemological Approaches in Information Systems Research

Soft positivism is also appropriate for poorly understood phenomena that are relatively stable and can be objectively observed, providing a research method that allows for in-depth insight and theoretical development (Dawson et al. 2011; Abraham & Junglas 2011a). Soft positivist approaches have been used in information system research on:

- e-government implementation (Chen et al. 2009; Chen et al. 2014),
- The role of information technology in crisis management (Leidner et al. 2009) and organisation transformation (Abraham & Junglas 2011b),
- Information systems alignment (Ravishankar et al. 2011),
- Theory building (Dawson et al. 2011),
- Relationships between information technology vendors and health facility managers (Du & Pan 2010; Dawson et al. 2011) and
- Information technology implementation and adoption (Bush et al. 2009; Goh et al. 2010; Hanmer et al. 2011).

In using a soft-positivist approach, evidence collected based on positivist and interpretive epistemologies are reviewed based on a logic model pre-developed for the study, comparable literature and themes derived inductively from the data.

1.4.2 Theoretical Models in Information Systems Research

In this section, three theoretical perspectives used in information systems research are depicted, followed by a review of four theoretical models for evaluating information systems. Conceptual frameworks used in eHealth research are also described.

In earlier years of eHealth system implementation, James Anderson and Carolyn Aydin discussed three theoretical perspectives in information technology (IT) system evaluations (Anderson & Aydin 2005). First was the perspective that the IT system is an external force that affects users and the organization. A second perspective stated that the organisations' managers and system users regulate the design, implementation and impact of information systems through intricate social interactions within the organization. Third, there are two-way interactions between complex social interactions within organizations that determined the use and impact of information systems.

Assumptions of change derived from these perspectives followed three narratives, as shown in Figure 2. One narrative envisaged increased efficiency, improved skill requirements, more mutually dependent jobs and enhanced communication, as anticipated by the project designers, system developers and implementers. A contrary narrative was the pessimist position that predicts negative outcomes of the information technology, such as robbing workers of their capabilities and decreasing their interactions through job routinization and fragmentation, and breeding conflicts over control of information and other resources (Anderson & Aydin 2005). As some eHealth research studies evolve, it becomes progressively clear that a pluralist

narrative emerges, observing that the computer system can have both sequestering and assimilating capabilities, with actual impacts dependent on what the organization, managers and users do with the technology and how the implementation has been managed (Anderson & Aydin 2005).

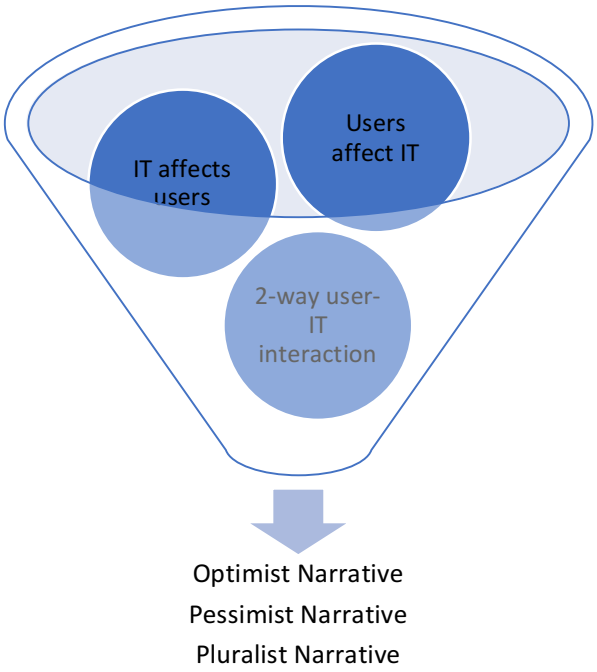

Figure 2 Theoretical Perspectives in Information Systems

A theoretical model often consulted when examining the enablers and inhibitors to the adoption of eHealth systems is the Diffusion of Innovation (DOI) theory. Developed by Everett Rogers (Rogers 2003), this theory envisages adoption of innovations as being dependent on the innovation being more beneficial than, and compatible with, the existing systems, and that these benefits are evident, with the innovation being able to be modified, and that the innovation is simple and easy to understand and use (Butler et al. 2013). It categorises diffusion of innovations to transition through society from Innovators, Early Adopters, Early Majority, Late Majority to Laggards (Rogers 2003). Although this theory is more descriptive, with its predictive ability for change management not well-established, it is helpful for giving prominence to social factors in IT design and development (Car et al. 2008). Since health systems are complex social systems, the DOI theory has been used to

determine social characteristics that affect decisions to adopt or reject IT systems at an individual level, and categorize adopters based on these social characteristics (Morton & Wiedenbeck 2010). Modifications to the theory have been made to include other dimensions such as the attitude of users towards the information system, its interoperability with other systems, availability of technical support, how it impacts workflow, how users communicate with each other, and continuous presence or absence of expert support (Castillo et al. 2010). Many qualitative literature on adoption of health information technologies base their conceptual models on the diffusion of innovation theory in its pure form, or as modifications, such as those done by Trisha Greenhalgh (Greenhalgh et al. 2004; Greenhalgh et al. 2008; Greenhalgh et al. 2010), Hossein Ahmadi (Ahmadi, Nilashi, et al. 2014; Ahmadi, Darvishi, et al. 2014; Ahmadi et al. 2015) and others (Butler et al. 2013; Xierali et al. 2013; Hochron & Goldberg 2014; Menachemi & Collum 2011; Adams 2015).

A further theoretical model that influence eHealth research is the Technology Acceptance Model (TAM) to study inhibitors and enablers of acceptance and adoption of an eHealth system. Developed by Fred Davis (Davis 1989), this model centres on factors that determine the behavioural intentions of users toward using a new technology based on their perceived usefulness of the system and its perceived ease of use (Wilkins 2009). For instance, Mary Morton and Susan Wiedenbeck used the TAM to assess physicians' acceptability of an eHealth system (Morton & Wiedenbeck 2010). They noted that often there were other variables apart from perceived ease of use and perceived usefulness that predicted intention, making it necessary to develop an extended model for explaining factors that impact user acceptance. For instance, their quantitative study found that none of the physicians' social attributes correlated with any of the TAM variables.

However, user beliefs and attitudes have been found to change over time as users gain personal experience in using the information system, which may thereby change their ensuing behaviour in using the information system (Bhattacherjee &

Premkumar 2004), either toward enhanced use of the information system or its abandonment, which the TAM does not address. Several other authors also raised other concerns about other limitations of TAM, particularly its inability to address inhibitors to acceptance (Lin et al. 2012), with researchers making modifications to overcome such deficiencies. Indeed, the model has often been modified, as shown in Figure 3, for instance by including clinical, individual and regulatory factors (Rho et al. 2014), taking into account external variables and barriers to adoption such as access or knowledge (Jimoh et al. 2012), and adding demographics, IT support and user satisfaction variables (Chow et al. 2012).

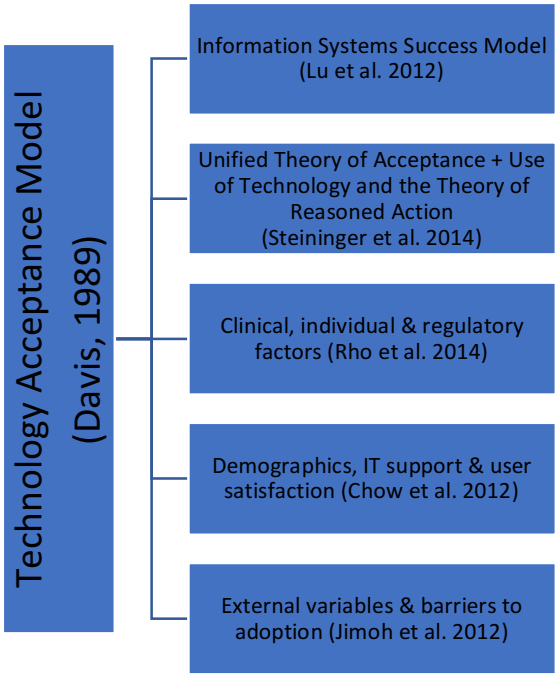

Figure 3 Modifications to, and Models Used in Combination with, the Technology Acceptance Model

Apart from making modifications to TAM, other authors have also used the model in combination with other theoretical models (Gagnon et al. 2014), such as:

- in combination with the Information Systems Success Model (Delone & Mclean 2003) to benefit from its "comprehensive and specific categories of evaluation, proven validity, and applicability in the evaluation of health information systems" (Lu et al. 2012);

- in combination with the Diffusion of Innovation theory to cover the social processes surrounding implementation and adoption (Morton & Wiedenbeck 2010; Morton & Wiedenbeck 2009); and
- in combination with both the Unified Theory of Acceptance to reflect characteristics of a contextual eHealth system implementation, and the Use of Technology and the Theory of Reasoned Action to predict behavioural intention in the social psychological setting (Steininger et al. 2014).

Although the Technology Acceptance Model has been mostly used for quantitative studies of health information technology adoption, it is useful in deductively identifying and referencing themes for the qualitative data.

Taking into consideration the complex nature of health systems, the complex adaptive systems (CAS) conceptual framework has also been found to be useful. CAS is the interplay between various agents working together and corresponding in a wider environment where the agents and the environment are coevolving (Mason 2015). CAS has been used to evaluate information systems in other sectors such as e-government (Brewer 2006), and it has also been used in health system strengthening research in low- and middle-income countries (Swanson et al. 2015). Based on CAS, Dean Sittig and Hardeep Singh developed a sociotechnical model for studying eHealth systems in complex adaptive health care systems that comprised components of hardware and software; clinical content; human-computer interface; people; workflow and communication; organizational policies and procedures; external rules, regulations and pressures; and system measurement and monitoring (Sittig & Singh 2010).

Sociologists of technology recognize the co-dependency between information systems and their users within complex sociotechnical systems.

Reviewing complex adaptive systems can lead to further focus of eHealth studies onto a more sociotechnical evaluation. Complex interactions between professional,

technical, economic and political characteristics in a society are reflected in technologies developed and adopted by the soceity (Bijker & Law 1992). Sociologists of technology recognize the co-dependency between information systems and their users within complex sociotechnical systems, where human and organizational factors influence or 'shape' the technology (Mohammed & Yusof 2013; Williams & Edge 1996), while conversely introducing technology may shape professional roles and work practices (McCullough et al. 2014; Ancker et al. 2013; McGinn et al. 2011; Berg 1999; Berg & Toussaint 2003). As such, evaluation of eHealth system implementation should be approached not simply as a technical project, but explored as a process of organizational development, which recognizes the social context and consequences of implementation, in which the information system is drawn upon as a strategic asset to transform organizational structures and routines, and further the organization's goals (Bush et al. 2009; Berg 2001).

Indeed, unquantifiable, intangible benefits are often the most difficult to measure, a characteristic of most sociotechnical studies (Gomez & Pather 2012). Even in the rare moments that there is total agreement on the goals of an implementation, there exists no formula for success due to the complexity of the behaviour of sociotechnical networks at stake (Berg 2001). Technology affects the distribution and content of work tasks, changes the information flows, and affects the visibility of these work tasks and information flows. Because of this, it also changes relationships between groups of health care professionals and/or other staff (Struik et al. 2014; Cresswell et al. 2012; Berg 2001). For instance, an evaluation of technologies implemented in developing country health sectors by Alex Shovlin and colleagues identified contextual, business, and communication and coordination challenges (Shovlin et al. 2013). This complexity became more evident as the thesis progressed. Sociotechnical evaluations have been shown to be powerful tools to research complex technological

Sociotechnical evaluations need to break down the technology being evaluated into its individual segments, unpacking the interplay between hardware, software, content and user interfaces.

changes, particularly if the aim is to investigate non-linear relationships between technological, organisational and social processes (Cresswell & Sheikh 2014).

Embracing a user-oriented perspective, sociotechnical approaches emphasize that thorough insight into the work practices in which IT applications will be used should be the starting point for design and implementation (McCullough et al. 2014; Berg & Toussaint 2003; Berg 1999). Information technologies may enable a diverse set of outcomes that are difficult to link from an attribution or cause-effect perspective (Gomez & Pather 2012). The deep intertwinement between technological and human elements of the networks at stake implies that any design and implementation attempt is necessarily related to the widespread transformations in these networks (Berg 1999). As such, information technology evaluations frameworks now often focus more on the intangible aspects of business benefits such as brand improvement, loyalty and trust.

From a development perspective, information systems must be viewed as enablers of socio-economic development (Gomez & Pather 2012). In this way, the sociotechnical view of work emphasizes the need to address cooperative work processes rather than discrete tasks for individuals (Berg 1999). Work practices and processes need to be studied in detail and these studies are a prerequisite for effective systemic change (McCullough et al. 2014; Lluch 2011; Tjora & Scambler 2009; Berg & Toussaint 2003). Further, sociotechnical evaluations also need to break down the technology being evaluated into its individual segments, unpacking the interplay between hardware, software, content and user interfaces. This allows the investigator to separate out the causes of particular eHealth system implementation or use problems, thus helping to identify specific solutions (Sittig & Singh 2010).

Although most frameworks give more emphasis either to organizational aspects or to the human and technological aspects, evaluation frameworks that covers all the three aspects have been proposed (Mohammed & Yusof 2013), most based on the

Information Systems Success Model (Delone & Mclean 2003; Gray & Sockolow 2016). For instance, the Clinical Adoption Meta-Model (CAMM) is a temporal model with four dimensions to describe eHealth implementation processes and possible challenges with adoption: availability, use, behaviour changes, and outcome changes (Price & Lau 2014). Another framework based on the Information Systems Success Model was the HOT-fit framework, which identifies the fit between human (or social), organisational and technological factors to explain implementation and adoption of eHealth systems. It has been used in diverse ways, from evaluating eHealth systems for critical care in Malaysia (Yusof 2015) to conducting systematic reviews on eHealth implementation factors (Cresswell & Sheikh 2013).

Conceptual frameworks for eHealth system implementation enablers and inhibitors have been developed specifically for low-income countries. For instance, a recent systematic review identified 32 articles on benefits of and challenges to implementing eHealth systems in low-income settings (Jawhari et al. 2016). They then developed a conceptual framework that identified systemic, human, process, product and outcome factors of the benefits and challenges. Systemic factors were infrastructure such as reliability of power, network and connectivity. Human factors were socio-technical interactions between facility staff, IT staff, patients and the technology. These human barriers included lack of IT support, inadequate computer competency, and high staff turnover. Process factors recognised that eHealth systems often brought to attention dysfunctional processes and workflows, requiring a variety of mitigating interventions, ranging from engagement of users and their leaders to providing ID cards to patients. Poor performing digital products with bugs and missing features were also barriers to successful eHealth implementation in low-income countries. Common product challenges included difficulties for staff to login due to complex security features, backup rules that were time-consuming, or reporting requirements that were too complex. eHealth system outcomes varied from simply providing unique patient identifiers, to complex clinical decision support.

1.5 Methodological Approaches

Various methods are considered in this section, including the case study design and mixed methods approach.

1.5.1 Case Study Design

The case study design is presented, along with its strengths and limitations. There are several designs of case studies, and this section presents them, and how validity can be ensured.

There are three possible research methods appropriate for eHealth study: (i) the application description study method, which are written by the implementer to detail their experiences implementing a particular application, (ii) action research, in which the author is a participant in the implementation of a system, but simultaneously evaluating a certain intervention technique, and (iii) the case study method. A strength of the first two approaches is the in-depth and first-hand insight obtained by the researcher. However, a weakness is the potential lack of objectivity resulting from the researcher's stake in influencing a successful outcome for the organization. Further, it may be difficult to generalize the intervention technique to other situations where it is applied by people less knowledgeable than the researcher (Benbasat et al. 1987).

Case study methodology is designed as "an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident, relying on multiple sources of evidence" (Yin 2014). Case study allows the exploration and understanding of complex issues (Zaidah & Zainal 2007). When the form of the study question is how and why (e.g. how was the eHealth system implemented, how did the eHealth system affect quality and use of data for clinical and managerial decision

making, why did expected changes not happen, etc), a case study method is more appropriate (Benbasat et al. 1987). Further, when the behavioural events of programme designers, implementers and users can not be controlled, a case study is more appropriate than other approaches, such as experimental approach. Also, case study method focuses on contemporary events, although some limited historical events can be reviewed (Yin 2014).

Within the information systems research community, case study research has been accepted as an effective research strategy (Myers & Klein 1999). Case studies have been used to describe the implementation and challenges surrounding the wide adoption of eHealth in affluent regions such as North America (Safadi et al. 2015; Noblin et al. 2013; Abraham & Junglas 2011b), the UK (Greenhalgh et al. 2010; Greenhalgh et al. 2008; Cresswell et al. 2012), Denmark (Høstgaard et al. 2011), and Sweden (Rahimi et al. 2008). It has also been employed in low-income countries (Cripps & Standing 2011) including Nigeria (Idowu et al. 2006; Adindu & Babatunde 2006), Morocco (Bennani et al. 2012), South Africa (Hanmer et al. 2011), India (Scholl et al. 2011), Malaysia (Ahmadi et al. 2015) and Malawi (Douglas 2009; Driessen et al. 2013; Waters et al. 2010; Douglas et al. 2010)

Case studies are categorised as single case and multiple-case. A single-case design is most appropriate in cases where there are no other cases available for replication, or the case is unique, extreme or revelatory (Darke et al. 1998) and longitudinal (Yin 2014). To overcome a single-case design's inability to provide a generalising conclusion, triangulating the study methods confirms the validity of the process (Zaidah & Zainal 2007). Multiple-case designs, on the other hand, are more appropriate when the research intends to build or test a theory (Benbasat et al. 1987). Single and multiple case studies are further categorised into embedded and

Since the information systems area is characterised by constant technological change and innovation, researchers often trail behind practitioners in recommending changes or in presenting methods for developing new systems

holistic (Yin 2014). Holistic designs are more appropriate for studies that aim to present abstract findings without going into detail of individual cases. An embedded design, however, allows cross-case analysis and comparisons, similar results to be predicted (literal replication) or for contrasting results to be produced for reasons that are predictable (theoretical replication) (Yin 2014), and are enhanced by replicating the case through pattern-matching, where several pieces of information from the same case are linked to a theoretical proposition (Zaidah & Zainal 2007). Theoretical propositions for that can be the eHealth system's logic model and frameworks that describe the contingency factors to eHealth implementation, adoption and outcomes.

Most information system researchers now use the case study method, which is most appropriate for understanding the relationships between the information technology and organisational contexts (Darke et al. 1998). Case study may, however, not be appropriate for information systems research where the phenomenon being studied is mature and well understood and there already exist constructs that are well developed (Darke et al. 1998). Since the information systems area is characterised by constant technological change and innovation, information systems researchers often trail behind practitioners in recommending changes or in presenting methods for developing new systems (Benbasat et al. 1987), thus the insatiable need for case study methods to continuously review theories and assumptions in this field full of flux.

Just like any other research strategy, case study method has disadvantages, as no strategy is more suitable than all others for every research purpose (Benbasat et al. 1987). First is the danger of bias, as the processes of data collection and analysis in case studies are exposed to the influence of the researcher's characteristics and background, relying to a large extent on the researcher's interpretation of events, documents and interview material (Darke et al. 1998). However, even in the design and conduct of other types of research, bias is unavoidable (Yin 2014). Personal reflections need to be included in the study and continuously explore possible sources of bias. Secondly, case studies are often accused of lack of rigour, particularly if the

case study investigator has been sloppy, allowing oblique evidence or biased views to influence the findings and conclusions (Zaidah & Zainal 2007). There needs to be continuous triangulation of data during the writing of the research findings, verifying claims with documentary evidence where possible and accounting for missing evidence, and testing qualitative findings against quantitative results. Thirdly, since case studies use a small number of subjects, some conducted with only one subject, they may provide very little basis for scientific generalisation. However, case studies aim for theoretical and analytical generalisation, and not statistical generalisation (Yin 2014). Further, longitudinal studies that use two or more waves of interviews and data collection several months apart can help ensure generalizability of the findings (Venkatesh et al. 2016). Lastly, case studies are often viewed to be too long and difficult to conduct, producing an enormous amount of documentation (Zaidah & Zainal 2007). However, systematic management and organization of the data produced by the study in appropriate backed-up folders ensures evidence is preserved.

1.5.2 Mixed-Methods Approach

Mixed methods are firstly differentiated from multiple methods approaches in this section, followed by characterisation of mixed methods studies, and their appropriateness in information systems research. Examples of use of mixed methods in information systems research are portrayed later in the section.

Case studies allow for both quantitative and qualitative data analyses (Zaidah & Zainal 2007), and mixed methods were thought to provide more rigour to the case study approach, as discussed above. Mixed methods should not be confused with multimethod research, which uses two or more methods but of the same worldview (e.g. two methods of quantitative research). Mixed methods use two or more methods from varying worldviews (i.e. quantitative and qualitative methods together), either concurrently or sequentially (Venkatesh et al. 2013), although in some studies the

terms are used interchangeably, e.g. (Soffer & Hadar 2007; Piccoli & Ives 2003). Mixed methods case studies are particularly appropriate for studying the interaction between information systems and social and organisational complexities (Kaplan & Duchon 1988; Venkatesh et al. 2013). Using both quantitative and qualitative data, mixed methods studies facilitate explanation of both the process and outcome of a phenomenon by observing, reconstructing and analysing the cases being studied (Zaidah & Zainal 2007). Mixed methods has the advantages that it has the ability to simultaneously address both confirmatory and exploratory research questions, provide more robust inferences than a single method or worldview, and provide an opportunity for a greater variety of interpretations that are divergent and/or complementary (Venkatesh et al. 2013). Using mixed methods of data collection provides opportunities for triangulation, giving more vigorous support to the researcher's conclusions (Benbasat et al. 1987).

There is growth in information systems research that employs a mixed methods approach (Venkatesh et al. 2013). While qualitative data can help to illuminate social processes and perceptive attributes such as individual attitudes and expectations, organisational strategies and policies that have been planned, and the context of technology use, quantitative work can complement these qualitative data by probing the impacts of technology on social systems that can be directly measured, for instance, investment and maintenance costs, benefits and returns on investment, and the system's impact on quality of care (Cresswell & Sheikh 2014). Mixed methods have been used in information systems research for various reasons (Venkatesh et al. 2013), such as:

- To gain additional views about the same case or relationships, e.g. (Soffer & Hadar 2007),
- To obtain a thorough picture of a phenomenon, e.g. (Piccoli & Ives 2003),
- For inferences from one methodological strand to raise questions for the subsequent strand (sequential mixed methods), or one strand testing hypotheses that were developed from the previous strand, e.g. (Becerra-Fernandez & Sabherwal

2001),

- For understanding derived from one strand of the study being explained or expanded in the subsequent strand, e.g. (Koh et al. 2004; Leidner et al. 2009),
- To use one approach to test the reliability of conclusions obtained from the other approach, e.g. (Bhattacherjee & Premkumar 2004),
- For one strand to compensate for the weaknesses of another approach, e.g. (Dennis & Garfield 2003), and
- For attaining diverse views of the same phenomenon, e.g. (Chang 2006).

Due to the complexity of introducing new eHealth systems and difficulty in demonstrating their impacts (Harris et al. 2006), mixed-methods case study methodology are used to overcome some of this complexity and gain an understanding of the implementation processes, the challenges encountered and solutions involved, and outcomes. This methodology also helps in understanding how different system components operate and interact with user factors to influence defined outcomes, and in analysing contextual factors and extraneous seemingly unrelated influences, in order to aid interpretation.

1.6 Analytical Approaches

Analysis of both qualitative and quantitative data for both case studies is described in this section.

1.6.1 Qualitative Data Analysis

Analytical methods used are related to theoretical frameworks, and methods for ensuring validity of the qualitative analysis is presented in this sub-section. Use of framework analysis for qualitative data, and its rationale and description are outlined. Both inductive and deductive analytical approaches are also given.

Qualitative methods are thought to be particularly useful in collecting and analysing data pertinent to the design of eHealth systems (Anderson & Aydin 2005). Qualitative studies have been shown to yield more reliable results when conducted by an outsider with considerable inside experience (Forsythe 1999). Both top-down and bottom-up techniques are used for data reduction, as advocated by proponents of mixed methods case studies (Yin 2014).

Mark Constas developed a two-dimensional model for ensuring validity of qualitative analysis (Constas 1992). This model reviews origins of categorization, sources of verification, nomination of categories and temporal designation of themes. These can be derived deductively from goals and objectives of the computerization programmes based on the logic model and literature of similar studies, as well as inductive categories derived in vivo from research transcripts. Sources of verification use the rational approach (which relies on reasoning and logic), the referential strategy that utilizes existing research findings or theoretical arguments, and participative approach by providing some of the

Framework analysis is specifically geared toward generating policy- and practice-oriented findings among health researchers.

participants the opportunity to review and possibly modify the conclusions of the study. Nomination of categories were similar to the origins of categorisation: computerisation programme goals and objectives, eHealth system's logic model, literature, and inductive coding of the transcripts. Temporal designation of themes were iterative, having been set *a priori* and *posteriori*, using framework analysis (Srivastava & Thomson 2009).

Framework analysis is specifically geared toward generating policy- and practice-oriented findings among health researchers (Green & Thorogood 2014), providing more depth than thematic analysis yet without the complexity of theory-building grounded theory analysis (Mills et al. 2014). Framework analysis follows a five-step process: familiarization; identifying a thematic framework; indexing; charting; and mapping and interpretation (Srivastava & Thomson 2009).

For an early career researcher using the framework analysis approach, translated interview transcripts are coded, optionally with the aid of software such as NVivo (QSR International Pty Ltd n.d.), making use of both deductive and inductive coding approaches (Green & Thorogood 2014; McAlearney et al. 2014). A deductive coding framework is then built based on the eHealth system's logic model and literature reviewed about implementation and adoption of information technologies in healthcare organisations, e.g. (Lluch 2011; Lau et al. 2013; Cresswell et al. 2012; McCullough et al. 2014), for instance from low-income countries, e.g. (Cripps & Standing 2011; Akhlaq et al. 2015; Lewis et al. 2012; Laing et al. 2014).

New themes that emerge from the data are coded inductively. Interview guides and transcripts can be reviewed to identify broad themes and issues in a preliminary coding process in order to organize the data into categories and themes around the interview questions (McAlearney et al. 2014; Constas 1992). Themes such as those around social shaping of technology can be explored (Williams & Edge 1996), thus gaining a holistic overview of the implementation and adoption landscape whilst still

allowing new themes to emerge (Cresswell et al. 2012). Collaborative work assists capture of richer data and drawing of more confident conclusions (Benbasat et al. 1987). As such, findings need to be discussed with other researchers, for instance principal investigators, to review emerging themes, paying attention to prior assumptions and how interpretations were reached, and alternative explanations can be sought. For the same reasons, findings should also be shared with designers, implementers and users of the eHealth system being studied, and academics. The initial logic model can further be validated and revised by iteratively moving back and forth between empirical data, relevant literature, and the emerging model, to ensure their alignment (Chen et al. 2014).

Content analysis quantising is a common method used in mixed-methods studies where, together with qualitising, it is the highest level of triangulated mixed methods data

Qualitative information can be transformed into quantitative data for quantitative analysis in a process called quantizing (Loehnert 2010; Miles & Huberman 1994). During this process, qualitative data is coded numerically so that it can be subjected to statistical analysis (Neale & Carroll 1999), a process called content analysis (Krippendorff 2004), different from qualitative content analysis. It is a common method used in mixed-methods studies where, together with qualitising, the conversion of quantitative data into qualitative categories or themes, it is the highest level of triangulated mixed methods data integration (Happ 2009). Themes from small or moderate samples can be dichotomized (made binary) to develop truth tables that can be used for qualitative comparative analysis, while dichotomized qualitative data from larger samples can be subjected to more complex statistical analyses such as bivariate or multivariate regressions, multidimensional scaling or correspondence analysis, where multivariate exploratory analyses have the advantage of not requiring data variables to have normal distribution (Bazeley & Kemp 2012). These dichotomized themes can also be analysed as inter-respondent matrices, which show which respondents contributed to a specific theme, or intra-respondent matrices, which show which data (statements or observations) contributed to a specific theme,

from which various types of effect sizes can be determined (Onwuegbuzie 2003). Despite concerns that dichotomizing themes strips them of their complexity (Sechrest & Sidani 1999), those complex meanings are assumed to be understood by both the subject and the investigator, and can be overcome by revisiting those qualitative data that have provided significant quantitative results (Venkatesh et al. 2016).

Qualitative data is coded numerically so that it can be subjected to statistical analysis, a process called content analysis.

For instance, in a comparative study between high- and low-performing Texas high schools and across school sizes (Perfetto et al. 2013), themes from the schools' mission statements were coded and quantized for quantitative analysis. Frequency of mention of each theme was converted into percentages to be used as prevalence rates, which acted as effect size measures. Pearson chi-square analysis was then performed to find differences that were significant among the themes between high- and low-performing schools and across school sizes.

Another study asked older adults aged 46 to 89 years undergoing cognitive screening open-ended questions about their experiences of Alzheimer's disease (Tappen et al. 2011). Ensuing qualitative responses were coded and quantized, and these quantized data were linked to participants' descriptive quantitative data and underwent chi square analysis for categorical data while interval data underwent analysis of variance (ANOVA). To illustrate guidelines for this type of mixed methods research in information systems, qualitative data from a study on factors that influenced adoption of technology in households was re-analysed (Venkatesh et al. 2016), where quantized qualitative data underwent descriptive analysis and correlations were run to determine the adoption factors.

1.6.2 Data Quality Assessment

Quality of data from eHealth systems are assessed by comparing their data to

benchmarks, and various methods of such comparisons are appraised, resulting in measures for completeness and accuracy of the data captured by eHealth systems.

Inconsistencies between the information appearing in patients' electronic and paper-based medical records can create challenges for health workers seeking to provide optimum care (Stausberg et al. 2003). Dimensions of data quality most commonly measured are completeness and accuracy (Weiskopf & Weng 2013), where completeness means the presence of the data element in both records, and accuracy means the data elements are correct, or in our case, both records have the same value for each element.

As part of the evaluation of eHealth systems, the equivalence of paper-based and electronic records was therefore assessed. Systematic reviews reporting levels of completeness and accuracy of electronic data are very rare (Hawley et al. 2014; Majeed, Car & Sheikh 2008). In a recent systematic review of quality of data in low- and middle-income countries (Ndabarora et al. 2013), completeness was found to range from 49.7% to 81%, and an average of 12.6% of electronic data were accurate.

Choosing data elements to include in these kinds of evaluation is not a straightforward process, sometimes requiring Delphi processes from a workshop to determine the appropriate data elements (Forster et al. 2008). Data elements have to reflect the type of information needed to fulfil the purpose of that system, whether patient care, disease surveillance, billing or research (Dixon et al. 2013; Köpcke et al. 2013).

Many data quality assessments quantitatively compare equivalent patient data in the electronic record and paper record (Jick et al. 1991). In such comparisons, the paper record is often treated as the 'gold standard' against which the electronic record may be judged (Roukema 2006; Wallace et al. 2002; Ayoub et al. 2007; Hohnloser et al. 1994), although in some studies the reverse has been done (Gadabu et al. 2011). Using

the term 'gold standard' can be misleading, as it implies that the paper-based data is absolutely accurate, which is often not the case (Ndabarora et al. 2013; Shovlin et al. 2013; Gadabu et al. 2011; Aqil et al. 2009; Stausberg et al. 2003; Kinonen et al. 2017). As such, the term 'benchmark' has been used in preference to 'gold standard' in this thesis.

However, paper-based records are not always recommended as benchmarks (Stausberg et al. 2003), and some evaluate discrepancies between the paper and electronic records without either one necessarily being treated as a benchmark (Mikkelsen & Aasly 2001; Stausberg et al. 2003). In such cases, either the electronic or the paper records, or both, are compared to an external benchmark, for instance:

- Interviewing the patients themselves (Pringle et al. 1995; Logan et al. 2001);
- Comparing with the expected number of data, such as diagnoses and treatments, per case, e.g. (Stausberg et al. 2003);
- A review of the data by an expert, e.g. (Tang et al. 2007);
- Comparing selected disease prevalence in the records with other facilities', regional or national prevalence, e.g. (Pringle et al. 1995; Stausberg et al. 2003); or
- Determining the economic outcomes of data capture, e.g. (Mieth et al. 2002), for instance by switching primary and secondary diagnoses (Simborg 1981) or simply through misclassifying them (Hsia et al. 1988).

In order to obtain a higher precision of completeness and accuracy (Stausberg et al. 2003), data elements in the benchmark and the electronic record are distinguished as being (a) present in both sources and correct, (b) present in both sources but incorrect in the electronic record, (c) present in benchmark record but absent in the electronic record, and (d) absent in the benchmark record but present in the electronic record (Logan et al. 2001). Completeness and accuracy can thus be calculated.

In instances where none of the records are a gold standard, the agreement between

the two records can be plotted using Bland-Altman analysis (Bland and Altman 1982). This method plots the mean between the two records (independent variable) against their difference (dependent variable). It then shows the distribution of the differences between the two records within limits of agreement, depending on the confidence interval chosen (Bland & Altman 1994; Zaiontz 2017). It has been used in medical informatics quasi-experimental studies (Harris et al. 2006), and more recently in assessing quality of paper registers in 22 Kenyan hospitals (Kihuba et al. 2014).

1.7 Ethical Considerations

Considerations for ethical conduct of the study are described, including methods for recruiting participants and obtaining their consent, data security, and acquisition of ethical clearance from the University of Edinburgh, Malawi Ministry of Health's Health Sciences Research Committee, proprietors of the participating facilities and respondents.

The research had minimal potential to induce any psychological stress or discomfort in participants since the focus was on professional practice and recorded outcomes. During the interview, the participants were asked questions about their experiences with the change management activities and with the computers and software. Their interaction with the eHealth system was also observed in order to understand how it fitted in with their workflow. There were also covert observation of electronic and paper health records to measure accuracy and completeness of the records. Being an interview, document review and observational study, it did not involve any physically invasive or potentially physically harmful procedures, and could not adversely affect participants in any other way. Interviewed participants were selected based on their strategic roles within the organisation and their involvement in the planning, delivery or use of the eHealth system over the period since its initial introduction. In-depth interview participants were recruited through direct approach purposively by the researcher, while focus group discussion participants were recruited through announcements posted at the facility notice boards inviting volunteers to participate in the study, and these posters provided information about the study and what would be expected of them.

Participants were given an information sheet before seeking their written consent. This information sheet was read with the focus group discussion participants as a group, and read by the in-depth interview participants individually. The information sheet and consent form were translated into Chichewa, the local language in Malawi.

An information sheet was provided to the participants together with a separate consent form for them to sign. It asked them whether they agreed that they have read (or someone has read to them) the information provided in the information sheet, they had been given an opportunity to ask questions and all their questions had been answered to their satisfaction. They were then given a copy of the consent form, and by signing the form, they willingly agreed to participate in the research. They also consented to being audio-recorded, except one participant, and the recorder was paused when that respondent spoke. These consent forms were kept securely in a locked drawer. Participants did not receive any financial or other benefit from their participation, although soft drinks were provided. None of the participants were particularly vulnerable, including being in a professional or client relationship with the researcher, and none were under the age of 16 years of age. None of the participants were interviewed in situations which compromised their ability to give informed consent.

In-depth interviews and focus group discussions were audio recorded for later transcription and translation. The study did not require collection of personal information from any persons without their direct consent.

All research projects carried out by staff or students in the University of Edinburgh's Centre for Population Health Sciences (CPHS) require due ethical process and approval. As per requirement of all research projects, a Level 1 form was completed, signed and submitted to the CPHS Ethics Review Group. As this project was identified by the Level 1 Self-Audit form as requiring formal ethical review, a Level 2/3 form was also filled out, signed and submitted. Approval to conduct the study was granted on 6th September 2015 by the CPHS Ethical Review Group, as shown in Figure 4.

Ethical approval was also sought from the Health Sciences Research Committee (HSRC) at Malawi's Ministry of Health. Approval from the HSRC was granted on 10th

November 2015 (approval number NHSRC #15/5/1424), as shown in Figure 4. Further approval to conduct the study was obtained from the proprietors of the health facilities where the research were to take place, on 23rd April 2015, 29th June 2015, 3rd July 2015 and 7th July 2015.

Telephone: + 265 789 400
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All Communications should be addressed to:
The Secretary for Health

In reply please quote No. MED/4/36

MINISTRY OF HEALTH
P.O. BOX 30377
LILONGWE 3
MALAWI

10/11/15

Paul Kawale
Nkhoma Hospital

Dear Sir/Madam,

RE: Protocol #15/5/1424: Strengthening health systems in Malawi through ICT: Evaluation of AfyaPro

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 # 15/5/1424
  The above details should be used on all correspondence, consent forms and documents as appropriate.
- APPROVAL DATE : 10/11/2015
- EXPIRATION DATE : This approval expires on 10/11/2016
  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) 789744, 0888344443 or by e-mail on mrcodoccentre@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

SECRETARY FOR HEALTH
2015 -11- 10

PROMOTING THE ETHICAL CONDUCT OF RESEARCH
Executive Committee: Dr B.Chilima (Chairman), Prof. K. Mulanje (Vice Chairperson)
Registered with the USA Office for Human Research Protections (OHRP) as an International IRB
(IRB Number IRB00001905 FWA00009976)

THE UNIVERSITY of EDINBURGH

CENTRE FOR POPULATION HEALTH SCIENCES
Ethics Review Group
Medical School
Teviot Place
Edinburgh EH8 9AG

Telephone 0131 650 3239
Fax 0131 650 6909
email: cphs.ethics@ed.ac.uk

06 September 2015

Dear Mr Kawale

Re: Strengthening health systems through ICT: evaluation of a health Information system for hospital and community care in Malawi.

Thank you for resubmitting your documentation with the amendments that were requested by the CPHS ethics committee. The amendments have been judged satisfactory. I am therefore pleased to be able to inform you that the above study has been granted ethical approval.

Please be aware that this ethical approval is in respect of the protocol and methods as described in the documents submitted to the committee (with amended documents superseding predecessors). If there is in the future *a change* to the study design/protocol/methods, you should check whether this means your level 2 application form needs to be revised, and submit to the committee (via me), any documents that have been revised (study materials/protocol/level 2 form), using tracked changes. You should make clear in your covering email whether:

(i) you are requesting ethical review of a study amendment; or

(ii) you are not sure whether such is needed and, in the first instance, would like the committee's opinion on whether a formal approval is needed of the amended design/methods.

Yours sincerely

Lesley McGoohan

Ethics Review Group Administrator

CPHS: http://www.cphs.mvm.ed.ac.uk/
Ethical Review Group: http://www.cphs.mvm.ed.ac.uk/intra/research/ethicalReview.php *(staff & PGR students only)*

Figure 4 Ethical Approvals from Edinburgh and Malawi

Summaries of the main findings were shared with facility and department in-charges through presentations at their meetings. In addition, supervisors at the district level were presented with more detailed findings of the research and asked to share this with clinic staff for the purposes of facilitating local implementation and adoption. In order to maintain anonymity, health facility names were changed in the final manuscript, and each health facility was given a pseudonym. This decision was

validated when the results were presented to research participants at the health facilities.

CHAPTER 2 STUDY CONTEXT AND INTERVENTION DESCRIPTION

Chapter Aims

- Describe the macro-and micro- context in which the study took place
- Profile the socio-economic situation in Malawi
- Depict health systems strengthening policies, strategies and interventions and their outcomes in Malawi
- Outline efforts to implement eHealth for improving health information management in the region
- Describe the bespoke eHealth system and implementation programme on which the PhD case study is based

2.1 Profile of Malawi

This section starts by describing the socio-economic profile of Malawi. Thereafter, health systems strengthening policies, strategies and interventions and their outcomes in Malawi are profiled, as well as the role of eHealth in strengthening the country's health information system. Results of the health systems strengthening policies, strategies and interventions are then given.

2.1.1 Overview of the Malawian Society

This section starts with a description of how the Malawian society is structured, followed by its demographic, health and economic profile.

A beautiful small, narrow southern African country, Malawi shares boundaries with Zambia, Mozambique and Tanzania. It has an area of 118,484 km^2, 1.5 times larger than Scotland, a fifth of which is covered by the magnificent Lake Malawi and other smaller lakes and rivers (Ministry of Health 2011), as shown in **Error! Reference**

ource not found.. Homes in Malawian communities are clustered into villages, which are further clustered into Group Village Headman (GVH) areas. Each GVH has a Village Health Committee comprised of 10 volunteers who oversee health issues in the community. This committee works with the Village Development Committee (VDC), also comprised of 10 volunteers from the community, who coordinate all socio-economic development activities in the GVH area. They report to the Area Development Committee (ADC), comprised of representatives from the Village Development Committees, and is presided by the Traditional Authority, who oversees the Group Village Headmen. Often the Traditional Authorities are clustered into constituencies, each represented by a Member of Parliament in the 193-member National Assembly from the country's 28 administrative districts.

Burdened with high total fertility rate (TFR), estimated at 5.7, and a low contraceptive prevalence rate (CPR) of 35% (National Statistical Office 2010), Malawi's population was estimated to be 14.4 million in 2011 (Ministry of Health 2011a), having almost doubled from 8 million over a 20 year period. More than half the population 95250 were women, and 44% were estimated to be of childbearing age.

Figure 5 Map of Malawi (Source: Ashley Stafford (https://monpcaffair.wordpress.com/malawi/))

By 2011, public health facilities served 56% of the population (National Statistical Office 2012), while the rest were served by traditional and spiritual healers, private pharmacies and private facilities. Many of the private facilities are non-profit Christian Health Association of Malawi (CHAM) facilities, which served 37% of the population, mostly located in rural areas where 85% of the country's population lived, and provided 22% of antenatal and 23% of delivery services to the Malawian communities (Christian Health Association of Malawi 2017). In 2011, antenatal attendance in Malawi had risen to 97% of pregnancies coming to term, and 84% of births were assisted by skilled personnel. Most of the households (93%) in the 2011 Demographic and Household Survey (MDHS, National Statistical Office 2012) had a child aged under five years of age, of whom 48% were stunted, 31% were underweight and 11% were wasted. Among the chronic diseases, HIV and TB accounted for 8% of the chronic disease burden, while malaria accounted for 6% (National Statistical Office 2012).

Agriculture was the predominant economic activity of the country, accounting for 35% of the GDP, 93% of export revenue and employing 80% of the workforce. Public services were funded 60% by taxes (personal income, company profits and trade) and 40% by donor grants. When these revenue streams were unable to cover the budget, the government borrowed from domestic banking and non-bank services, or from donor and foreign banks (Ministry of Health 2011a).

2.1.2 Health Systems Strengthening Policies and Strategies

Starting from the constitutional provision in 1994, Malawi's health systems strengthening efforts are described in this section, as reflected in the country's development and health policies and strategies to meet the country's constitutional obligation.

Malawi's Constitution safeguards the health of its citizens as its 13th principle of

national policy (Malawi Government 1994). Adopted in 1994 soon after the change to multi-party democracy, it set the goal "to provide adequate health care, commensurate with the health needs of Malawian society and international standards of health care" in its Chapter III Clause 13(c). In pursuit of this goal, in 1999 the Ministry of Health produced its strategic vision to strengthen Malawi's health systems by the year 2020 (Malawi Ministry of Health and Population 1999). This strategy defined the Essential Health Package (EHP), a quantifiable, costed package of health services to be accessible by every citizen free of charge within 5 kilometres. It also introduced the Sector Wide Approach (SWAp), a consortium of health sector development partners with a secretariat at the Ministry of Health. At the same time, Malawi embraced its "Vision 2020", the country's development vision for the year 2020, which acknowledged improvement of the availability, accessibility and quality of health services as one of the country's social sector strategic challenge (Malawi Government 2003).

From 2004, these health systems strengthening strategies began to be guided by an annual Programme of Work (PoW) in implementation of its interventions to deliver the EHP. In terms of SWAp, government ministries and departments, donor partners, international and local civil society and the private sector, developed, implemented and monitored the annual Programme of Work. In 2011, with key lessons from the evaluation of the PoW and SWAp, the Malawi Health Sector Strategic Plan (HSSP) succeeded the PoW to guide implementation of interventions in the health sector between 2011 and 2016 (Ministry of Health 2011a). One of the key strategic changes was the inclusion of non-communicable diseases in the EHP after noting their increasing burden in Malawi (Msyamboza 2011), particularly mental health, hypertension, diabetes, cancers and other lifestyle diseases. Other health systems strengthening interventions in the HSSP were public health programmes, including activities addressing environmental and behavioural risk factors, programmes to make resources for health services more accessible (infrastructural and human resources), and programmes to improve the quality of those health services.

At the same time in 2011, the Government of Malawi had developed and started implementing the second Malawi Growth and Development Strategy (MGDS II), the country's medium term strategy for the period 2011 to 2016. It followed the expiry of the first MGDS that covered the period 2006 to 2011. With a focus on poverty reduction, sustainable economic growth and infrastructure development, one of the nine key "priorities within priorities" of MGDS II was the category Public Health, Sanitation, Malaria, and HIV and AIDS Management (Ministry of Finance and Development Planning 2011).

At policy level, the National Health Policy (NHP) was being developed, encompassing reforms in infrastructure, human resources, medical supplies, quality assurance, public-private partnerships, financing and management. In the draft policy, while the Ministry of Health was responsible for health policy, human resources management and medical supplies, the Ministry of Local Government and Rural Development was responsible for management, public-private partnerships and service delivery, and the Ministry of Finance was responsible for health financing (Ministry of Health 2011a).

2.1.3 Strengthening Malawi's Health Information System

This section deals with the development and use of eHealth systems in the context of Malawi's policies and strategies to strengthen its health information system as part of wider health systems strengthening strategies, and the state of ICT in the country, focusing on both challenges encountered and efforts to improve the country's health information systems through eHealth.

In 2013, the Ministry of Health developed the Malawi Health Information Systems Strategic Plan that aimed to develop "a sustainable, integrated National Health Information System capable of generating and managing quality health information

for supporting evidence-based decision-making by all stakeholders at all levels of the health system" (Ministry of Health 2013). In the strategic plan, adoption of electronic medical records (EMR) systems was one of the key products aimed at improving data quality, and the plan was to implement them in all hospitals by 2016.

In 2014, the National Health Information System Policy was developed (Ministry of Health 2014a), providing policy guidelines for designing, developing, implementing, and utilizing health information systems in Malawi, guided by the principle of "information for action, action for improving efficiency, quality, and equitable coverage" at all levels of the health system. In the same year, the Ministry of Health also developed the eHealth Strategy aimed at computerising health services. Starting with an eHealth situation assessment, the process for developing the strategy was based on the eHealth Strategy Development Toolkit (World Health Organisation & International Telecommunications Union 2012). Malawi's eHealth strategy aimed to strengthen health systems by improving access to and quality of health care, and strengthening monitoring and evaluation (Ministry of Health 2014b).

Several eHealth interventions started being implemented in the country, some of these are described in Section 1.2.3. Efforts to computerise the pharmacies so that drug logistics could be managed electronically, and implementation of an integrated electronic human resource management information system, were some of the government's early eHealth interventions (Ministry of Health 2014b). Pioneers of eHealth systems in southern Africa included Partners in Health (PIH), who implemented OpenMRS in Rwanda in 2005 to support and improve HIV and TB patient care (Amoroso et al. 2010). OpenMRS was modified in Malawi by Baobab Health Trust to also capture HIV and TB data (Waters et al. 2010; Gottlieb 2008), and some years later chronic diseases and primary care. At district level, the District Health Information System (DHIS) was implemented in Malawi along with other middle and low-income countries (Health Information Systems Programme 2017), developed by the Health Information System Programme (HISP) led by the

University of Oslo (Braa et al. 2012; Monawe et al. 2015). DHIS was first developed as Excel sheets, then later as Microsoft Access files, and then web-based (DHIS2).

Mobile technologies were also developing as health system strengthening tools in Malawi. As of 2012 there were 4 million mobile phone subscribers, just over a third of the population, at 99.55% land area signal coverage. By 2015, an estimated 71.8% of Malawians owned mobile phones (Malawi Communications Regulatory Authority 2015), with most people owning a basic feature phone with only voice and SMS capabilities. There were several mobile health (mHealth) projects being implemented at community, facility and national levels, including Chipatala Cha Pa Foni (CCPF) Project for strengthening maternal, neonatal and child Health and Rapid SMS Project to strengthen surveillance of child nutrition (Malanga 2017), UNICEF's Programme Mwana strengthening early infant diagnosis of HIV and mother-infant postnatal visits, and John Snow Inc's cStock to strengthen community supply of drugs (The Johns Hopkins University 2017) and several other projects by D-Tree and the Clinton Health Access Initiative.

2.1.4 Malawi's Health System Strengthening Results

Results of health system strengthening strategies are given in this section, embedded with exemplar implemented interventions. In 2016, the Malawi Demographic and Health Survey (MDHS) (National Statistical Office & ICF Macro 2017) reported changes in the country's socio-economic and health indicators following the country's implementation of its second Malawi Growth and Development Strategy (MGDS II) and the Ministry of Health's first Health Sector Strategic Plan (2011 – 2016). These are portrayed below, compared to the situation in 2011 when these health systems strengthening strategies began, as depicted in the 2011 MDHS (National Statistical Office & ICF Macro 2011). Effects of health system strengthening interventions on access to, quality and outcomes of maternal and child health services, prevention and treatment of HIV, malaria prevention, and management of human and financial

resources for health in Malawi are shown.

MDHS reported improvements between 2011 and 2016 in household access to clean water, improved sanitation, electricity and mobile phone ownership, and more equal distribution of wealth, as shown in Table 1 below. In the middle of this period, it was estimated in 2013 that an average Malawian was earning only US$750 a year, 11.4% of which was spent on health (World Health Organization 2015), and wealth inequality decreased by 0.03 between 2011 and 2016.

Table 1 Socio-Economic Indicators for Malawi

Indicator	**2011 (%)**	**2016 (%)**
Access to clean water	79.7 (6.6 piped)	87.2 (8.3 piped)
Access to improved sanitation	8.2	51.6
Access to electricity	8.7 (1.7 for cooking)	10.8 (2.1 for cooking)
Mobile phone ownership	39.0	53.7
Wealth inequality (Gini coefficient)	0.42	0.39

Education attainment was also reported by the DHIS to have improved, with the rate of women without any schooling dropping slightly from 15.2% in 2011 to 13.9% in 2016, although women completing primary education remains low and dropped further from 9.3% in 2011 to 5.0% in 2016. Over two-thirds of households were male headed (69.4%), but the rate of uneducated men increased from 6.6% to 7.9% between 2011 and 2016, as the rate of men completing primary education declined from 9.2% to 6.0% between the two surveys. However, literacy levels were relatively high, with 72.1% of women and 82.4% of men being reported literate in 2016, slight improvements from 67.6% for women and 81.0% for men in 2011.

Between 1990 and 2013 maternal mortality ratio in Malawi decreased by 53% (WHO

et al. 2014), estimated at 439 maternal deaths per 100,000 live births in 2016, a decrease from a maternal mortality ratio of 675 in 2011. Strategies to improve measurement and prevention of maternal deaths included involving community members to identify and discuss maternal deaths, and a study showed that communities identified 25% more maternal deaths than health facilities (Bayley et al. 2015).

Legislation drafted to make abortion services more accessible in Malawi, advocated as a strategy to reduce maternal deaths, received mixed reactions in the country, with some arguing that the number of maternal deaths that could have been prevented by an abortion was not significant enough to justify the legal changes (Mwagomba et al. 2017). DHIS reported that in 2016, 91.3% of pregnancies resulted in live births, 3.4% resulted in stillbirths, 4.7% ended up as miscarriages, while only 0.6% ended in induced abortion (National Statistical Office & ICF Macro 2017), but was not reported in 2011. Attention has been drawn to health facilities also addressing the socio-economic effects of a maternal death, such as loss of financial and parental support to orphaned children in Malawi (Bazile et al. 2015). After the death of a woman, children no longer living with their father accounted for 1.8% of under-18 children in 2016, a reduction from 2.0% in 2011 (National Statistical Office & ICF Macro 2017; National Statistical Office & ICF Macro 2011).

Perinatal deaths in Malawi have been estimated to be 35 deaths per 1,000 pregnancies, with the rate going up to 40 and 82 deaths per 1,000 pregnancies in urban and educated women, respectively.

Neonatal care quality improvement interventions have been shown to reduce neonatal deaths in Malawi (Fottrell et al. 2015), but neonatal deaths remained high in many other facilities. Perinatal deaths in Malawi have been estimated to be 35 deaths per 1,000 pregnancies (National Statistical Office & ICF Macro 2017), with the rate going up to 40 and 82 deaths per 1,000 pregnancies in urban and educated women, respectively. This was, however, an improvement from 40 deaths per 1,000 pregnancies in 2011 (National Statistical Office & ICF Macro 2011).

Uptake of postnatal services have remained low, slightly reducing from 43.0% in 2011 to 42.4% in 2016 (National Statistical Office & ICF Macro 2011; National Statistical Office & ICF Macro 2017), admittedly of dubious statistical significance, given the level of measurement error involved. A study in Malawi found that barriers for parents to bring their infants for check-up two days after delivery included beliefs and perceived risks and benefits of postnatal care (Zamawe et al. 2015). MDHS reported a decline in the rate of children dying before their fifth birthday, from 112 deaths in 2011 to 63 deaths in 2016 per 1,000 live births (National Statistical Office & ICF Macro 2011; National Statistical Office & ICF Macro 2017). Some interventions in Malawi, such as the use of mobile phones to promote home based child care (Fotso et al. 2015), care groups (Perry et al. 2014) and integration of child health into HIV and maternal care services (Gunda et al. 2017), showed improvements in child health outcomes and reduced burden on health facilities.

Widespread implementation of provider-initiated HIV testing in maternal health clinics have been attributed to increased uptake of HIV testing services in Malawi (Ahmed et al. 2016). HIV prevalence in Malawi was reported by the MDHS to have reduced from 10.6% in 2011 to 8.8% in 2016 (National Statistical Office & ICF Macro 2011; National Statistical Office & ICF Macro 2017), although this change reflects both incidence and mortality changes combined, and so is not readily interpreted on its own. There has been increased attention to provision of HIV services to men who have sex with men (MSM) in Malawi (Graham & Harper 2017). A study found that HIV prevalence among MSM in Malawi was 12.5%, but 90% of them were previously undiagnosed, reportedly due to stigma and other structural challenges to getting tested (Wirtz et al. 2013). Similarly, low HIV testing among Malawian MSM was reported more recently (Wirtz et al. 2017), where HIV prevalence was 18.2% among MSM with over 99% of them having never been diagnosed with HIV or started treatment. One of the strategies to

HIV prevalence remained high among widows, being 50.1% in 2016, a rise from 31.8% of widows having HIV in 2011.

overcome these barriers was HIV self-testing, shown to have up to 89% adoption rate in Malawi, particularly among young girls, with 78% of those finding themselves with HIV seeking care (Choko et al. 2014). Fear of stigma was also reported among secondary school girls as one of the reasons why only a third of them had ever tested for HIV (Munthali et al. 2013). HIV prevalence remained high among widows, being 50.1% in 2016, a rise from 31.8% of widows having HIV in 2011.

Malawi's most significant outcome of HIV interventions in the HSSP period was the achievement of a 68% reduction in new paediatric infections, the highest change among global HIV priority countries (Adetokunboh & Oluwasanu 2016), which could be attributed to improvements in HIV treatment retention among pregnant and lactating women. Numbers of women with HIV remaining on treatment even after childbirth were high at 93.7% in 2011 while 80.7% reported giving their infant HIV drugs soon after birth (National Statistical Office & ICF Macro 2011). These indicators were not reported in the 2016 MDHS. One of the interventions implemented to improve treatment adherence for people with HIV in Malawi was the pill count strategy, which was found to have a 79% positive effect on treatment adherence (McKinney et al. 2016). Treatment adherence was even more urgent as Malawi became the first country to implement option B+ (Schouten et al. 2011), where HIV positive pregnant women were enrolled into lifelong treatment, regardless of the state of their immune system or viral load. Retention into treatment among these particular women was low, with as much as 58% dropping out of treatment at some facilities (Tenthani et al. 2014), due to logistical challenges (Coutsoudis et al. 2013) and socio-economic and cultural factors (Hoffman et al. 2017).

Malawi DHIS reported that, although insecticide treated mosquito nets (ITN) had long been widely distributed for malaria prevention, only 33.9% of the population actually used them in 2016, up from 29.0% in 2011 (National Statistical Office & ICF Macro 2017; National Statistical Office & ICF Macro 2011). However, prolonged widespread use of these nets in the country led to insecticide resistance (Riveron et

al. 2015), and use of ITNs was found to reduce malaria incidence by as little as 30% (Lindblade et al. 2015). This resistance also affected the outcomes of the country's indoor residual spraying (IRS) strategy for malaria vector control, such that the National Malaria Control Programme considered changing to a new type of insecticide for IRS (Chanda et al. 2015). Although it was described as the main strategy for malaria control in Malawi, only 2.2% and 4.9% of households had been sprayed in 2011 and 2016, respectively (National Statistical Office & ICF Macro 2011; National Statistical Office & ICF Macro 2017). As malaria emerged as increasingly affecting school children (Walldorf et al. 2015; Mathanga et al. 2015), spraying boarding schools and their surrounding communities presented an effective strategy.

Malawi also responded to a shift in global attention to focus on non-communicable diseases (NCDs), such as espoused by Sustainable Development Goal 3.4 (World Health Organisation 2017). For over a decade, eHealth systems had taken strides towards the global goal of ending epidemics such as HIV and TB (Fraser et al. 2007), while responding to emerging crises like the recent *Ebola* epidemic (Oza et al. 2017). However, there was still need to transfer best practices from these HIV interventions, such as use of eHealth for treatment adherence, to prevention and management of non-communicable diseases, as had been done by mHealth systems (Bloomfield et al. 2014) for hypertension (Hacking et al. 2016), diabetes (Dobson et al. 2015) and mental health (Marcano-Belisario et al. 2017).

Organisational interventions to strengthening human resources in Malawi's health system included recruitment of additional community- and facility-based staff at primary level, and improving district management's oversight role. Human resource interventions included sustained training and deployment of Medical Assistants to provide basic clinical care, particularly at rural facilities, as a temporary measure until the country had enough medical doctors (Muula 2009). At community level, training and recruitment of additional community-based Health Surveillance Assistants (HSAs) in Malawi significantly improved access to preventive and some curative

health services (Perry et al. 2016). Although HSAs were reported to be motivated by their work, their peers and their communities, and 79.2% of community members expressing positive perceptions of their HSA, the HSAs have also reported being demotivated by their working conditions, with their managers conversely reporting negative opinions of the HSAs (Kok & Muula 2013).

Regarding their role of supervising the health facilities, mid-level district health managers in Malawi have reportedly perceived it as a form of control and inspection, unlike those in neighbouring Tanzania who regarded the role as support for improvement (Bradley et al. 2013). In addition, a randomised controlled trial in these same countries showed that even with intensive supervision, the improvements in basic knowledge and skills were very modest, with insignificant effects on clinical outcomes (Kalua et al. 2014). Another study in these same countries, however, showed that a formal supervision process predicted mid-level health workers' improved job satisfaction and retention (McAuliffe et al. 2013).

Government has continued to commit to finance Christian Health Association of Malawi (CHAM), private non-profit facilities to offer free maternal and child health services through Service Level Agreements (SLA). Unfortunately, this private-public partnership had not lived up to its potential to provide universal health care to the most vulnerable (Abiiro et al. 2014) due to the failure of the Government to place adequate funds behind their commitment and due to the limited infrastructure and human resources at the CHAM facilities (Chirwa et al. 2013). Nevertheless, a more recent study reported improved facility usage, such as 15% and 11% increases in antenatal visits and facility deliveries, respectively, as a result of the SLAs (Manthalu et al. 2016). Despite these increases in service uptake, quality remained poor (Tambulasi 2014).

2.2 Description of the Intervention and its Logic Model

This section describes the bespoke eHealth system that is the subject of this study. Also given in this section is the logic model developed for the eHealth system implementation, adoption and outcomes.

2.2.1 The Bespoke eHealth System

A bespoke modular, integrated eHealth system was implemented at 10 rural health facilities in Malawi as a means of enabling data collection and sharing for patient care, hospital management, revenue collection and public health reporting. It was developed in Tanzania with the support of a Dutch non-profit agency specializing in ICT for Development, and it had been used in at least 15 hospitals in Tanzania. Implementation was informed by the WHO change management guide for health management information systems (World Health Organization 2004) and the Roundtable approach to stakeholder involvement (Moens & Broerse 2006) aimed at facilitating eHealth system ownership, increasing eHealth competencies and assisting with institutional integration of eHealth systems. There were eight modules available in the eHealth system: outpatient registration, outpatient billing, diagnosis and treatment, reproductive and child health (antenatal care, delivery, postnatal care, family planning, under five care), inpatient module (registration, billing, diagnosis and treatment), laboratory module (requesting and recording lab tests and results), stock and inventory module, and HIV/ART module (including HTC and PMTCT).

This integrated eHealth system used client-server Windows-based technology, where one computer hosted the system as a server and other computers stationed at different service points would connect to the server to access and use the eHealth system modules. In this way all data was stored and accessed from the server, hence there was to be (i) shared access to the data, (ii) real-time updates of the data, (iii) security and safety of the data, (iv) use of minimal resources for scaling up, as all

additional modules and clients would be added onto the existing server, (v) easy management of the whole system, as changes or adjustments would only be made on the server and would reflect on all service points, and (vi) easy to create backups for offline storage. Two powerful computers were to be used for servers, one as a real-time server and the other as a backup server to use in case of emergencies. All the client computers were thin client nano-computers that were affordable, easy to manage and had very low power consumption.

2.2.2 Logic Model of the Bespoke eHealth System

Discussions held early in the study with stakeholders involved in the development and implementation of the eHealth system consistently indicated that the programme was influenced by the developers' claims that the system would improve the quality and use of data for decision making during patient care, reporting and financial management. Based those discussions, the bespoke eHealth system project documents and the literature reviewed in Section 1.2, a logic model was developed, which is shown in Figure 6. This logic model charts the available interventions, their presumed mechanisms of impact and their expected outcomes. There were three parts of the intervention: organizational change management, infrastructural facilities (hardware) and eHealth system modules (technology). These three parts of the intervention are collectively referred to as the "eHealth system".

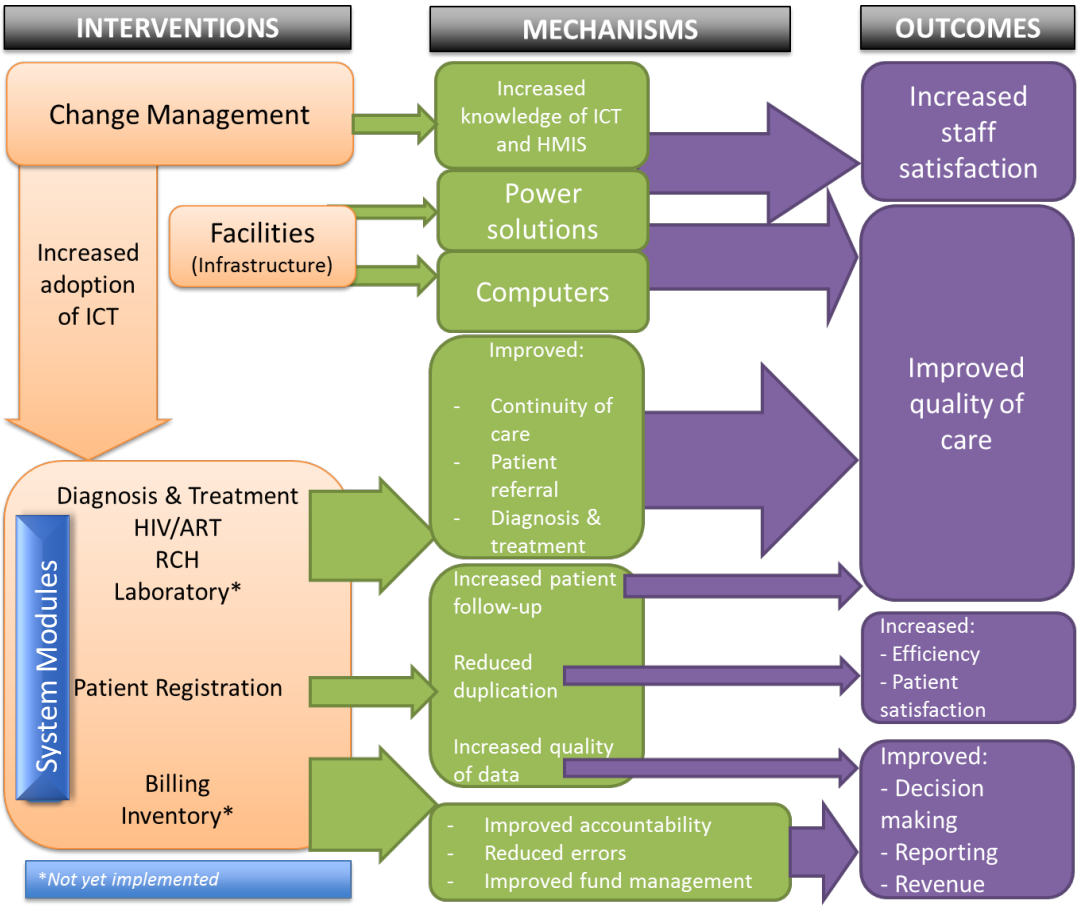

Figure 6 Logic model for eHealth Implementation, Adoption and Outcomes

The change management process was aimed at increasing knowledge of ICT among health facility staff, leading to increased staff satisfaction and adoption of the eHealth system. Implementation of the eHealth system was planned to tackle both the managerial and administrative side, as well as the technological aspects. Information systems were understood to work well if there was willingness and motivation to properly use the system, strengthened by a robust and useful eHealth system. It was understood that a technological solution that did not have the backing and support of all users and management would yield negative results. One focal area in developing the eHealth system was the ability to use the collected and processed information for decision making. This involved a 6-step process described below, as developed by Nic Moens and colleagues (Moens & Broerse 2006; Moens et al. 2008; Moens et al. 2010), which included the creation of awareness, setting up committees

and user groups, training them in basic computer use and data entry in the various modules, and continuous support to build a business case for the eHealth system.

Below are the six steps that were planned to be undertaken in implementing the bespoke eHealth system at the 10 health facilities in Malawi:

A. ***Change management workshops*****:** These were workshops aimed at making both staff and management understand the concept of ICT and prepare them for implementation. They were divided into two categories:

a. High level workshop: To be done with management members of the facility, this was to set a steering committee to oversee project implementation in line with a pre-set vision.

b. Implementation level workshops: These were to be done with all staff and set up implementation committees for specific modules to be deployed.

B. ***Requirements gathering*****:** This was a process where the implementation committees for specific modules were to visit the health facilities and interact with staff to understand how work was done, with a focus on data collection processes. These requirements were to be documented and used to build a system to suit the facility.

C. ***Local area networking, security reinforcement and power solutions*****:** As the system was a client-server based technology, client computers needed a means to connect to the server. To achieve this, a wired or wireless local area network was to be built to enable the client computers access the eHealth modules on the server. To protect the servers and client computers, infrastructural reinforcements were to be put in place at the facilities. Another part of the eHealth system intervention was to install solar power at health facilities with intermittent or no power from the national power grid, and backup power at facilities that were connected to the national power grid. These also aimed at increasing staff satisfaction and improving quality of care, as the computers and power systems would have other benefits for staff and the health facility.

D. ***Basic computer training for staff*****:** Most of the users in low-income country rural

health facilities had little or no knowledge of computers. This step of the implementation was to equip staff with basic computer knowledge and skills.

E. ***Roll out and on-site system user training*:** At this stage, the IT team was to deploy the servers and client computers, as well as installing the eHealth system modules. After installing the modules, users were to be oriented on how to use the system and to be continuously supported on daily basis for two weeks on site while using the system.

F. ***Support*:** This was to be an ongoing process of supporting the system users on the hardware and software problems they may encounter. Support was to be offered via remote or onsite.

Mechanism and outcomes sections of the logic model in Figure 8 above show that implementation of the bespoke eHealth system modules was to affect quality of care through improvements in continuity of care, patient referral, diagnosis and treatment, and patient follow-up. Reduced duplication of registration data and patient history was expected to increase efficiency and patient satisfaction. Data quality was envisaged to affect reporting, decision-making and revenue. Revenue was anticipated to also be affected by improved accountability, reduced errors and improvements in fund management.

CHAPTER 3 MADALO HOSPITAL: RETROSPECTIVE CASE STUDY

Chapter Aims

- Present an in-depth biographical analysis of the planning and implementation of the eHealth system
- Analyse the formal processes and the socio-technical dynamics characterising the technology customisation and implementation
- Describe the effects of the eHealth system on quality and use of data for service delivery, reporting and financial management
- Analyse the cultural and behavioural factors influencing acceptance, use and effectiveness of the system

3.1 Methods

This subsection presents the methods that were used at Madalo Hospital, outlining both the qualitative as well as the quantitative approaches used. Qualitative methods included document review and key informant interviews, while quantitative methods were used for finance data and data quality assessment.

3.1.1 Philosophical and Methodological Design

A soft-positivist epistemology was adopted for the thesis, where evidence was built using realist and interpretive approaches (Green & Thorogood 2014). The theoretical perspective through which the evidence was analysed was: There are two-way interactions between complex social-technical and organisational factors within the health facilities that determine the use and outcomes of the eHealth system. Assumptions of change followed a pluralist narrative, observing that the eHealth system could have both sequestering and assimilating capabilities, with actual outcomes dependent on what the facilities, managers and users did with the technology and how the change had been managed (Anderson & Aydin 2005). An analytical framework specifically developed for Sub-Saharan Africa was used

(Jawhari et al. 2016), identifying dynamics among systemic/organisational, product/technological, process/change management and people/social factors, and outcomes.

A *retrospective* single-case, embedded design was used (Yin 2014). Madalo was the only hospital implementing the bespoke eHealth system and its change management process, and it was representative of referral and fee-for-service health facilities. Embedded units of analysis were (i) outpatient department (outpatient, maternal and child health, and HIV sections) and (ii) inpatient department (medical, paediatric and maternity wards).

To overcome a single-case design's inability to provide a generalising conclusion, study methods and data sources were triangulated to confirm the validity of the evidence. Further, pattern-matching was used, where several pieces of information from the case study were linked to a theoretical proposition, based on the logic model of the study (Zaidah & Zainal 2007).

Measures were taken during the study to ensure construct validity, internal validity, external validity and reliability (Yin 2014). A chain of evidence was established by using multiple sources to ensure construct validity, as well as presenting the findings to research participants to validate the evidence measured and conclusions drawn. Since this was an explanatory study, internal validity was ensured by addressing conflicting explanations through triangulation of methods and sources. Use of the logic model developed for the study (Section 2.2.2) also enhanced internal validity. Theories described in Section 1.4 were used so that the study could have external validity in the global health informatics domain, and use of the eHealth system implementation and adoption framework designed for Sub-Saharan Africa (Jawhari et al. 2016) ensured external validity in the developing world domain. Research protocol and case study database are available to enhance reliability of the case study's findings, such that they can be repeated.

A retrospective mixed methods case study design was utilised at Madalo Hospital to investigate implementation and adoption of the eHealth system, and its outcomes. Mixed methods were introduced in Section 1.5.2, while the case study design is appraised in Section 1.5.1. Topics of interest investigated during the study were the expectations for the eHealth system from various stakeholders, challenges faced during its adoption, and strategies that Madalo Hospital used to overcome these challenges. Effects of the eHealth system on quality and use of data for service delivery, reporting, hospital management and financial management were also reviewed.

3.1.2 Qualitative Methods

Qualitative methods were used in this study because they are particularly useful in collecting and analysing data pertinent to the design of eHealth systems (Anderson & Aydin 2005), and they yield more reliable results when conducted by an outsider with considerable inside experience (Forsythe 1999). Although the researcher worked at the research sites before this study, his involvement in the implementation of the eHealth system was limited, with the project being led by a manager, his IT team, and Dutch and Scottish technical advisors, yet the researcher had considerable knowledge of the project.

Validity of the qualitative process was ensured by following the model developed by Mark Constas (Constas 1992). This model examines origins of categorization, sources of verification, nomination of categories and temporal designation of themes. This case study's origins of categorisation were derived deductively from the logic model of the study as described in Section 2.2.2, the analytical framework described above (Jawhari et al. 2016), as well as inductive categories derived in vivo from the transcripts. Sources of verification used the rational approach (which relies on reasoning and logic), the referential strategy that utilised existing theoretical

frameworks, and the participative approach that provided some of the participants the opportunity to review and validate the findings and conclusions of the study. Nomination of categories were similar to the origins of categorisation: the study's logic model, the analytical framework and inductive coding of the transcripts. Temporal designation of themes were iterative, having been set *a priori* and *posteriori*, using Framework Analysis described in Section 3.1.4 below. Also, themes of the analytical framework were presented following implementation chronology and along a typical patient flow at the health facility.

This case study specifically used document review, artefact collection and key informant in-depth interviews as described below.

Document Review

Historical documents consisted of the proposal for implementation of the eHealth system at Madalo Hospital, 160 documents that included meeting minutes contained within the hospital's management archives and key reports, and 92 emails from 46 email conversations with the system user champion and 2,627 emails from the eHealth programme's technical advisor, which also described elements of the wider context of the intervention, such as government policy changes or national eHealth intervention programmes. Documents were annotated and summarised as part of the research process.

Key informant interviews

Thirteen semi-structured in-depth interviews were carried out with key stakeholders at Madalo Hospital, who were selected based on their strategic roles within the organization and their involvement in the planning, delivery and use of the eHealth system over the period since its initial introduction (Table 2). Using key informants can help to maximize the quality and usefulness of the data captured, by prioritizing those with the most knowledge and experience on which to draw (Marshall 1996). Respondents included four hospital managers, five health workers from clinical and

nursing departments, three IT staff and a ward clerk. Interviews took place at the hospital, where the researcher also observed the use of the eHealth system in practice. Interviews were conducted between September and December 2014, with follow-up interviews taking place iteratively to clarify findings as the study progressed. Each interview lasted an average 46 minutes and was documented by hand using annotated field notes, as well as audio recorded with the consent of the participants.

Table 2 In-depth Interview Key Informants

Respondent	Department	Gender	Role
1	Clinical	Male	Management
2	Clinical	Male	Management
3	Pharmacy	Male	Head of Department
4	Nursing	Female	Management
5	Finance	Female	Management
6	IT	Male	Technician
7	IT	Male	Technician
8	Reproductive and Child Health	Male	Clinician
9	Paediatrics	Male	Middle-Management
10	Reproductive and Child Health	Male	Middle-Management
11	Paediatrics	Male	Data Clerk
12	IT	Male	Head of Department
13	Nursing	Female	Middle-Management

3.1.3 Quantitative Methods

Data Quality Assessment

Records from Madalo Hospital included onsite observation of the paper-based outpatient health management information system (HMIS) register, and data from the eHealth system that included registration and inpatient modules. Off-site records collected were 93 monthly reports from the online District Health Information System (DHIS2).

Further, at Madalo Hospital, patients' paper files were sampled for data quality assessment. All 1,549 patients who were discharged between 1st January and 31st March 2016 were included in the sampling frame, since this period represented the

most recent quarter at data collection time. To obtain a statistically representative sample of records to be reviewed from this sampling frame, sample size was calculated using Raosoft Online Sample Size Calculator (http://www.raosoft.com/samplesize.html) with 5% margin of error and 95% confidence interval. In a recent systematic review of quality of data in developing countries (Ndabarora et al. 2013), completeness was found to range from 49.7% to 81.0%, and an average of 12.6% of electronic data were accurate. A sample size of 235 records was returned, and systematic random sampling was used with an interval of 235. Electronic and paper records were obtained from the maternity, medical, paediatric and surgical wards.

Elements of the records selected to be assessed in this study were discharge date, gender, birth date, admission date, diagnosis, treatment and the discharging clinical officer. Values were only for the last hospitalization of the patient, discounting previous hospitalizations.

Financial Data

Monthly revenue from all fee-paying services from 2006 to 2013 were obtained from Madalo Hospital records as electronic and paper files, and exchange rates were calculated using a historical currency converter (http://www.oanda.com/currency/historical-rates/). Monthly patient numbers attending the hospital from April 2007 were obtained from the Malawi Government database (www.hispmalawi.org.mw/dhis/). The independent variable was implementation period, covering the months Jan 2006 – Aug 2009 (pre-implementation of the eHealth system) and Sept 2009 – Dec 2013 (post-implementation), and the dependent variable was monthly hospital revenue.

Monthly income data for the 44 months pre-implementation and the 52 months post-implementation was collected and analysed. Total revenue was calculated from combining separate patient fees arising from consultation (January 2009 onwards),

and from inpatient and dispensed drugs (July 2010 onwards). Other sources of hospital revenue such as donations and grants were excluded from the analysis. Raw revenue figures were adjusted for inflation using annual Consumer Price Index (CPI) values, obtained from the National Statistical Office of Malawi, and converting to equivalent 2013 prices, following the procedure recommended by Lilani Kumaranayake (Kumaranayake 2000).

Revenue data were sought from comparable hospitals, but they were not available for the period as far back as 2006. Within Madalo Hospital, revenue data for the main hospital was compared to revenue for a specialised care department that had not yet implemented the eHealth system. It should be noted that this specialised department was heavily funded by donors, with the programme actively going out to seek clients and the donors paid for them.

3.1.4 Analytical Approaches

Collaborative work assisted the researcher with capturing richer data and drawing more confident conclusions (Benbasat et al. 1987). Findings were discussed with supervisors to review emerging themes, paying attention to prior assumptions and how interpretations were reached, and alternative explanations were sought. For the same reasons, findings were also shared with developers, implementers and users of the eHealth system who participated in the study. The initial logic model was further validated and revised by iteratively moving back and forth between empirical data, relevant literature, and the emerging model, to ensure their alignment (Chen et al. 2014).

Qualitative Data Analysis

Review of Facility Documents and Artefacts

Project documents and email correspondence were reviewed manually to obtain the

timeline of implementation and the contextual factors. These documents and email correspondences were then imported into NVivo. A word search was executed based on the inductive and deductive themes from the Framework Analysis described below, and the study's logic model developed from both project documents and information systems literature on the implementation, adoption and effects of eHealth systems (Section 2.2.2).

Framework Analysis

Framework Analysis was employed because this type of analysis is specifically geared toward generating policy- and practice-oriented findings among researchers (Green & Thorogood 2014), providing more depth than thematic analysis yet without the complexity of theory-building grounded theory analysis (Mills et al. 2014). Framework analysis follows a five-step process: familiarization; identifying a thematic framework; indexing; charting; and mapping and interpretation (Srivastava & Thomson 2009).

During the familiarization step of the Framework Analysis, the investigator immersed himself in the data by listening to the interview recordings, transcribing and translating the interviews, and reading the translations and field notes several times. During the second phase, a deductive thematic framework was built based on a review of interview guides and on the logic model that was developed for the study (Section 2.2.2, Figure 6) to identify broad themes and issues so that the data could be organised into categories and themes (McAlearney et al. 2014). This was refined inductively by emerging themes or issues identified in the data transcripts, first tentatively and thereafter refined at subsequent stages of the analysis.

During the indexing phase of analysis, sections of the data that corresponded to particular themes were identified, as shown in Figure 7. Use of NVivo was beneficial at this stage. These sections of the data were arranged in charts of themes, a process called charting, corresponding the data to headings and subheadings derived

through the second phase of the analysis. Finally, mapping and interpretation involved analysis of the key characteristics as arranged in the charts, reviewing the theoretical framework and logic model to guide how the data was interpreted.

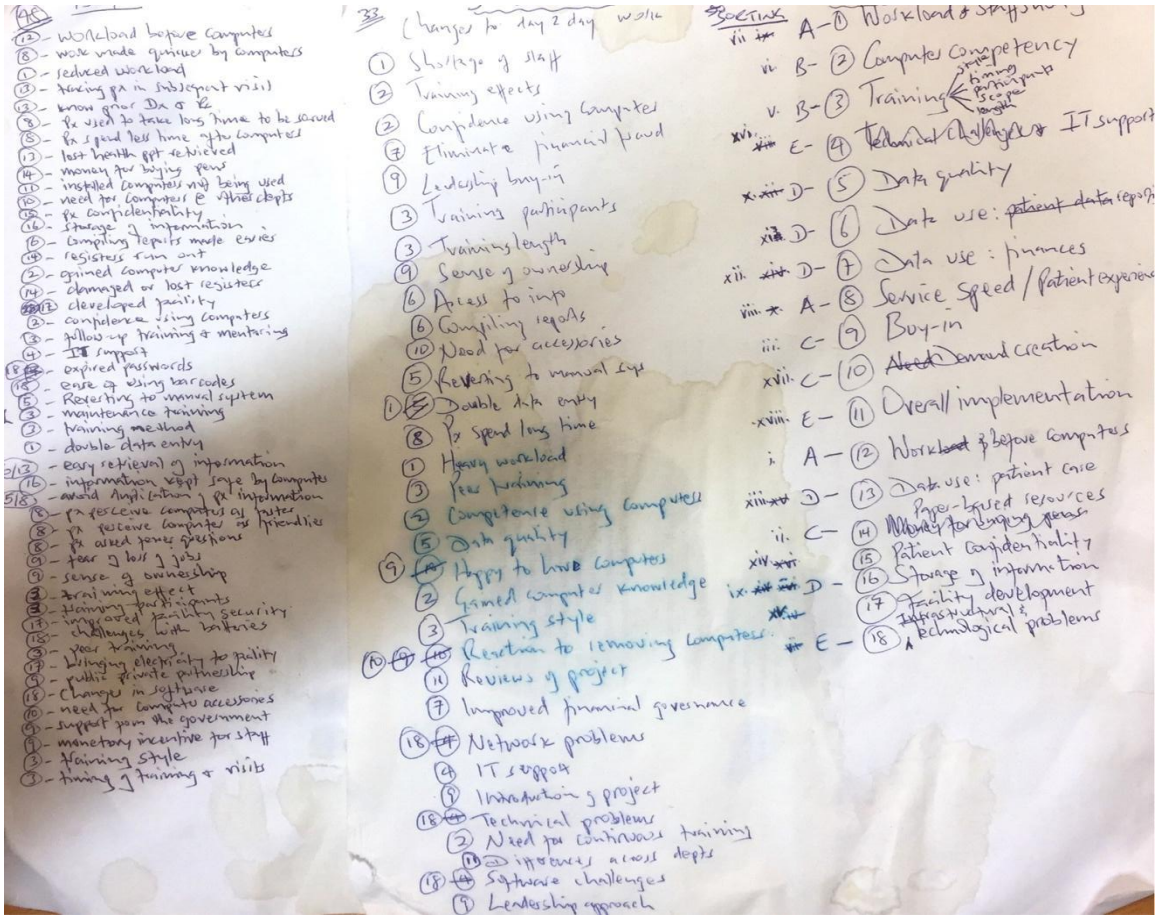

Figure 7 Indexing and Charting Process of the Qualitative Data

Quantitative Data Analysis

Data Quality Assessment

Data quality analysis was done using Microsoft Excel. Data elements in the benchmark paper-based patient files and the eHealth system were assessed as being (a) present in both sources and correct, (b) present in both sources but incorrect in the electronic record, (c) present in paper record but absent in the electronic record, and (d) absent in the paper record but present in the electronic record. Completeness and

accuracy were thus calculated as:

$$\text{Completeness} = \frac{(a) + (b)}{(a) + (b) + (c)}$$

$$\text{Accuracy} = \frac{(a)}{(a) + (b) + (d)}$$

Bland-Altman Analysis

It was assumed that all values in the hospital's monthly reports were different between the eHealth system and DHIS2. As such, agreement between the two reporting systems was measured using Bland-Altman analysis (Bland and Altman 1984; Giavarina 2015). For each month, the difference between the number of outpatient clients recorded by the paper-based registers into DHIS2 and those recorded in the bespoke eHealth system was calculated. Thereafter, the average between the values in the eHealth system and DHIS2 was calculated for each month. These averages were plotted against the differences in a scatter diagram. Upper and lower limits were determined by multiplying the standard deviation of the differences by 1.96, then this product adding to the mean difference for the upper limit and subtracting it from the mean difference for the lower limit, to give a 95% confidence interval. Bland-Altman analysis and its scatter plot were performed in MS Excel, while test for normality of the distribution of the differences between the two datasets was done in SPSS v.22 using the Shapiro-Wilk test, since the sample size was less than 2,000 months (Landau and Everitt 2004).

Analysis of Financial Data

Initial financial data descriptive analysis was done in the Statistical Package for Social Sciences (SPSS v.22). A test for normality was conducted using the Shapiro-Wilkand test, since the sample size was less than 2,000 months (Landau & Everitt 2004). It was found that the revenue did not follow a normal distribution ($p<0.001$). Using the non-parametric Mann-Whitney U-test (Landau & Everitt 2004), the effect of the eHealth implementation (independent variable) on hospital revenue (dependent variable)

was estimated by computing the median monthly revenue realized during pre- and post-implementation phases, and comparing the distribution across these phases. Alpha was set at 0.05.

3.2 Description of Madalo Hospital

Madalo Hospital was a 300-bed rural Christian Health Association of Malawi (CHAM) non-profit facility on the border of two districts in Malawi. The hospital had medical, surgical, paediatrics, laboratory, x-ray, outpatient, ophthalmic, isolation, TB and primary health care departments. Pharmacy, administration, human resources, finance and information technology (IT) sections supported these departments. It serviced a rural catchment population of approximately 65,000 people and provided referral care to a population of approximately 550,000 individuals. Nine (9) rural health centres, described in Chapter 4, provided primary health care, including antenatal and delivery care, for the population that was not directly served by the hospital, and referred patients to the hospital for specialist care.

According to the hospital's 2015 annual report, the annual operating budget for hospital activities was $1,067,000. Madalo Hospital was funded by:

A. The Malawi Government, paying approximately 40% of the budget, mostly for salaries and medication for specific diseases (e.g. tuberculosis, childhood immunizations)
B. Revenue from patient fees, comprising 28% of income. There was a private ward at the hospital, where the charges were higher. However, "the departments were still not able to meet their costs, as the hospital did not turn people away when they had no money, while the community did not have enough money to buy food, and neither could they afford medicine and treatment", as quoted from the Hospital's annual report.
C. Outside help covered the remaining 32% of the running cost in the form of donations for specific programmes e.g. TB program (Dutch funder), malnutrition (US and Dutch funders), malaria control (US funders), community health development (US and German funders), and ad hoc donations.

Most uncomplicated cases were managed by para-medical clinical staff, using clinical protocols and guidelines. Medical doctors reviewed the more complicated cases. In 2015, there were 52,806 patient visits in the outpatient department and 11,323 admissions, including maternity admissions. There had been a decline in the number of children admitted in the hospital due to a reduction in the number of malaria and anaemia cases. Malaria cases had declined, as shown in Table 3 below, mainly as a result of the indoor residual spraying (IRS) programme that had been implemented since 2009.

Table 3 Malaria Prevalence Before and After Indoor Residual Spraying (Source: Pemba 2015)

Year	Community Malaria Prevalence at various altitudes		
	Below 999m	1000-1199m	Above 1200m
Before IRS-2011	72%	70%	63%
1 year of IRS-2012	52%	49%	3%
2years of IRS-2013	44%	29%	0%
3 years of IRS-2013	40%	23%	1%
4 years of IRS-2014	49%	27%	1%

Madalo Hospital entered into a Service Level Agreement (SLA) with the Malawi Government, for the hospital to provide care to pregnant and under-five children and be reimbursed monthly by the district health office. However, the hospital had suffered from inconsistent payment of SLA dues from the government, and had to suspend the SLA, leading to increases in morbidity and mortality, since, according to the annual report, "parents waited longer before bringing their children to the hospital for treatment, leading to more children presenting late, sometimes with fatal consequences". Despite challenges with SLA payments to cover services for pregnant women, other maternal health interventions funded by the Scottish and Dutch governments led to reductions in maternal mortality, as shown in
Table 4 below.

Table 4 Maternal Mortality at Madalo Hospital from 2008 - 2015

Year	Maternal Deaths	Total Live Births	Maternal Mortality Ratio (deaths per 100,000 live births)
2008	31	2041	1518
2009	14	2466	567
2010	7	2757	253
2011	11	2970	370
2012	7	3090	226
2013	9	2962	303
2014	6	3526	170
2015	3	2743	109

3.3 Biography of the eHealth System at Madalo Hospital

A biography of the eHealth system at the hospital is presented, including the preparatory phase, staff recruitment, implementation in the outpatient and inpatient departments, early successes and challenges, further developments to the system, modification to and support for the system, and how the system was planned to be scaled up and sustained. This biography discourses research question 1: How was the eHealth system implemented? How did complex interactions between technological, organisational and human factors affect implementation?

Figure 8 below shows the timeline of the implementation of the eHealth system at the hospital, from 2008 up to 2012. Key points in the implementation journey are presented in the figure, and a detailed biography of the process, as well as contextual events at local and national levels, are described below.

In 1889, Dutch Reformed Church missionaries from South Africa established a mission station Malawi and built a clinic in 1915 that grew to become the large referral Madalo Hospital. Since then, the Dutch have had an evolving relationship with the hospital up to this day. Prior to 2008, two Dutch non-governmental organisations (NGOs), ICCO and Cordaid, Protestant and Catholic institutions receiving funds from the Dutch government, respectively, embarked on work to computerise the hospital, focussing on administrative functions. This was after another Dutch NGO, Malawi Missions Work Team (MMWT) had identified substantial deficiencies in the administrative and financial management at the hospital. Then in February 2009, a Dutch doctor at the hospital developed a plan to expand the computerisation work into a comprehensive eHealth system. With funding from the Church of Scotland, a Data Manager was recruited to assist the development of an eHealth system that would first bring internet to Madalo Hospital, and later connect the hospital to the nine rural clinics that referred patients to the hospital, as portrayed in Chapter 4. Initially, there were plans to install OpenMRS, an electronic health record (EHR)

system.

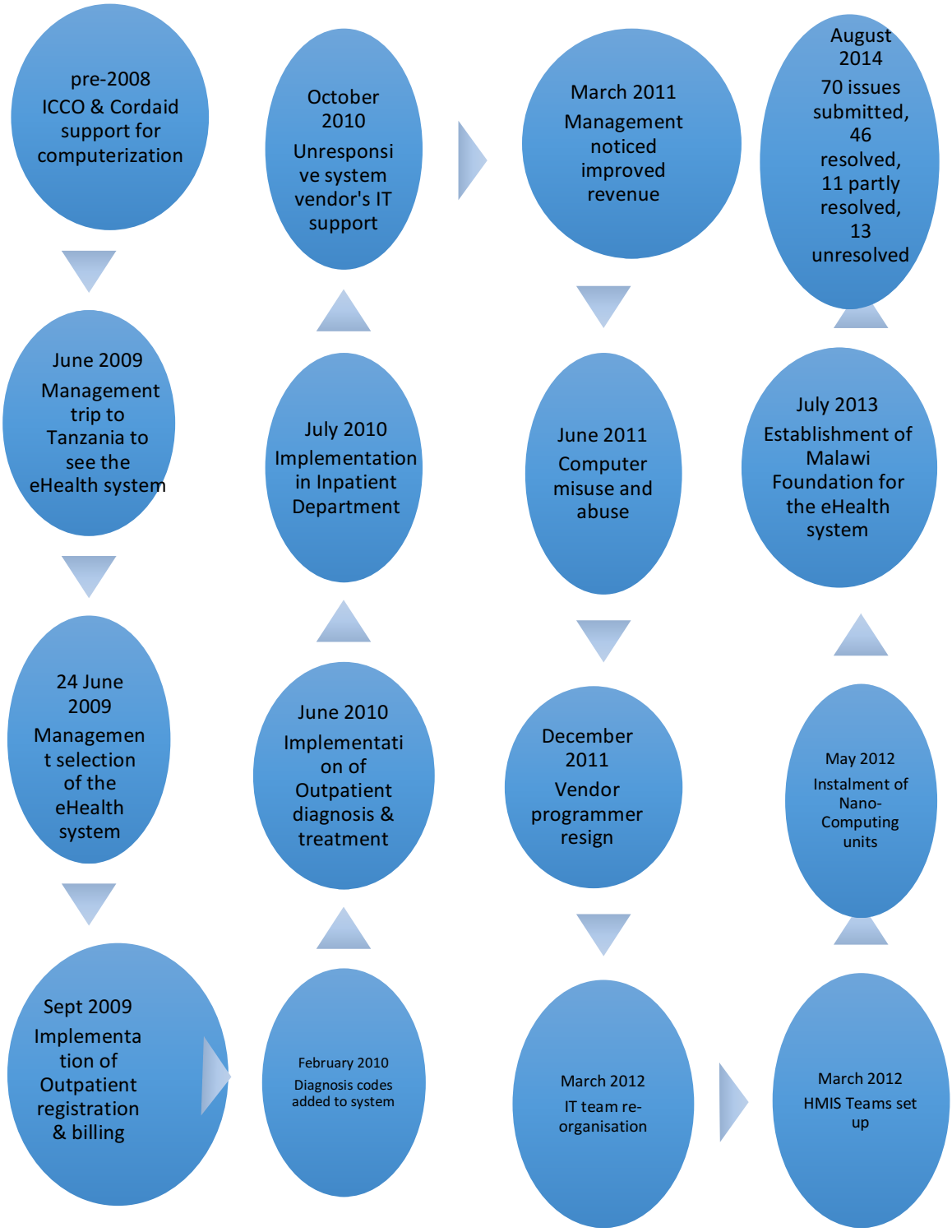

Figure 8 Timeline of the Implementation of the eHealth System

During that time, a Standards Technical Task Force was formed in the country's Ministry of Health, led by Baobab Health Trust, developers of an EHR system supported by the US Centres for Disease Control and Prevention (CDC). This EHR system was based on OpenMRS and further developed to capture HIV data at the country's facilities. On 18th December 2008, a five-member team, led by Baobab, was mandated to develop terms of reference for the Standards Task Force. During this meeting, the Work Group was further divided into three sub-groups: Data, Architecture and Security. Madalo Hospital was allocated to the Data Sub-Group. At the same time, the Statistical Association of Malawi started the process of discussing electronic data capture systems in Malawi, which fed into the Standards Task Force, and discussions of interoperability across the country's eHealth systems began. At that time, there were seventeen known eHealth systems deployed in the country (Gottlieb 2008).

At Madalo Hospital, a concept paper was submitted to a Dutch NGO International Institute for Communication and Development (IICD) on 1st February 2009 for the implementation of an eHealth system at the hospital, but did not specify the information and communication technology (ICT) solution to be implemented. IICD responded on 3rd February, and they were open to any ICT solution that was appropriate, although they also brought to the attention of Madalo Hospital an integrated eHealth system that they had helped develop and implement in several hospitals in Tanzania. On 12th February, the Dutch doctor approached Baobab Health Trust to discuss the potential of implementing their eHealth solution at Madalo Hospital, and on 25th February, Baobab presented a rough costing to Madalo Hospital for implementing their system at the hospital.

Then on 28th February 2009, a programme manager from IICD visited Madalo Hospital to confirm their interest to support the development of the hospital's eHealth system. He met the hospital's management, administrative staff, clinicians, nurses and the three-member information technology (IT) staff. By 4th March, a search

of eHealth solutions in Malawi was conducted, by then eighteen systems in the country. One of the systems, Luke International Health system developed by the Taiwanese, was further explored by Madalo Hospital, apart from Baobab and OpenMRS, which were the most well-known systems by then. On the same day, developers of a bespoke eHealth system, as well as its implementation guideline, the Change Management Guide, were presented to Madalo Hospital management. On 18th March 2009, reports that Madalo Hospital submitted to the District Health Office were presented to the developers as some of the requirements for the development of an eHealth system. It was also on this day that the plan for the hospital's eHealth system was finalised.

Meanwhile, the Malawi Ministry of Health's sub-committee of the Data Standards Committee produced a proposal for developing unique identifiers, mainly based on the Baobab system that was being implemented across the public facilities. At Madalo Hospital, a representative of the IT team visited Neno Hospital, where OpenMRS was being implemented. Three eHealth solutions were approached by 13th April 2009: Baobab, Care2x and the bespoke eHealth system from Tanzania. In June 2009, three members of Madalo Hospital management team visited Tanzania to see the bespoke eHealth system at several facilities. In the same month, Madalo Hospital put a tender in newspapers and directly to potential supplies for developing an eHealth system for the hospital. One of the potential suppliers, ITS Enterprises, requested and was provided with the hospital's process descriptions for the outpatient department (OPD) and billing on 10th of June. By the close of the tender period, 23rd June, three companies had submitted tender documents: Malawian companies ITS Enterprises and FutureFirst, and the Tanzanian company for their bespoke eHealth system. Baobab Health Trust did not submit a bid, as they had received a large grant to develop and scale up their HIV eHealth system across the country, and could not commit time to develop a billing module, which they did not have. On 24th June, management reviewed the three tenders, and the Tanzanian eHealth system was selected.

> *"The Malawian proposals are very lean and do not address most issues in the call for proposals. Interestingly, ITS Enterprises has started developing a system for Daeyang Luke Hospital, a new and well-funded CHAM hospital that is supported by the Korean church. It seems they developed the system from scratch."* – Madalo Hospital Technical Advisor, in an email correspondence to IICD on 23rd June 2009

Implementation of the eHealth system begun immediately, with a call for bids published in newspapers on 10th July for the supply of the eHealth system's hardware. At the same time, the Dutch NGO MMWT had placed a Business Development Manager at Madalo Hospital, and he embarked on a "Turn Around Project" to improve financial and administrative systems at the hospital, starting with a meeting with senior and middle management on 19th August and 2nd September. This was also the time, on June 27th, that the Dutch NGO ICCO expressed interest to implement an eHealth system at the health centres around Madalo Hospital, which refer patients to Madalo. IICD picked up this interest and asserted that the Tanzanian eHealth system had an interface with DHIS2, the web-based health information system that the Ministry of Health was using at district health offices for all facilities, developed with assistance from the University of Oslo. Fourth September 2009 was when the hospital held a function to officially launch the eHealth system. By the next month, October 15th, the hospital was impressed with the system and decided to showcase it to stakeholders.

> *"It is now a month since the system was launched. Although there are some challenges as expected, the good thing is that it has been a necessary investment. The users are now talking of how interesting their work has become. Management has all the necessary registration and billing information at its finger tips by just clicking on [the eHealth system] right in their offices. What a great transformation for [Madalo Hospital]!!!!!"* – Principal Hospital Administrator in an email correspondence calling for a stakeholders' meeting to be briefed and shown the system on 6th

October 2009

Another hospital specialising in HIV care started developing a partnership with Madalo Hospital to improve Madalo's HIV services, and a discussion on 5th November 2009 included the possibility of implementing the eHealth system at this partner hospital using a large grant they had secured. However, the bespoke eHealth system implemented at Madalo Hospital did not have a well-developed HIV module, and the HIV hospital installed the Baobab system instead. Eight years later, in 2017, the partner hospital would implement the Baobab system at Madalo Hospital's HIV clinic, with the possibility of extending to the rest of the hospital, due to long-standing challenges faced with the bespoke Tanzanian eHealth system, as will be discussed below.

This multi-faceted eHealth system was first introduced at Madalo Hospital in September 2009, with modules for patient registration, billing, and diagnosis/ treatment introduced at the *outpatient* department. From July 2010, these modules were also introduced in the *inpatient* maternity, medical, surgical, private, TB/isolation and children's wards. In January 2012, dedicated administrative staff, known as ward clerks, were introduced into the maternity, medical, surgical and paediatric wards as part of a wider quality improvement drive. Thereafter, the ward clerks assumed the remit for data entry using the eHealth system and for preparing accurate bills for issuance by the accounts office. These historical factors have been superimposed onto Figure 9 below, in order to aid interpretation.

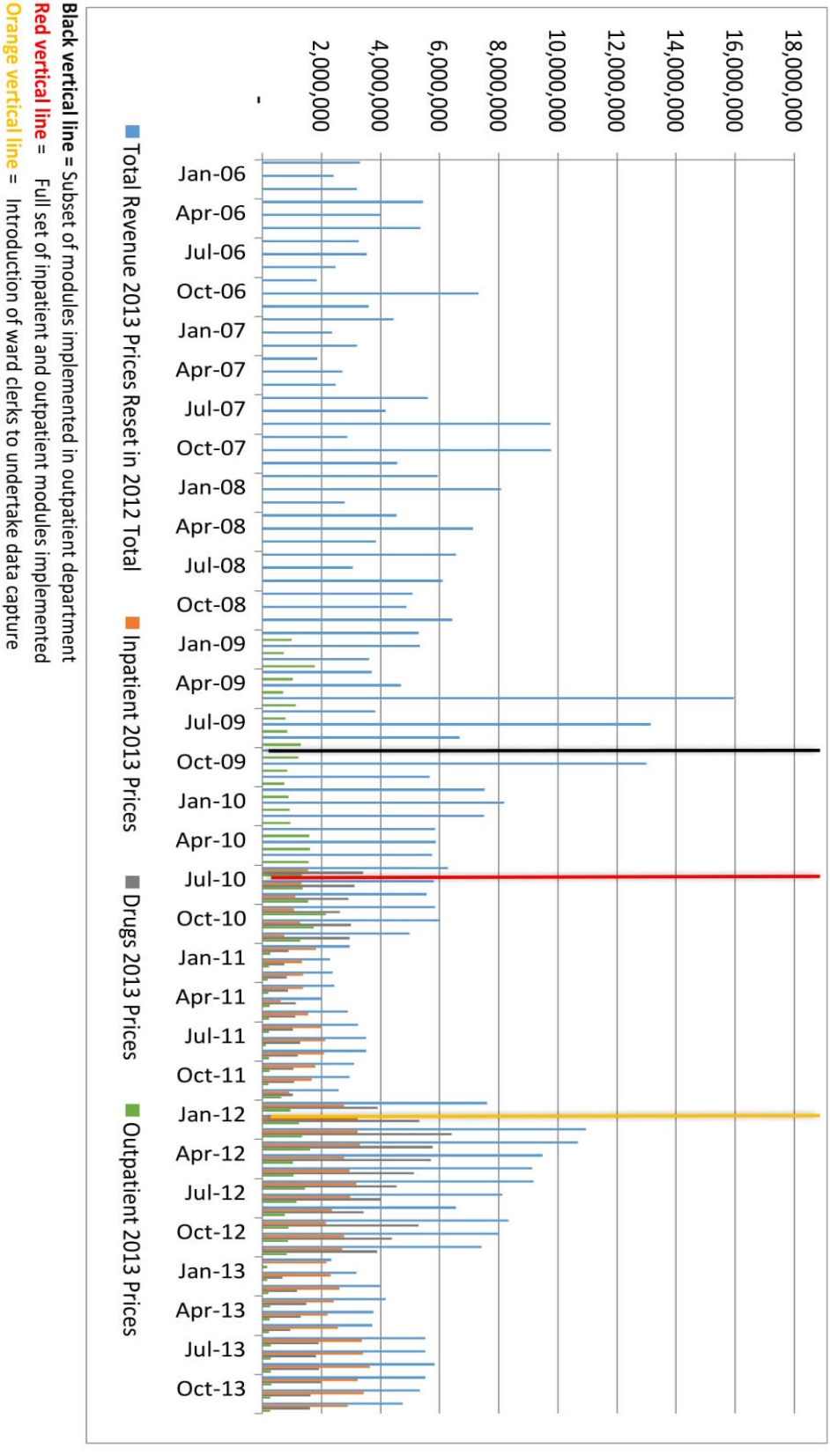

Figure 9 Monthly Hospital Revenue, 2006 – 2013, With Implementation Timeline

3.4 Change Management Dynamics

3.4.1 Paper-Based System Processes

During the use of the manual system, patient flow in the inpatient department of Madalo Hospital was divided into admission, hospitalisation and discharge processes. During admission, a clinician would write patient history, physical examination and admission diagnosis on the admission sheet, which was added to a paper file. Then a clerk registered the admission in a paper register. Thereafter, the patient would go to the ward where the nurse assigned a bed. In an ideal scenario, a paper file was to be retrieved from the records office at subsequent admissions, but this mostly did not happen as a new file was often created at each admission.

During hospitalization, a medication chart was used. Medication was ordered per course, not per day, resulting in the patient being billed for drugs that might have later been cancelled if treatment was not successful or based on new diagnostic findings. Drugs were then recorded in the medication chart. At the end of the stay, the nurse chose drugs from a standard list and entered the quantity used. For some patients, lab requests, an x-ray or ultrasound was ordered by writing the order in the patient-held health passport. However, all other procedures were recorded in the hospital-held patient file. All these processes would be added to the bill.

A third and last component was discharge. During this component, discharge diagnosis (primary and secondary) were entered in the hospital's discharge register by the discharging nurse. A summary was written in the patient-held health passport, and the patient's file was then sent to the records office, which would be organised according to the date and patient's name. Thereafter, the bill was compiled by the nurse using a standard form. This involved counting drugs used and all procedures undertaken. The patient then paid to the inpatient cashier. If the patient was on

insurance, then a standard invoice which stated the diagnosis and standard fee was forwarded to the accounts office.

A general problem was that documents (patient files, admission sheet, medication chart, x-rays) would get lost (IDI328). This was complicated by the paper registers often being out of stock, such that the staff had to improvise to capture patient data (IDI395).

> *"[Data quality was] not reliable. [The paper registers] always go out of stock, such that we have to improvise our own ways to capture data."* - A male clinician, MCH department (IDI395)

A wider application of patient labels was put in place to solve this problem, where ID stickers with barcode were to put on any patient document, printed at admission and added to patient file. Initially, new stickers could be retrieved from patient admission registration. Later, a label printer was stationed in each ward and other points where documents were generated (x ray, laboratory). However, these label printers were removed from the wards because it became difficult to source labels. To minimise the number of patient documents, the health passport was being used as much as possible as the document that the patient carried with orders. So, instead of creating a laboratory, x ray or ultrasound form, the order was being written in the inpatient order form. Patient follow up was done through patient records kept in the patient-held health passport at the outpatient department, and hospital-held patient file at the inpatient department.

Staff had the *motivation* to adopt the eHealth system as they could recall challenges with the paper-based system, and could mention their expectations of the electronic system in terms of data quality. Several interviewees at Madalo Hospital perceived paper-based data as unreliable (IDI117, IDI178) and highly dependent on the person entering the data (IDI060, IDI345).

"[Data quality] was only as good as the people who wrote them. We didn't ask the diagnosis. It used to take two people, one with the admissions book and one with the discharge books. They were not filling out the books completely, with no information on where they were coming from." – A female ward clerk (IDI345)

3.4.2 Staffing and Workload

A key decision in implementing the eHealth system in the outpatient department was who would record patients' diagnosis and treatment data. Two options were available: the clinicians or dedicated data clerks. Having dedicated data clerks would have enabled forecasts of the hardware needed: If clinicians were to record the data into the eHealth system, and the hospital increased the number of clinicians working at a time, additional hardware would have been needed for the additional clinicians, while if data clerks were entering the data, adding clinicians would not have affected the number of hardware needed.

However, having clinicians enter data into the eHealth system would enable them to easily view the patients' medical history and other information needed for accurate diagnosis and treatment, such as laboratory test or X-ray results. Further, data quality would be better as spelling errors by data clerks would be eliminated. As such, management at Madalo Hospital decided to have clinicians enter patients' diagnosis and treatment data into the eHealth system, as it provided the most direct benefit to patient care. However, management did not enforce the outpatient clinicians to enter the data until they knew the system worked. As such, only one clinician, a system champion, was using the eHealth system for outpatient diagnosis and treatment.

Although the outpatient registration and billing module worked well with the reception clerks and cashiers, respectively (IDI424), the outpatient and inpatient diagnosis and treatment modules were not working well. Clinicians also faced the

challenge of heavy patient load and slow typing speed, such that it required more time to enter all patients' data into the eHealth system without the help of clerks (IDI431). Although there were clerks who entered diagnosis and treatment data into the outpatient paper registers (IDI389), multiple enquiries to hospital management could not yield reasons why these clerks could not be entering data into the eHealth system as well.

In the inpatient department, staff also faced high patient volumes and requirements to complete multiple paper registers for the Ministry of Health, and staff considered the eHealth system as added work (IDI305). Devolving data entry to ward clerks was thought to have eased the burden of recording both clinical and billing data.

> *"It eased the work of the accounts. At a click, they can check how many consultations and whether they tally with the money [collected] … It is restricted to clerks and accounts department staff to be able to go into the billing system."* – A clinician in the reproductive and child health department, IDI009

Staff also described how the ward clerks helped to ensure that clinicians and nurses documented all services to be billed and that these services were entered correctly into the eHealth system, thus assisting the hospital to avoid loss of revenue as a result of incomplete documentation of services provided or lost/delayed charge slips. Changes to the system also made it easier for the ward clerks to make corrections in the system (IDI331).

> *"I didn't know I would be able to check all invoices and cash payments, because it is impossible to correct mistakes in that area. I [also] struggled with data for registration. There was no way to edit the date, so it messed up the statistics. Now it's fixed, but we still don't have the edit screen for discharge data. That was my biggest frustration. I could correct the bill, the invoices, but the whole thing about the discharge date."* – A female Ward Clerk (IDI135, IDI136)

These Ward Clerks were male and female aged 25 to 60 years old, with secondary education and are in the clerical Grade M salary scale, similar to accounts and stores clerks. They were easily trained, and received continuous training from the hospital. Since they were junior positions, most of them were recruited from the surrounding villages.

3.4.3 Process Reorganization

eHealth system implementation was associated with a range of non-technical changes (IDI047). In the outpatient department, this included recruitment of staff to register patients into the eHealth system before consultation, training accounts staff to provide computer-generated receipts, and requiring patients to have a printed receipt before drugs may be dispensed. This brought an end to the issuance of manual bills by individual staff. Patients could therefore not pay at the cashier if they were not registered in the eHealth system at reception (IDI048), and could not receive drugs if they had not paid at the cashier (IDI013). Pharmacy staff pointed out that while processes had been improved, they remained imperfect. For example, in the outpatient department it still depended on the discretion of the person dispensing to check that the patient had an electronic receipt. Nevertheless, they expressed optimism that implementation of the pharmacy module would help to close this loop-hole.

> *"[Drugs] prescribed cannot be paid for if there is no consultation fee payment. But currently, without the dispensary software, there is still a window of abuse where medicine can be dispensed and not paid for. Hopefully, with the implementation of a pharmacy module, then it will be even more difficult to abuse the system."* – A pharmacy staff member, 8 October, email communication

Further, x-ray and ultrasound were expensive procedures, and were often not paid

for when using the paper system. When the eHealth system was introduced, the cashier would enter the diagnostic procedure in the computer and receive payment. The diagnostician would then check if the patient paid the bill by entering the patient number. Inpatients did not pay for X-ray or ultrasound at the time of the test, but at discharge as part of the total bill.

3.5 Organisational Dynamics

Hardware implementation involved installation of computers at eight workstations in the outpatient department, the dispensary and six workstations in the inpatient department (IDI335). All clinician's rooms in the outpatient area, the dispensary and nurses' stations had two network sockets. The software ran on the eHealth system's server, which was housed in the server room. All workstations were equipped with a 0.8kVA UPS, while the server had a 3kVA UPS. All sockets in the workstations and the server room were connected to the main generator, which switched on automatically after a power cut.

Electricity fluctuations and outages adversely affected implementation of the eHealth system (IDI033), as the hospital was mostly unable to get enough power from the national power grid, or received no power at all. Original desktop computers used demanded a lot of power. To counter this, by March 2011 the IT team had uninterrupted power supply (UPS) in almost all points of eHealth system use, but soon most UPSs had run out of battery power due to over-use. These desktop computers were thus replaced with nano-computing (N-Computing) thin client units, which consumed very little power and were stable in environments with difficult power supply. On 21st March 2012, Madalo Hospital bought twenty N-Computing L300 Access Devices, ten N-Computing L250 Access Devices, and a low power hub server. They also bought additional UPS batteries to replace those worn out.

To ensure security of the equipment, metal bars and security locks were installed at all openings to the rooms with workstations in the outpatient department, while the nursing stations in the inpatient department was staffed 24 hours a day. All screens were further locked to the desk, and the UPSs were locked in steel boxes against the wall. Management developed a policy which prescribed who was responsible for opening and closing the doors at the beginning of the day, end of the day and during lunch; which room would be available during the night; and how guards would

monitor the outpatient department. To ensure security of the data, a standard back up protocol was developed, and an offsite back up was made every 24 hours.

3.6 Technological Dynamics

3.6.1 Hardware and Software Challenges

Hardware and software challenges made adoption of the eHealth system more difficult at Madalo Hospital (IDI381). There was the problem of slow and often non-working desktop computers that were very old (IDI042, IDI148, IDI323, IDI324). This demotivated system users as they already had so much work to do and giving them these poorly performing computers took much more of their time. As such, the diagnosis and treatment module was being poorly used in the outpatient department.

> *"When it started, it was very fast. There was only OPD registration, inpatient department, and diagnosis and treatment (modules). Things were very fast then. We even had better computers. The queues were not as long as they are now."* – A male IT technician (IDI256)

As a solution, the IT department procured 20 new N-Computing units (nano-computers which work from a central server) to be placed in all areas where they had problems of slow computers. They also bought label printers and barcode scanners to be used in all points where the system is used to make it more user-friendly than using keyboard and mouse. Three years from then, when finances allowed them to do so, they replaced the critical servers with new powerful ones. The process took a month and they had fully installed units by the beginning of May 2012.

Another technical problem was the slow and inconsistent network between the workstations and the server (IDI034, IDI097), which significantly affected the system usage. Issues related to that were damaged equipment taking time to be replaced, slow server performance, power unavailability and malfunctioning cables. This was partially solved by assigning a dedicated person responsible for maintaining the network, allowing the IT department to rapidly follow up on network issues. Also,

they undertook a major maintenance on their network. Part of the hospital's network was done by a private company, and it was realised later that they did not do a good job. Working on erratic maintenance of the network had not been helpful enough, so the IT department decided to redo the network themselves, documenting everything in the process. From June to September 2013, the IT department started maintaining and further developing the eHealth system. This included internal network reconstruction that involved network maintenance of each of the eleven building blocks at the hospital. After assessing the network, resources were checked and allocated, then maintenance work began with securing the server room door to be airtight, assessing the air conditioner leakage (IDI036), then working on all network switches and deploying UPSs. A maintenance plan was put in place to regularly check network points and hardware.

A new version of the eHealth system software was then deployed, although it still had outstanding problems, including data filtering for patient addresses being incapable, customization of reports and speed of the system, which was a technical issue that needed restructuring of the eHealth system's architecture. This new version was deployed on a V-Space server, which needed upgrading.

> *"We first started the system with normal servers, which are not adequate for the growing hospital. [New larger servers] will improve the speed of the system. We have limited servers – we don't have servers, we have desktops."* – Male IT technician (IDI223)

It was also during this period that the reproductive and child health (RCH) and HIV/ART modules were deployed onto the server and tested. Users were invited to test the system, and performance of the system and the users was monitored by the IT team. It was found that, while the first modules worked well, these new modules were problematic (IDI217). By June 2014, Madalo Hospital had the following modules working: outpatient registration, diagnosis and treatment, billing, inpatient, and

reproductive and child health for only antenatal clinic and cervical cancer screening. ART/HIV and inventory modules were still pending.

3.6.2 Other Uses for Improved End-User Engagement

Computers were deemed to be insufficient in the various departments (IDI033, IDI041, IDI045). However, along with the eHealth system came a communication network for the hospital, connecting the various offices and departments, and even the health centres, through a Voice-Over-Internet-Protocol (VOIP) network, which eased communication (IDI016).

In June 2011, management had noted that computer usage was being heavily abused, such that it was disturbing normal business flow and professionalism at the hospital. Management therefore established rules of computer usage with consequences for any diversion from these rules. These rules were to discourage sharing of login credentials; playing of games, videos or music on the computers; storage of personal music files, videos, pictures and games on the computer; removal of cables from the computer; and encouraged staff to always log off their account after use, no matter how small a break they were taking. There were incidences, for instance, where a child was dying while the clinician was on Facebook (IDI065).

> *"Earlier in the implementation, staff were using the computers for Facebook and games instead of attending to patients. We had to discuss this, and we told them to be responsible, and only allowed Facebook and games at night to stay awake. Now they are banned during the day. Also, watching movies. Now [the situation] is okay."* – Female nurse, inpatient department, IDI089

Even though some staff used the eHealth system to search how to treat unfamiliar conditions on the internet (IDI086), by November 2011, the hospital could no longer allow staff to have internet access from the inpatient and outpatient department

computers (IDI030, IDI337). As an alternative, the IT laboratory was set up so that staff could have access from 4pm to 8pm Monday through Fridays and 8am to 1pm on Saturdays. However, by November 2014, the problem had not been resolved, and many items were removed from the server, with an employee found to have taken 15Gb of space on the server (IDI263). Some of this led the eHealth system to crash (IDI257).

> *"The system crashed in 2012 … and we lost all the data. Seventy-five percent of the data has now been recovered … There is a problem of viruses."* – A male IT technician (IDI257)

3.7 Social Dynamics

3.7.1 Awareness Raising and Orientation

After management had selected the bespoke eHealth system, three management members went to Tanzania to get oriented on the use of the system at various hospitals. IT department members also went to Tanzania to learn more about the software and how to manage it. These management and IT team members formed the eHealth project's Steering Committee. There was commitment from management to make the system work, and they supported the IT Team as much as possible (IDI219, IDI244, IDI272). Both a core team of implementers and the Deputy Medical Director, who was the system champion, helped push the eHealth system programme forward (IDI279), although some staff perceived that IT support was mainly given to him because of his influence, while queries from the other staff were not heeded (IDI382).

> *"In the first stages, there was cooperation with management, such that we were provided with everything that we needed."* – Male IT Technician, (IDI219)

There was then orientation of staff before implementation, held over several Implementation Committee meetings (IDI094), and departmental meetings took place for training in basic computer skills and use of the eHealth system (IDI103). Staff interested in computers were seen as one of the factors that helped implementation (IDI154), while poor attitude of other staff, especially clinicians and nurses, derailed the programme (IDI213, IDI226, IDI376).

> *"The mind-set at the hospital has changed to accommodate [the eHealth system] after visits from the Scottish teams at management level, but not at user level. We have an example of someone who would unplug the computer so that [the accountant] could authorise use of manual receipts because he benefited from the manual system. This was at the cashier's office."* – A male IT technician (IDI230)

When an IT manager was recruited, who had both technical and inter-personal skills, attitudes to and usage of the system improved among many staff (IDI271, IDI440), particularly in the inpatient department where ward clerks had been recruited (IDI272, IDI376). Due to the instability of the eHealth system, management did not commit to make it mandatory for outpatient clinical staff to use it, although some clinicians advised that hospital management should make it a requirement for them use the eHealth system (IDI376, IDI404), just as they did for use of insurance charge slips (IDI390).

> "*I expected all the clinics to use [the eHealth system], but it's only [the system champion clinician], registration, pharmacy and accounts who use [the eHealth system], but most nurses and clinicians do not want to use it. When you are bringing new things, for other people you have to negotiate, for others you have to dictate. The clerks are surprisingly using [the eHealth system] more than the nurses and clinicians. There is need for a focus group discussion to find out why they are not using it. (**Interviewer:** Why don't you use it?) Why don't I use it? Hahaha. Too many clients to be entered in two registers and the excel sheet. It used to delay my work until we got a clerk. We get up to 15 clients a day and it takes two minutes to enter in the computer. I am not forced to enter into [the eHealth system], and there is no report as an incentive. There is no incentive. Reports are a good incentive, and we must make it a requirement to enter in [the eHealth system].*" – A male clinician, RCH department, IDI376

3.7.2 Training and User Competence

An administrative challenge to be addressed was regular user training. Being a rural hospital, staff turnover was very high (IDI442). Beside the staff leaving the hospital, the existing medical staff were often rotated among different departments within the hospital, bringing in staff who were unfamiliar with, and often unwilling to use, the eHealth system, from departments that had no eHealth system (IDI280).

> *"What had made it more difficult is new staff, change of staff from an active [Clinician 1] to the lazy [Clinician 2]. Rotation of staff across the wards has had a negative effect."* – A male IT technician (IDI280)

However, there was no refresher training for old staff and no initial training for new staff (IDI099, IDI129). There was need for more training and orientation, more in-depth and hands-on, especially for new staff, as well as focussing on those staff using the system every day (IDI425 as read with IDI410 and IDI416). Realising this, the IT team started organising regular training sessions for existing and new system users to offer a chance for exchanging experiences, having some of their concerns resolved, unlocking more potential from the eHealth system and the users, and making corrections where things would not be going well. It was thought by the IT team that the training sessions would motivate users and bring a sense of ownership and value of the eHealth system among staff. Extracting reports and using them to assess and appreciate their own work was part of the training sessions. However, some staff perceived these training sessions to be ineffective.

> "*Training did not work. You train people but you don't put in measures to make sure they use it. There was lack of hands-on practical work. The confidence to use the system after the training is not there. There is need to follow up and address the issues. Train two or three people and make sure they are confidently using the system then train the next two or three."* – A male clinician, RCH department (IDI388)

Some staff expressed that computer knowledge and competency had not been achieved (IDI122, IDI375), since there were others who were willing to learn while others reportedly had negative attitudes towards the eHealth system (IDI039, IDI376, IDI380), something the IT team had not anticipated and were not prepared for (IDI213). Nevertheless, staff supervisors could perceive that staff at Madalo Hospital had more computer skills than those joining the hospital from elsewhere (IDI423 as

read with IDI404). Training was extended to all cadres of staff, most with no prior computer experience (IDI011).

> *"People who couldn't type on computers can type on computers, especially the cadre of patient attendants. They are not professionally trained, but they are able to put data into [the eHealth system]. The training that [the IT manager] was conducting helped a lot. They called them end-user trainings."* – Male Clinician, MCH department (IDI011)

3.7.3 IT Support

Lack of in-country support for the eHealth system was one of the hindrances to its development and usage (IDI162). At first, there was good collaboration between Tanzanian developers and Madalo Hospital, and according to a male IT technician, *"They would give us hints on how [the eHealth system] works so we can help users very well. That helped our work with the users."* (IDI220). However, from October 2010, the developers started to be unresponsive, and the requested customizations were not being processed. This was aggravated by the source code of the eHealth system not being accessible to Madalo Hospital, and the files in the system folders being encrypted. This was despite the service agreement with Madalo Hospital stating that the developers would release the source code to the client (Madalo Hospital) under the condition that the client does not share that with any third party.

In August and September 2011, Madalo Hospital listed updates that needed to be done by the IT Department and the developers. This list included thirty items that needed to be addressed by the developers, updates ranging from the inpatient modules to laboratory module, and 28 modifications to be done by the local IT team, including system administration and reports. It took four months to resolve 17 of the local modifications, and four *years* to resolve the next nine local modifications.

In December 2011, the only developer for the eHealth system software had left the IT company in Tanzania for a new employer. Madalo Hospital had invested in the eHealth system to operate the hospital and had also received funding for three projects (HIV, home based care, health centres), which relied on the same eHealth system. Further, the hospital had also applied to the Scottish government for expanding the health centre project the following year (depicted in Chapter 4) with the intention to continue working with the same eHealth system. However, the level of support the hospital had received with the first three modules (registration, billing, and diagnosis and treatment) was reported to be unsatisfactory. By this time, the hospital had been waiting for over a year for updates and corrections which were not yet complete. In response, the Tanzanian developers assured Madalo Hospital of continued support, and went on to resolve three more issues. Madalo Hospital came up with an additional list of twelve issues that needed to be sorted out, and the developers and Madalo Hospital's IT team immediately resolved seven of those issues.

In March 2012, the IT department developed an ambitious plan to get things back on track, using administrative and technical solutions, and the IT department displayed commitment and responsiveness (IDI029), unlike before (IDI156), particularly as the new health centres project had taken the attention of IT team away from the hospital (IDI300). The administrative plan aimed at firstly addressing the delayed responses to queries. One of the challenges they had been facing was support from the Tanzanian developers since, according to a male IT technician, *"the IT staff [at Madalo Hospital] were not trained in system modification, [despite not] getting the source code"* (IDI300). Challenges were on both sides: the Tanzanian developers would be ready for an update but Madalo Hospital would have problems, and often the other way around.

> *"The software is complex. It's big! What we are using is minimal. For us to change the system, we need someone to work on the programme. That took so long as we*

outsourced those services. Though the coming in of [the programmer based in Malawi recruited by the Tanzanian company] sort of solved some of the problems, it wasn't to our expectations, as he has to oblige to the requests of his employer and it took time to solve the problems. We need to train someone local (a Madalo Hospital staff) to fix errors. When correcting errors, other errors are simultaneously created." – Male IT technician (IDI222)

On the Madalo Hospital side, they increased IT staff by recruiting a Systems Administrator who was fully responsible for systems running. Also, they devised a plan and schedule of work in which everyone had specific responsibilities. To that effect, the IT Manager became responsible for the overall performance and monitoring of the system, and coordinating all stakeholders of the eHealth system implementation. The Systems Administrator became responsible for software configurations, changes, user trainings, reports and checking levels of supplies such as barcode rolls. One of the IT Technicians became responsible for making sure that all hardware was in good condition. The other IT Technician became responsible for ensuring that there is network all the time, with adequate speed and performance. Staff noticed that there was improved IT support when issues were reported (IDI095, IDI102, IDI437), although it was difficult to always get IT support (IDI405), especially outside working hours (IDI098). However, these efforts to streamline the IT department to become more efficient were hindered by high staff turnover in the IT department (IDI214, IDI274).

By January 2013 all the eleven modifications to the eHealth system software had been addressed by the Tanzanian company, and it appeared that the Tanzanian developers had started being responsive (IDI028). However, Madalo Hospital encountered further challenges with those modifications, and sent the same list of eleven issues to Tanzania. In April 2013, the nine-member Madalo Hospital ICT meeting, which was supposed to be monthly, took place and discussed the eHealth system amongst its agenda. It was observed during this meeting that, in terms of hardware, the

outpatient department had problems with their receipt printers. It was also observed that in terms of the eHealth system, there was an outstanding list of things that the hospital had been having for two years.

In August 2013, Madalo Hospital and partners from the Netherlands, Scotland and Tanzania established a foundation that aimed at providing in-country IT support. Even with this local support structure in place and plans to scale up the eHealth system to other facilities in Malawi, there was still no final product developed. By December 2013, there were still eleven issues that needed to be modified in the eHealth system software. Some of the issues were new, and were the fault of Madalo Hospital (for instance the number of beds kept changing hence bed occupancy rate could not be calculated correctly). These requirements were revised and sent to the foundation's recruited programmer in January, February, March and May of 2014, with new issues coming up as others were being resolved, and some issues remaining unresolved. By July 2014, the list of modifications needed had grown to thirteen, and in the same month four were fully resolved and four were partially resolved, and six new issues were added to the list. In August 2014, six more issues were resolved, but 3 partially resolved. This meant that by August 2014, Madalo Hospital had submitted seventy issues that needed to be modified in the eHealth system. Of these, 46 had been fully resolved, eleven partly resolved and thirteen needed to be resolved.

3.8 Outcomes

3.8.1 Data Quality Outcomes

An interviewee reported that the eHealth system had helped to improve data completeness by using data entry templates and validation checks that prevented the user from proceeding if these had not been properly filled (IDI397).

> *"[The eHealth system] forces me to follow protocols as it does not allow me to save if critical fields are not entered."* – A male clinician, RCH department (IDI370)

As a result, respondents reported better quality data, especially for registration, billing, and inpatient diagnosis and treatment (IDI127). Staff expressed that with the eHealth system, they registered more patients and could group the most common conditions, such as malaria, pneumonia, tuberculosis, hypertension and diabetes (IDI119).

> *"There is more accurate admission and discharge records, and more accurate outpatient registration."* – A male management member, Clinical department, personal communication, 15 September 2016

In the outpatient department, almost all patients were registered into the eHealth system before they went for consultation with a clinician, providing a list of patients to be seen by the clinicians. However, most clinicians did not enter patient diagnosis and treatment data into the eHealth system, but into the paper-based, patient-held health passport (IDI062). These patients' data was then captured again by the eHealth system when paying for the consultation and drugs. On exit, there were two workers who entered data from the health passport into the paper-based health management information system (HMIS) outpatient register, which was reported to government through hospital management. However, this information was not entered in the

eHealth system (IDI389), which contributed to the eHealth system data being different from the paper-based data reported in DHIS2 (IDI298). As a result, outpatient registration data for 26 months (Jan 2015 – Feb 2017) was found to be 76.0% complete in the eHealth system as compared to DHIS2. Further, as patients would sometimes buy a new health passport at subsequent visits, or have multiple health passports, this compromised the quality of the data in the eHealth system, as the same patient would have several patient numbers in the electronic system (IDI264).

Bland-Altman analysis showed that the eHealth system recorded an average 577 less outpatient clients than the paper-based system reflected in DHIS2, as shown in Figure 10 below. This negative bias was not significant, as the line of agreement (y=0) was near the mean difference (y=577) and within the 95% confidence interval [-3107, 1953]. Only one month (April 2015) recorded a difference higher than the upper limit.

Figure 10 Bland-Altman Plot for Madalo Hospital

When interpreting the Bland Altman charts, from the literature 95% confidence

interval is just a guide; one needs to decide what difference is acceptable or not – the difference between statistical significance and clinical or organisational significance. Human judgement is needed. Graphing the percentages over months to see if there are events that could explain variations are helpful. As such, in the following graph, instead of having the same x axis there is the calendar month to see if there is a temporal pattern. There are the percentages and the actual numbers in two different axes of the plots. Visual inspection of Figure 11 below shows a significant downward trend in the difference between paper-based DHIS2 data and data from the eHealth system. This may indicate a maturation effect of the eHealth system, where data quality improved over time, as shown by the linear trend-line, particularly from August 2015 where the number of clients registered in the eHealth system were more than those registered in the paper-based DHIS2.

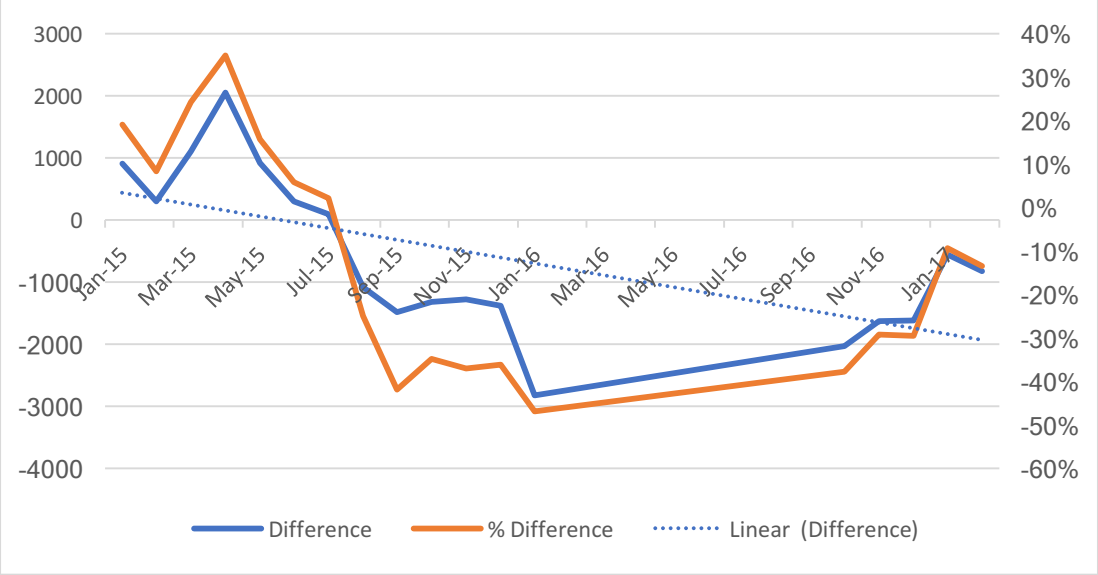

Figure 11 Difference and Percent Difference Between eHealth Data and Paper-Based DHIS2 Data at Madalo Hospital

On the other hand, data entry in the inpatient department was done by ward clerks, specially recruited to use the eHealth system (IDI209), although that data recording was reported to also not be very accurate, as some diagnoses not found in the eHealth system were guessed to the most correct one by the ward clerks (IDI319). Further, some patients were discharged before they had been entered in the eHealth system,

particularly during weekends (IDI327).

> *"We expected nurses to use the computers, but it has turned out to be a problem for the nurses to work on the computer and deal with patients at the same time. That's when ward clerks came in. They are getting data from folder to computer."* – A male technician, IT department, IDI209

However, a female ward clerk reported that data quality with the introduction of the eHealth system was *"one hundred percent better, because we didn't know where people were coming from and what conditions they had. We would guess malaria by looking at [the treatment] quinine."* (IDI347). It was nevertheless noted that there was need for more training on using the eHealth system so that data entered could be of better quality.

> *"Data collection is easier, but there is need for more training and orientation, which should be more in-depth and hands-on, especially for new staff and those working with the system every day."* – A male clinician, paediatrics department, IDI425

Table 5 below shows the quantitative measures of completeness and accuracy for various data elements in the eHealth system relative to the paper records in the inpatient department. Overall, there was 93.6% relative completeness of the electronic data and 68.9% relative accuracy. Completeness in the eHealth system was mostly affected by the absence of diagnosis (73.3% complete), and, to a lesser extent, the absence of the discharging clinician (absent in 17.4% of the records). Accuracy was mostly affected by admission date (13.7% accurate). This may be due to patients not being entered into the computer as soon as they had been admitted, but later, often during their discharge from the ward. Of more concern, accuracy was also affected by differences in the date of birth between the paper and electronic systems, where over half (55.7%) of the dates of birth were different between the electronic system and the paper-based system.

Table 5 Overall Data Quality at Madalo Hospital

	Discharge Date	Name	Gender	Birth Date	Admission Date	Diagnosis	Treatment	Clinical Officer	Overall Average
Relative Completeness (%)	100.0	100.0	99.5	100.0	100.0	73.3	0.0	82.6	93.6
Relative Accuracy (%)	81.3	98.5	93.6	44.3	13.7	92.6	N/A	58.2	68.9

It is peculiar that treatment data was not entered into the eHealth system, as this was where most hospital revenue was derived. A hospital manager explained this discrepancy:

> *"This is because the pharmacy module was never implemented. Providers and ward clerks could enter treatment by typing it in for each patient as patients were seen, but [only one clinician does] that. Billing was done according to treatment prescribed, but it was not clear how that could be found in the [eHealth] system. That is, if a patient was prescribed ampicillin and paracetamol, the clerk would enter the number of tablets and the system would calculate the bill based upon the price per tablet and number of tablets given*." – Male clinician, 27th April 2017, email correspondence

As such, information for billing treatment provided was not derived directly from the patient's electronic record in the outpatient and inpatient departments, but rather from their paper files, with the eHealth system being used as a cash register, rather than an electronic health information system.

Quality of data entry was assessed for the four ward clerks, as shown in Table 6. All the ward clerks entered all the data present in the paper record into the electronic record 91.8% of the time, with Ward Clerk C entering most completely (97.7%).

However, only 70.0% of the entries were relatively accurate, with Ward Clerk D being the most accurate (75.1%).

Table 6 Data Quality Per Ward Clerk

	Ward Clerk A	Ward Clerk B	Ward Clerk C	Ward Clerk D	Average
Relative Completeness	77.3%	94.4%	97.7%	97.6%	91.8%
Relative Accuracy	69.5%	65.9%	69.4%	75.1%	70.0%

3.8.2 Service Delivery Outcomes

Although as of January 2015 the eHealth system had 135,180 patients registered in a *"big 1 terabyte offline backup, 500 gigabytes for online system and 1 terabyte backup server on an external drive"* (a male technician, IT department, IDI259), the eHealth system could not have electronic medical record capabilities because the outpatient clinicians were not using it due to high patient load (IDI191).

> *"We are underutilising the services of [the eHealth system]. [The system champion clinician] writes in [the eHealth system] and I admire him for that, but us clinicians only write in health passports so we are underutilizing it. We can't use it offline, then we would access the server through our laptops like [the system champion] does. You are faster on your own keyboard. People don't use the desktops, they prefer their own laptop. The laptops should connect to the server."* – A male clinician, MCH department, IDI011

In the inpatient department, Madalo Hospital booked more success in using the eHealth system, as ward clerks were specially recruited to enter patient details from patient files to the eHealth system, and they used the electronic system to easily locate

patient files (IDI026, IDI257, IDI307, IDI311), since the hospital had changed storage system of patient files as a result of the eHealth system (IDI169, IDI170).

> *"Yes, the record keeping, we also see that is easy to retrieve the record when the patient comes, we can retrieve the patient's records easily."* – A female management member, Nursing department

> *"I am able to find a patient in the inpatient report that shows admissions, discharges and deaths."* – A female data clerk, paediatric ward, IDI311

Records for patients who had visited the facility before were easily retrieved upon a subsequent visit to the hospital, such as for epileptic and diabetic patients (IDI050, IDI470, IDI473) and readmission, contributing to continuity of care, particularly when they had lost their health passport (IDI109, IDI185), and patient files could easily be traced, which was previously taking a long time (IDI123).

Nevertheless, the eHealth system was not yet being used across hospital departments as an integrated eHealth system (IDI400, IDI401), since it was not being used by clinicians in the outpatient department, as well as difficulties in the HIV (IDI235), reproductive and child health (IDI234) and laboratory departments.

> *"[The eHealth system] is failing to link all information together. Only accounts and pharmacy are linking well, but [the] other modules are not linked."* - A male clinician, RCH department, IDI371

However, other staff indicated that patients could be referred to another department through the eHealth system (IDI026, IDI125) as well as to a referral hospital (IDI124, IDI471), so there may have been a knowledge gap among the rest of the staff or the transfers were only between certain departments. Patients who were admitted could, however, be followed up during their subsequent visit to the outpatient clinic (IDI126,

IDI184). Apart from reported improved patient follow-up (IDI288), especially in the inpatient wards, at a higher level the eHealth system was found to be a useful tool for measuring quality of care.

> *"[The eHealth system] reports deaths, which we use to calculate mortality rates for the various departments. Mortality rate is an indicator of quality of care. For example, mortality rate for the maternity ward is not supposed to exceed 5%."* – A male management member, Medical department, IDI141

3.8.3 Reporting and Decision Making Outcomes

As of March 2012, the reports that had been coming from the eHealth system were reported as not satisfactory (IDI052), although inpatient reports were perceived to be much better (IDI168), thought to be over 90% reliable (IDI239). A team was set up to be checking the quality of eHealth system reports, make sense of them and share them with colleagues within their departments and to management for decision making. As such, apart from the default reports in the eHealth system, Madalo Hospital designed reports in the eHealth system to suit their needs (IDI164, IDI228, IDI266, IDI384).

However, some of the options for diagnosis in the eHealth system were perceived as not being relevant to Malawi, while other conditions that were common in Malawi were absent from the system (IDI087), making the ward clerks record only the diagnosis that most closely fitted what the clinical staff had written (IDI318). Some of which were resolved (IDI049) but others remained unresolved at the time of the interviews (IDI102). Also, some drugs were absent from the system (IDI088), although additional drugs were later added into the eHealth system (IDI105) in efforts to make them compatible with the national drug formulary.

> *"Some drugs are also not available in the system. Some have been added, but there are*

still some drugs that are prescribed but cannot be charged in the system." – Female Nurse, Medical Department, IDI088

When ward clerks were asked for statistics, they would count the paper registers, with some diagnoses and statistics not being reported. This was perceived to have been resolved for ward clerks who had knowledge of the eHealth system's reporting modules (IDI343). However, other staff found the system not set up to produce a consolidated report, something that still had to be done manually (IDI136, IDI369). In addition, one could reportedly not separate outpatient from inpatient data. However, some departments were able to produce reports from the eHealth system, such as the Reproductive and Child Health Department (IDI014) and vertical disease programme reports from the inpatient departments since July 2010 (IDI149), which were presented to hospital staff (IDI426 as read with 412 and IDI418) as well as submitted to other stakeholders.

"There was one time when a report was delayed to the District Health Office. It was a big issue and they requested to have a data clerk in the reproductive health unit. He is not using registers to write reports. [The RCH clerk] is using [the eHealth system]. It's a new change. STI, just click. Antenatal care, just click. Postnatal care, just click. But I don't know if the numbers are adding up to what [the maternity ward clerk] is recording for postnatal checks. Some are done at maternity, others here." A male clinician, RCH department, IDI014

Data from the eHealth system was used for organisational decision making. One manager described the various reports produced (IDI140 – IDI142), particularly four reports that were found to be useful (IDI195 – IDI198). First was the discharge diagnosis summary report that showed the primary diagnoses over a requested period. Second was the inpatient department daily census, which pulled diagnoses for each ward, and was used when the hospital had an Infection Prevention Shield presentation ceremony, although it was prone to human error, such as males being

found in maternity ward, which were actually male babies who were supposed to be reported under the Kangaroo Mother Care room of the maternity ward. Third was the diagnoses listing summary report, which reported the major diagnosis for each ward, and helped hospital management to procure adequate medicines and make sure there was enough staff trained in managing those major diagnoses. Fourth was the monthly HMIS-15 report to the district health office, which was inaccurate due to many reasons, such as the eHealth system not capturing diagnoses in the outpatient department, not registering state insurance patients (IDI147), not being linked to the MCH module, thus not matching the ANC maternity reports, making the HMIS-15 report produced virtually unusable.

Another useful report from the eHealth system was the calculation of bed occupancy rate (BOR) for the hospital wards. This indicator:

> *"… [tells us] what wards are busy which part of the year. Like currently bed occupancy rate in the maternity ward is 150 to 160 percent and in the children's ward it's 40%. As such, management is considering changing the lower paediatrics ward into a maternity ward. This will be considered after observing another malaria season to see if the lower children's ward will be needed."* – A male management member, Clinical department, IDI140

A middle-manager (IDI141) reported that the eHealth system's data had been instrumental in grants for a nutrition intervention, continuation of an exchange programme with Norway, establishing Madalo Hospital as a teaching hospital, having Malawian and international students doing their electives at the hospital, and grants for infrastructure projects such as staff houses, an extension of the labour ward and a guardian shelter.

3.8.4 Financial Management Outcomes

One of the challenges with the paper-based system was that some procedures were not included in the final patient bill because they were not written down. As a solution, all procedures (wound dressing, reduction, suturing, catheter, ear lavage) were being entered straight away by the nurse performing the procedure into the patient's medical file, and into the computer by the ward clerk. The nurse who compiled the bill at the end of the stay checked if all processes were entered, including laboratory procedures. Another solution was the development of a form that was used by the nurse to record a procedure, and the ward clerk entered the data into the eHealth system as soon as possible.

By March 2011, hospital management looked at the revenue being generated and believed that the billing module was saving the hospital a lot of money, but it was difficult to prove that, because there were many variables, like reductions in the amount of stationery being used for billing processes, and difficulties in receiving payment for state insurance, which the eHealth system was not able not resolve (IDI147). Further, the eHealth system could not link the patient who had a bill in the outpatient department when the patient presented another time at the outpatient department to add to the outstanding bill (IDI208).

> *"I thought we could do billing straight from [the eHealth system] for insurances and service level agreements. Outpatient billing is not registering them. The system is designed for cash patients only."* – Male management member (IDI147)

Nine of the thirteen interviewees believed that implementing the eHealth system had reduced errors, improved accountability and increased revenue (IDI053, IDI082, IDI167, IDI233, IDI258, IDI339, IDI340, IDI427 as read with IDI413 and IDI419). They reported that, prior to the eHealth system, many patients presenting at the hospital were not recorded and were able to progress through the care process without paying

for consultation, admission or drugs. Electronic registration using the eHealth system had since enabled the hospital to more easily identify and track patients through the care process, recording the costs of services received within the inpatient and outpatient departments and through drug dispensing (IDI258). Not all outpatients were being entered, as initially it was only cash paying patients who were entered (IDI147), then insurance patients were entered.

> *"With the manual system, a patient could see a clinician without paying, just because they are related or friends with the clinician. Even in the in-patient wards, the bills could easily be altered and some costs removed from the manual bill. That cannot happen with the electronic system. There are no more fake receipts with this system."*
> – An IT staff member, 29 September, personal communication

An additional challenge in the inpatient department was accountability. The Finance Office at Madalo Hospital reported cases where staff had informally agreed with patients that they could leave the ward without paying. They also indicated that there had been incidences where patients were asked by ward staff to pay an amount smaller than their bill, after which they were allowed to leave the hospital. To counter this anomaly, ward clerks, and not nurses, became responsible for compiling the bill and arranging the discharge of patients (IDI108, IDI166). Ward clerks did the billing in the eHealth system then sent the patient or guardian down to the inpatient cashier to pay.

Interviews revealed that immediately after implementing the eHealth system in 2010 within the inpatient department, the system was managed by the same nurses and patient attendants who had previously been responsible for data capture on paper, and billing was undertaken by the same accounts staff who received payment from clients. Most of these staff were typically drawn from the surrounding villages, creating social obligations upon them to alter patient files and bills for relatives and friends. Before the introduction of ward clerks, the opportunity to do this was equally

available to these staff using the eHealth system as it had been with the paper-based system. A manager describes how the introduction of Ward Clerks and other non-technical changes helped to improve this situation:

> *"A possible explanation for the increase in income could be the difficulty with altering electronic data as opposed to hand written receipts, separation of duties by having ward clerks, and closer monitoring of staff managing finances."* – A hospital manager, 1 October, email communication

The movement of paper files between various departments had also provided opportunities for records to be lost or adjusted:

> *"With the paper-based system, some tests or procedures would be lost or altered as the patient's paper file [went] from the ward to pharmacy to accounts and then back to the ward. Now the bill can be generated at the click of a button as the patient is being discharged."* – An accounts staff member, 30 September, personal communication

Another accounts staff member emphasized the practical advantages of having ward clerks using the eHealth:

> *"This has been improved as, while there are still some departments that that do not have the electronic system and require collection of their paper records, bills can now be produced at one point [in the eHealth system], and only one person per department (the Ward Clerks) has the responsibility of getting the paper files from these departments and compiling the electronic bill."* – 24 October, personal communication

Now ward clerks compile the bills, the accounts staff enter the patient's number into the computer and the eHealth system generates an invoice, which cannot be altered.

Further, the accounts staff only receive payments on the invoice due, and do not have access to compiling the bill in the eHealth system and cannot alter the invoice.

Patients were requested to bring the state insurance invoice to the accounts office. Some patients would skip this step, since there was no incentive for them to bring the file to the accounts office. With the introduction of the eHealth system, the ward clerk was able to record on the computer whether a patient was eligible for state insurance (IDI289), although others reported that the system did not identify state insurance patients (IDI147). After the discharge, diagnosis was being entered into the eHealth system by the ward clerk, then the system automatically added the patient invoice to the state insurance bill (IDI289). The patient then got a receipt and a stamp in their health passport as proof of payment.

A challenge with inpatient department flow was that patients were asked to pay for drugs that may have been cancelled later. As a solution, patients were paying a deposit before admission, then only paying for drugs which they used. Drugs were being ordered and dispensed on a daily basis. This varied ward by ward in terms of how drugs were dispensed, but for inpatients there was only payment of a deposit and then at discharge. Further, previously patients would receive a bill without details of the services being charged for (IDI072), but the eHealth system allowed the clients to understand how the bill was derived, since all details were now on the bill (IDI082).

Staff also highlighted the power of the data captured by the eHealth system to inform analytics for the purposes of audit (IDI009, IDI427 as read with IDI413 and IDI419), planning and cost containment, especially since with the coming of the eHealth system revenue could be disaggregated between outpatient, inpatient and drugs (IDI054):

> *"… Other offices like the [Principal Hospital] Administrator or the [Hospital]*

Accountant can view what is happening during the day [through the eHealth system]." – A male clinician, paediatrics department, IDI419

This was corroborated by a key informant from the accounts department, who confirmed that, for the inpatient section:

"We are also able to know how many beds are occupied, and what the expected revenue is, and compare with the actual revenue. Even for drugs we know the prescription and number of pills given and the amount the patient is supposed to pay at any time." – 30 September, personal communication

The advantages of the eHealth system for enabling management oversight and decision making also extended to the detection of dishonest practices. As early as 2012, managers had discovered that monitoring financial data using the eHealth system could uncover irregular patterns indicative of possible fraud.

"Previously, patients were conniving with staff to reduce the bill. Now there are checks and balances to counter that practice." – An accounts staff member, 30th September, personal communication

Some staff were even thought to have sabotaged the system in the outpatient department in order to evade detection for taking informal payments:

"We have an example of someone who would unplug the computer so that the accounts could authorize manual receipts because he benefitted from the manual system. This was at the cashier's office." – An IT staff member, IDI230

It also occurred that patients would be unable to pay the hospital, but only say so after having accumulated an enormous bill. Since the eHealth system could handle advance payments and deposits, this was not an ICT issue and management could

decide when the patient pays. There were, however, patients who could not pay their bill. The eHealth system was able to distinguish between income and actual receivables and keep track of debtors' history (IDI340). It was further difficult to track debtors with the hospital having limited manpower and a paper system (IDI053). Each year, the hospital lost an average of MK9 million to bad debts. Since the eHealth system captured each client's full address, it also had potential to be used to follow-up debtors.

> *"We are not yet using [the eHealth system] to its full capacity because it is not yet generating the debtor statements by address so that the hospital can start collecting. Once this is in place then collections should increase even more!"* – A male hospital manager, 24 September, personal communication

Data on hospital income from patient fees was available for the 44 months prior to the eHealth system being first implemented and 52 months after, and is reflected in Figure 9 on page 101. A granular breakdown of the costs of individual services was not available consistently over the observation period, due to changes in accounting procedures. In the pre-implementation period, mean monthly income from patient billing was **MK2,528,185** (MK95% CI: MK2,037,970 – MK3,018,399), compared with **MK4,252,825** (95% CI: MK3,703,046 – MK4,802,605) in the post-implementation period. This was equivalent to US$7,320 vs US$12,313 at 2013 exchange rates (OANDA Corporation 2016), representing an apparent 68% increase. However, after adjusting for inflation, monthly revenue in the pre-implementation period averaged **MK4,986,795** (median: MK4,305,927; 95% CI: MK4,121,741 – MK 5,851,850), compared with **MK5,757,277** per month (median: MK5,700,291; 95% CI: MK5,044,025 – MK6,470,529) in the post- implementation period, equivalent to US$11,968 vs. US$13,817. This represented a positive difference of approximately 15.4%. Factoring in the cost of employing the four ward clerks (MK355,982) reduced the percentage increase in revenue still further, from 15.4% to 8.1%. However, the Mann-Whitney U test indicated that the difference between pre- and post-implementation median

monthly revenue was statistically significant (P=0.024).

The above statistical comparison offers only one perspective on the data, and visual inspection of Figure 9 reveals considerable variability across time. Documentary analysis revealed several co-occurring factors operating at the state and hospital levels which may have influenced revenue levels, and it was necessary to take these into account when interpreting the data. These were inflation, state reimbursement, and introduction of ward clerks.

Inflation: A proportion of the increased average revenue in the period since the eHealth system was implemented is accounted for by inflation. Correcting for this in a low-income country context like Malawi is challenging, since inflation rates can fluctuate considerably across and within years. For example, between 2006 and 2013 consumer prices in Malawi ranged from a record low of 6.30% in Dec 2010 to a record high of 37.90% in Feb 2013 (Trading Economics 2015). Costs of different types of service within Madalo Hospital also varied to a non-uniform extent. Decisions on fee changes for outpatient and inpatient services are typically based on comparisons with fees charged by other rural mission hospitals in Malawi, or else rounded up to the next unit. Drug fees are based both on changes in wholesale prices and a pragmatic differentiation of episodic versus long term treatments (e.g. hypertension medication), mindful of affordability to patients. Robust and highly differentiated pricing figures were impossible to obtain for the full observation period. Senior management offered a 'best guess' estimate of 20% inflation for billable services overall. However it was decided to use consumer price index (CPI), which were available across the observation period, to estimate the expected inflationary revenue for each month (Fleming et al. 2014; Choi et al. 2013), adjusting backwards based on 2013 prices.

State reimbursement: As discussed before, in 2007 new service level agreements (SLA) around maternal and child healthcare were implemented, whereby the Ministry of

Health began to reimburse hospitals for serving clients from agreed catchment villages and referral centres. This markedly increased the numbers of pregnant women and children under 5 years old attending the hospital in the period prior to the implementation of the eHealth system in 2009. Whilst, in theory, this could explain the overall increase in total revenue post-implementation, this study's analysis was concerned with revenue captured directly from patient billing and fee recovery. Although available revenue data included state reimbursement for the period before implementation in Sept 2009 and a period of six month after implementation (Nov 2009 to Apr 2010), the data did not include state reimbursement for the other forty-six months after implementation. Considering this confounding by the state-sponsored intervention, the difference between revenue in the pre- and post-implementation phases ought to be slightly higher.

Malaria intervention: During 2009, when the eHealth system was first implemented, the hospital and government also implemented a major anti-malaria programme, which reduced malaria admissions and thus total hospital revenue from patient fees between 2009 and 2011, as shown in Table 3. The malaria programme is now repeated annually between December and February and the number of malaria patients attending the hospital has stabilized.

Introduction of Ward Clerks: Ward clerks were introduced to manage billing practices and input data to the eHealth system in 2012. This was associated with a marked increase in revenue collection per patient in 2012 and 2013, despite almost constant patient numbers. The context and perceived influences of this intervention on data capture and accountability were discussed qualitatively above, and suggest that the good-governance practices of ward clerks were critical for harnessing the benefits of the system for revenue capture.

3.8.5 Staff Satisfaction with the eHealth System

When asked what they did not expect from implementation of the eHealth system, a male clinician said that he did not know it would consume so much of his time (IDI375), while a male management member exclaimed:

> *"Many sleepless nights! I didn't know it would be so difficult to get the system regularly functioning. Issues include staffing, power and planning, for example servicing plans."* – (IDI146)

Clinicians at Madalo Hospital expressed that implementation started well, and the eHealth system was generally good (IDI476), such that they would adopt it if they had their own clinics (IDI067), but they also acknowledged challenges encountered (IDI092, IDI435). However, there were too few clinical staff using the system to measure their satisfaction with the eHealth system (IDI186). Although usage by the inpatient ward clerks had reportedly gone well (IDI111, IDI173), outpatient diagnosis and treatment was still considered incomplete (IDI112, IDI472).

> *"First years it was excellent and fulfilling. At the later years, we've had problems as it is not doing what it is supposed to do, especially the reporting module. For RCH module, we are stuck."* – A male IT technician (IDI269)

Registration and general billing modules were perceived to be successful (IDI172, IDI233), and the provision of a bill and receipt for every transaction reportedly led to client satisfaction (IDI082, IDI187), and some respondents claimed the eHealth system could identify patients covered by the state insurance (IDI289), although others expressed the eHealth system's deficiencies in processing state insurance bills (IDI147). Staff also expressed that there was no linkage of the eHealth system across the hospital (IDI174, IDI401).

Further, the eHealth system had reportedly not reduced duplication of data (IDI182, IDI474), especially in outpatient diagnosis and treatment, although some claimed that the eHealth system had reduced duplication of data for those who had lost their health passports (IDI296), especially with the drop-down menus (IDI297, IDI368), while others claimed it had improved data quality in the inpatient department (IDI350).

There was reportedly definite improvement in the efficiency of billing and inpatient reporting (IDI183, IDI188), providing a strong argument for the hospital's indoor residual spraying programme for malaria control, for example (IDI189), while quality of care had not improved dramatically, only useful when non-communicable disease patients had lost their health passports (IDI184), and for retrieving patient files for periods beyond the patients' health passports (IDI185), although there was still duplication of patient files when the patients bought new health passports and registered as a new patients with new patient numbers, also when the patients had multiple health passports (IDI264). Although the eHealth system could keep prescription and billing data, it was not being used to its full capacity (IDI192).

3.9 Summary of Case Study 1

This chapter has presented the first case study, a retrospective biographical analysis of the eHealth programme undertaken at Madalo Hospital. After describing the hospital, a biography of its implementation was presented. These results were organised in line with the theoretical framework described in Section 1.4: soft-positivist epistemology, pluralist narrative, and a focus on the complex interactions between change management, organisational, and socio-technological factors affecting outcomes.

Implementation of the eHealth system illuminated the dysfunctional paper-based system, and firstly printed labels helped limit document losses. Another change management decision was to recruit data clerks only in the inpatient department, while over-burdened clinical staff in the outpatient department were expected to use the eHealth system. Change management also included process reorganisation by recruiting and training staff, and by introducing electronic receipts required by each client and service provider at the hospital. Organisational inhibitors were electricity fluctuations and outages that made even UPS units ineffective, but were resolved by introducing more power-efficient N-computing units. Other organisational enablers were security enhancements that included infrastructural and policy interventions to secure equipment and patient data.

There were hardware, networking and software challenges to eHealth implementation and adoption. Although the technology brought other benefits such as improved communication, it was subjected to such abuse by staff that even establishing rules and an IT centre to regulate usage in the hospital were ineffective, leading to a system crash in 2012. There was strong management support for the eHealth system, although staff attitude was mixed. Staff training at the hospital was hindered by high staff turnover and department rotations, requiring regular training. Staff did, however, report improvements in computer skills. Lack of in-country

technical support for the software was a strong barrier at the hospital. A foundation was formed to fill that gap, but the software was not a fully-developed product to sustain the foundation, and the developers of the software were unwilling to release the source code to the foundation. Although the hospital's IT team tried to cope with increasing demands by recruiting more staff and reorganising, this was defeated by high turnover among the team.

Despite these challenges, the eHealth system could show some tracer outcomes in data quality, service delivery, reporting and decision-making, and financial management. When compared to DHIS2 data, the eHealth system's outpatient registration data was 76.0% complete, under-reporting by an average 577 clients per month. When compared to the hospital's paper-based records, the eHealth system's inpatient data was 93.6% complete and 68.9% accurate. In terms of service delivery, the eHealth system was reported to have made retrieval of patients' paper files faster as it changed the hospital's filing system, and retrieval of data for patients with lost paper records, allowed linking of an out-patient to their inpatient record, and provided data to measure quality of care. Customised reports for the hospital were created and used for decisions such as allocation of wards, advocacy and funding applications. Financial management was reported to have improved due to better-quality data capture and tracking of service charges, separation of billing and receiving roles by recruiting ward clerks, enhanced oversight by management, and fraud prevention. Although median monthly revenue was significantly higher after eHealth system implementation ($P=0.024$), there were contextual micro- and macro-factors that confounded interpretation, and real improvement only came after recruitment of ward clerks towards the end of the study period.

CHAPTER 4 HEALTH CENTRES: PROSPECTIVE CASE STUDY

Chapter Aims

- Report the prospective case study of health centres, including research methods and analysis of findings
- Describe and analyse the contextual, socio-technical, change management and organisational enablers and inhibitors to implementation
- Analyse the effects of the eHealth system on the quality of data for service delivery, reporting and financial management

4.1 Methods

Following the broad overview of theoretical perspectives in Section 1.4 and of methodological and analytical approaches described in the Sections 1.5 and 1.6, this section outlines the methods selected and used for the Health Centres case study. These include qualitative methods of collecting facility documents and artefacts, and focus group discussions. Their analytical methods are also presented.

4.1.1 Philosophical and Methodological Basis

Similar philosophical and methodological principles were drawn upon in the design of the prospective health centres study as in the retrospective hospital study (See section 3.1.1). This included soft-positivist epistemology, a theoretical perspective of two-way interactions between complex socio-technological and organisational dynamics within the hospital to determine the use and outcomes of the eHealth system, and assumptions of change that followed a pluralist narrative (Anderson & Aydin 2005), using an analytical framework developed for Sub-Saharan Africa, identifying organisational, technological, change management and social dynamics, and outcomes (Jawhari et al. 2016).

A *prospective* embedded single-case design (Yin 2014) was chosen for this study, to also allow cross-facility group analysis and comparisons. Health centres were grouped into three levels of adoption, based on observations by the researcher, implementers and monitoring reports of the eHealth implementation project, in accordance with the Diffusion of Innovation Model (Rogers 2003). These were three facilities in the Early Adopters group, four facilities in the Late Majority group and two facilities in the Laggards group, as shown in Table 7 below. Winistoni, Ponekela, Jedawako and Sinelia health centres received the eHealth system in 2012, while the rest of the health centres received the eHealth system between January and March 2013.

Table 7 List and Categories of Health Centres

Early Adopter Facilities	**Late Majority Facilities**	**Laggard Facilities**
Winistoni Health Centre	Jedawako Health Centre	Filipi Health Centre
Ponekela Health Centre	Sinelia Health Centre	Bisitoni Health Centre
Dalitso Health Centre	Sauko Health Centre	
	Malilika Health Centre	

A prospective study design was undertaken. Data were collected in October 2014, seven months after implementation at the last facility (pre-study) and in March 2016, twenty-four months after implementation at the last facility (post-study).

4.1.2 Qualitative Methods

Rationale for the use of qualitative methods and measures taken to ensure their validity in this study were discussed in Section 3.1.2. There were three Bachelor degree-level research assistants that helped with data collection. Training for the research assistants covered the basic concepts of the study, terminology, processes

and methods, and taught the research assistants how to properly apply the techniques used in the study. Research assistants were also trained on protocols for case study research, including time deadlines, guidelines for collection of documents at the health centres and guidelines for field procedures to be used.

After research assistants were trained, the final preparatory preparation step was to select a pilot site and conduct a pilot test using each tool so that problematic areas could be uncovered and corrected (Yin 2014). Pilot study at Partners in Hope Medical Centre in Lilongwe City provided valuable feedback for the study, establishing clear protocols and procedures for the fieldwork.

4.1.3 Review of Facility Documents and Artefacts

Documents and artefacts collected included project documents (proposal and monitoring and evaluation reports), and managerial and administrative documents at the facilities guided by some of the Performance of Routine Information System Management (PRISM) tools (Aqil et al. 2009). These tools also checked the quality of paper-based health management information system (HMIS) reports by comparing them with manual count in the paper registers. They also explored the resources available for data collection and reporting, including infrastructure and human resources.

Data from the bespoke eHealth system's patient registration and diagnosis modules were also collected. Off-site records collected were facilities' monthly HMIS data as reported in the HMIS-15 report. These were collected from the District Health Information System, version 2 (http://www.hispmalawi.org.mw or http://live.hispmalawi.org.mw/dhis/dhis-web-commons/security/login.action), a web-based monthly reporting system for all registered health facilities, entered at the district level.

4.1.4 Focus Group Discussions

Eighteen focus group discussions were conducted, two at each facility, 24 months apart. All 297 staff members from thirteen cadres were invited to participate in the study. Focus group discussion participants were recruited through posters that were displayed at the health facilities inviting participants to take part in the focus group discussions, as described in Section 1.7. After getting written consent from all respondents, interviews were conducted, recorded, summarised and analysed.

Nine interviews were conducted seven months after the installation of the system at the last health facility, one focus group interview at each facility. Focus group participants are shown in Table 8 below by gender and cadre. There were a total of 83 participants, representing 27.9% of the workforce, with an average of 9 participants per focus group, a maximum of thirteen participants at Malilika Health Centre and a minimum of four participants at Ponekela Health Centre.

Table 8 Health Worker Participants in First Set of Focus Group Discussions

Cadre	Total Per Cadre	Total at 9 health centres	
		Male	Female
Hospital attendant	15	9	6
Nurse midwife	11	2	9
Ground labourer (Janitor)	4	4	0
Health Surveillance Assistants	18	12	6
Security guard	5	5	0
Medical assistant	7	6	1
HCT provider	7	6	1
Patient attendants	6	3	3
Home-craft worker	1	0	1
Accounts	3	3	0
Dental attendant	1	1	0
Lab technician	2	2	0
Anti-Retroviral Therapy clerk	1	1	0
Data clerk	2	2	0
Total	83	56	27

A second set of focus group discussions was held twenty-four months after implementation at the last facility, one at each of the nine health centres. There were 81 participants at these discussions, representing 27.2% of the workers at the health centres, as shown in Table 9. There were an average of nine participants per focus group, with a maximum of 12 each at Dalitso Health Centre and Ponekela Health Centre (Early Adopter Facilities), and a minimum of two participants at Bisitoni

Health Centre (Laggard Facility). All sessions were audio recorded and translated into English verbatim.

Table 9 Number of Participants on Second Set of Focus Group Discussions

Cadre	Total Per Cadre	Total for 9 Health Centres	
		Male	Female
Statistical Clerk	4	4	0
Ground Labourer (Janitor)	9	7	2
Hospital Attendant	17	10	7
Security Guard	5	4	1
Health Surveillance Assistant	21	19	2
Senior Health Surveillance Assistant	2	1	1
Nurse	9	3	6
Patient Attendant	4	1	3
Pharmacy Attendant	1	0	1
Lab Attendant	1	1	0
Cashier	2	2	0
Home-Craft Worker	1	0	1
Dental Attendant	1	1	0
Clinician	4	2	2
Total	**81**	**55**	**26**

4.1.5 Analysis

Data Quality Analysis

Data from the bespoke eHealth system was compared to data from the web-based District Health Information System (DHIS2) for two Early Adopter Facilities (Winistoni and Ponekela) and two Late Majority facilities (Jedawako and Sauko). These were the best-performing facilities in their categories and could give an indication of the maximum data quality. Indicators compared were DHIS2's outpatient department (OPD) attendance with the eHealth system's patient registration module. Data elements from DHIS2 and the eHealth system were assessed as being (a) present in both sources and correct, (b) present in both sources but incorrect in the eHealth system, and (c) present in DHIS2 but absent in the eHealth system. Completeness was thus calculated as (Logan et al. 2001):

$$Completeness = \frac{(a) + (b)}{(a) + (b) + (c)}$$

Observations at the health centres revealed that data was not consistently entered in the eHealth system for reasons discussed in Section 4.7.3 below. As such, data in the eHealth system was assumed to be inaccurate. Nevertheless, agreement between the paper-based system and eHealth system data was measured using the Bland-Altman analysis, as described in Section 3.1.4.

Framework Analysis

Qualitative data was analysed using Framework Analysis as described in Section 3.1.4 above. Framework Analysis was employed because this type of analysis is specifically geared toward generating policy and practice-oriented findings among researchers (Green & Thorogood 2014), providing more depth than thematic analysis yet without the complexity of theory-building grounded theory analysis (Mills et al. 2014). There were five steps followed when Framework analysis was being conducted, as detailed in Section 3.1.4: familiarization; identifying a thematic framework; indexing; charting; and mapping and interpretation (Srivastava &

Thomson 2009).

Content Analysis

In a process called content analysis (Krippendorff 2004), different from the qualitative content analysis, facilities were ranked according to their level of adoption of the eHealth system, from one (total failure) to nine (highest adopter). Thereafter, a total of 71 codes or themes were derived from the qualitative data using Framework Analysis described above, indicating the possible factors that determined the level of adoption by the facility. Each code or factor was given the value 1 if it had been coded for that facility, and the value 0 if it had not been coded. In order to determine whether there was a relationship between these coded themes and the facility's level of adoption, and to quantify this relationship, correlation coefficients were calculated. These were the Pearson's correlation (r) and non-parametric Spearman's rho. These were to test the null hypothesis that the correlation in the themes at the facilities was zero, indicating whether there was directional relationship between these factors and the level of adoption. Quantification of the themes provided meaningful descriptive information to triangulate findings from the inductive Framework Analysis described in Section 3.1.4 (Whittaker et al. 2009).

Findings from the health centres are presented below. Quotes from the interviews are appended to this thesis, and are depicted in parentheses in the findings as baseline (BL) interviews, post-implementation (PI) interviews and documents reviewed (DR). An analytical framework specifically developed for Sub-Saharan Africa was used (Jawhari et al. 2016), identifying process/change management, systemic/organisational, product/technological and people/social dynamics, and outcomes.

4.2 Description of the Nine Health Centres

4.2.1 Summary of the Nine Health Centres

This summary covers a general overview of the nine health centres, where they are located and who owns them. Three categories provided information to draw inferences about quality of care at the health centres: structure, process and outcome (Donabedian 1988). Descriptions of how the facilities are structured is given, covering human and infrastructural resources, followed by a description of the processes of patient flow, data management and delivery of patient care, and finally patient load and health outcomes for the year 2013.

Structure

These 9 rural health facilities provided primary health care, including antenatal and delivery care, for the population that was not directly served by Madalo Hospital, and referred patients to the Hospital for specialist care. Five health centres were in one district, while the rest belonged to another district. Seven of the health centres were free, public facilities, while two were Christian Health Association of Malawi (CHAM) facilities with user fees, just like the Hospital. All health centres referred maternal complications to the Hospital for specialist care, except one health centre which did not offer maternal and neonatal health services.

In 2013, a rapid assessment by the researcher counted 297 staff members at the nine health centres. At all the 9 facilities, each clinician served clients an average 15,225 visits, and each nurse served clients an average 9,240 visits in the year. Only four of the 9 facilities had a data clerk responsible for data entry and reporting. Each facility had an average of 18 (range 4 – 39) community-based health surveillance assistants (HSA), and an average of 14 support staff (patient and hospital attendants, HIV counselling and testing (HCT) providers, finance clerks, guards, ground labourers, etc.). Most of these staff members had not received any training in HMIS.

During the baseline assessment, it was found that the health workers had to collect and manage a large amount of paper-based HMIS data. Of the nine health centres, only 4 had a computer (with the bespoke eHealth system installed at 3 health centres), 5 had a calculators (4 of them at 4 facilities without a computer), and 8 had access to mobile phone network. Six of the 9 health centres were connected to the national power grid, although they experienced frequent power cuts. These facilities went at an average of 11 weeks in a year without antibiotics and other essential drugs.

Process

Patient flow was processed fairly similarly at all the nine health centres. When clients came to the facility they would buy a health passport book (if first visit), where a non-clinical staff member took their vital signs (weight, temperature) and date stamped the health passport. A clinician then attended to the client and wrote the diagnosis and prescribed treatment in the client's paper health passport. The clinician could also direct the client to the laboratory for further tests. The patient's details and results were recorded in the appropriate paper register, e.g. malaria, HIV, etc. The client then collected the drugs at the pharmacy or the clinician's room. On exiting the facility, a clerk recorded the client's details from the health passport (name, village, diagnosis, treatment) in the outpatient paper register. Reproductive and child health clients went straight to the appropriate department where the attendant nurse checked and recorded in the clients' health passport as well as the appropriate paper registers for reporting. At the end of each month and quarter, data was aggregated from all the registers and reported to the district health office and on to the Ministry of Health headquarters. Other reports went to relevant vertical disease programme managers such as for HIV, reproductive health, TB, malaria and immunization.

Outcomes

In 2013, eight health centres received 6,678 new antenatal clients. Only 12% of them were in their first trimester of pregnancy as recommended by the Ministry of Health and WHO. Women at the antenatal clinics were offered tests and results for HIV, and

3% of them were found to have HIV, adding 188 more women with HIV in the clinics' catchment area.

There were 5,219 babies born in the year. During delivery, the facilities treated 237 women and 182 new-born babies with complications. Almost all the deliveries (97%) were at the clinics with a skilled birth attendant. Some of the children born to women living with HIV (18%) did not receive treatment to prevent mother to child transmission. About two thirds of the new-born babies (68%) were brought to the clinic within the recommended 2 weeks of birth for post-natal care, including vaccinations.

4.2.2 Bisitoni Health Centre

Structure

Bisitoni Health Centre had one medical assistant, no nurses, 4 health surveillance assistants (HSAs), 1 guard, 3 hospital attendants and 2 ground labourers. The HSA filled in the monthly HMIS report. The medical assistant and one HSA had been to recent (2013) training in data collection, data analysis and data display and reporting.

There was no computer, no data backup, generator, regular phone, fax or access to Internet. There was a radiophone, calculator, personal phone for staff and mobile phone network coverage. There was no continuous electricity supply and no running water. All required paper registers were available and they did not experience recent stock-outs.

Outcomes

In 2013 Bisitoni Health Centre served 8,715 outpatient clients with 67 admissions. There were a total of 404 antenatal clients in the year, with 324 of them new clients and 39.8% of them in their first trimester of pregnancy. Of the 95 pregnant women tested for HIV and given results, 5.3% were HIV positive. There were 144 deliveries

by skilled attendance with 133 live births. Three women were treated for obstetric complications, with two women having postpartum hemorrhage, with no maternal death in the year. Twenty-four of the newborns had low birth weight, with 3 treated for newborn complications, and 71.4% newborns attended postnatal care within 2 weeks. Two babies were given nevirapine to prevent mother to child transmission of HIV. Bisitoni Health Centre suffered major stock-out of drugs, with most days without antibiotics.

4.2.3 Filipi Health Centre

Structure

Filipi Health Centre had 1 sister-in-charge, 2 medical assistants, 2 nurses, 5 patient attendants, 5 hospital attendants, 1 laundry worker, 1 driver, 1 cashier, 1 home craft worker, 1 HIV counselling and testing (HCT) provider, 5 security guards and 3 ground labourers. Medical assistants, patient attendants and HCT provider had undergone training in data collection, data analysis and data display and reporting. Medical assistants, nurses and patient attendants compiled HMIS monthly reports.

Reports were done with no computer, data backup, regular telephone, fax or data storage outside the site. However, Filipi had a generator, a radiotelephone, a facility mobile phone, personal mobile phones, a calculator and access to mobile phone network. There was continuous supply of electricity, but no room with air-conditioning. Running water was available at the facility. There was no stock out of all necessary paper registers, such as for maternity, antenatal, outpatient department, analysis book, HCT register, ART register, and primary health care services.

Outcomes

In the year December 2012 to November 2013, Filipi Health Centre saw 9,082 outpatients with 1375 admissions. There were 2,102 antenatal care (ANC) visits, 977 of them new ANC visits, 6.1% of whom were in their first trimester of pregnancy.

HIV tests and results were given to 1,048 pregnant women, with 2.5% of them testing HIV positive. There were 617 live births, with 95.8% of them being by trained health worker. Although 8 women were treated for obstetric complications at the facility (10 cases being postpartum hemorrhage), the year saw no maternal deaths. There were 38 newborns weighing less than 2,500g. There were 354 newborn babies brought to the facility for postpartum care within 2 weeks of birth, where nevirapine was given to all 26 newborns exposed to HIV to prevent mother to child transmission. Antibiotics were out of stock for 110 days in the year.

4.2.4 Malilika Health Centre

Structure

Malilika Health Centre had in 2013 a sister-in-charge, an administrator, 8 nurses, a cashier, 2 laboratory attendants, 19 health surveillance assistants (HSAs), 2 home craft workers, 15 patient attendants, 3 ground labourers and 5 guards. Laboratory attendants and health surveillance assistants compiled HMIS reports. In 2013 nurses, HSAs, cashier and laboratory attendants underwent training in data collection and data display and reporting.

There were 3 computers with the bespoke eHealth system installed in 2012, a printer, a broken radiotelephone, access to Internet using a dongle, 2 calculators, a facility mobile phone, personal mobile phones, and access to mobile phone network. However, there was no data backup unit, modems, UPS, generator, regular phone, and no data storage outside the site. There was continuous supply of electricity, which was occasionally interrupted. There was no air-conditioner in any of the rooms at the facility. Running water was available at the facility. Malilika Health Centre experienced no stock-out of paper registers such as for outpatient, antenatal, HIV counselling and testing (HCT), antiretroviral therapy (ART), maternity and nutritional rehabilitation unit (NRU) services.

Outcomes

In 2013 Malilika Health Centre treated 18,008 outpatient clients and 3,495 inpatients. A total of 865 antenatal clients were served, with 675 of them new clients and 4.9% coming in the first trimester of their pregnancy. HIV test results were given to 939 pregnant women, of whom 36 tested positive for HIV. There were 473 deliveries conducted by skilled birth attendants with 466 live births. Although 25 women were treated for obstetric complications, there was no maternal death. Twenty-four of the babies born were underweight (less than 2,500g), and 20 had newborn complications. Postpartum care was provided to 41.2% of babies within 2 weeks of delivery, with 9 given nevirapine to prevent mother to child transmission of HIV. Antimalarial drugs, oral rehydration salts and co-trimoxazole were out of stock for more than a week 12 times in the year.

4.2.5 Sauko Health Centre

Structure

Sauko Health Centre had two medical assistants, 3 nurses, 18 health surveillance assistants (HSAs), 2 drivers, 3 ground labourers, 6 hospital attendants, 2 security guards and 1 data clerk, who filled in the HMIS monthly reports. The data clerk had attended training in the recording, processing and reporting of health data.

There was neither computer nor data backup, generator, regular phone, facility mobile phone or radiophone. There was no access to the Internet. There was solar power installed. There were 4 calculators, all in working condition. All health workers had a personal mobile phone, and there was mobile phone network coverage. There was no fax machine. Sauko had paper registers for outpatients, family planning, antenatal, antiretroviral therapy (ART) and maternity services, and they had experienced no stock-outs of any of the registers.

Outcomes

In 2013 Sauko Health Centre served 25,715 outpatient and 667 in-patient clients. There were a total of 3,093 antenatal clients served, with 1,122 of them new clients and 14.4% coming in their first trimester of pregnancy. HIV tests and results were given to 735 pregnant women, with 6.8% testing positive for HIV. Two pregnant women were severely anemic and one pregnant woman had preeclampsia. There were 648 deliveries by skilled birth attendance with 645 live births. Although 7 women were treated for obstetric complications, there was no maternal death in the year. Twenty-five of the live births were underweight (less than 2,500g) and three had newborn complications. Fifty of the newborn babies were given nevirapine to prevent mother to child transmission of HIV, and 70.7% of the new-born babies came to the clinic within 2 weeks for postpartum care. Anti-malarial, oral rehydration salts and antibiotics were out of stock for more than a week 18 times.

4.2.6 Sinelia Health Centre

Structure

Sinelia Health Centre had 1 medical assistant, 1 nurse, 2 senior health surveillance assistants (HSAs), 14 HSAs, 6 hospital attendants, 2 ground labourers and 2 guards. In 2012 the medical assistant, nurse, HSAs and ground labourer attended basic computer training. Senior HSAs compiled the HMIS monthly reports.

Sinelia had no computer, data backup, generator, regular telephone, access to Internet, or fax machine. There was no calculator or access to mobile phone network, although some of the staff members had mobile phones. There was electricity supply using solar power, although there were regular interruptions. No room was air-conditioned. There was running water available. There was extensive stock-out of registers such as for outpatient, antenatal, maternity, family planning, antiretroviral therapy (ART), Supplementary Feeding Programme and immunisation services.

Outcomes

In 2013 Sinelia Health Centre served 12,072 outpatient clients and 258 admissions. There were 1,822 antenatal visits at the facility, of which 954 were new and 34 were in their first trimester of pregnancy. HIV test results were given to 762 pregnant women and 5 of them tested positive for HIV. There were 564 live births with 99.1% deliveries by skilled birth attendance. Fourteen women were treated for obstetric complications, with 2 cases of delivery sepsis and one case of postpartum hemorrhage, but no maternal death in the year. Among the newborn babies, 5.3% had were born under-weight, 3 had newborn complications and 5 were given nevirapine to prevent mother to child transmission of HIV. Postpartum care was provided to 33.9% (n=191) newborns within the recommended 2 weeks of birth. There was no stock-out of drugs for more than a week.

4.2.7 Jedawako Health Centre

Structure

Jedawako Health Centre had one medical assistant, 2 nurses, 13 health surveillance assistants (HSAs), 1 data clerk, 7 hospital attendants, 1 ground labourer and 3 guards. The data clerk compiled the monthly HMIS reports. In 2013 the medical assistant, HSAs, hospital attendants and data clerk underwent training in data collection, data analysis, and data display and reporting. The data clerk attended the training twice.

The facility already had the bespoke eHealth system implemented in 2012, with 8 computers, a regular telephone, a facility mobile phone, personal mobile phones, access to Internet and mobile phone network coverage. However, there was no data backup unit, no printers, no modem, no UPS, no generator and no radiotelephone. There was no calculator or storage service outside the site, and no fax. There was continuous power supply, but with daily electricity supply interruptions. Running water was available. Jedawako experienced no stock-out of registers such as for outpatient, maternity, antenatal, HIV counselling and testing, under-5, and under-1

services.

Outcomes

In 2013 Jedawako Health Centre served 38,887 outpatient and 502 inpatient clients. Of the 1,597 antenatal clients served in the year, 679 were new clients and 92 were in their first trimester of pregnancy. Ten pregnant women tested HIV positive, representing 1.3% of HIV test results given to pregnant women. Skilled birth attendants delivered 96.4% of babies born, from 524 live births. Although 53 women were treated for obstetric complications, there was no maternal death in the year. Twenty-nine newborns had complications and 23 live births weighed less than 2,500g. Postpartum care was provided to 493 babies within 2 weeks of birth, where 9 babies received nevirapine to prevent mother to child transmission of HIV. Antibiotics were out of stock for more than a week once in the year.

4.2.8 Dalitso Health Centre

Structure

Dalitso Health Centre had 2 clinicians, 6 nurses, 1 environmental health officer, 38 health surveillance assistants (HSAs), 1 data clerk, 5 hospital attendants, 2 ground labourers, and 5 guards. The data clerk filled in the HMIS reports. Both clinicians, all nurses, the data clerk and some HSAs had received training in the recording, processing, and reporting health information in December 2012.

Dalitso also had the bespoke eHealth system, with 4 computers, 2 in working condition. There was no backup data unit, modem, UPS, generator, regular telephone or a radiotelephone. There was a barcode printer, a calculator, a facility mobile phone, personal mobile phones and cellular network coverage. There was no fax machine. There was continuous power supply, but with daily power interruption, and the room where computer hardware was kept was not air-conditioned. Running water was available. All paper registers were available, with no stock-outs experienced in

the year.

Outcomes

In 2013 Dalitso Health Centre saw 31,174 outpatient attendees, with 1,493 admissions. Of the 5,455 antenatal patients seen, 38.8% were new and only 5.3% were in their first trimester of pregnancy. There were 2,159 pregnant women tested for HIV and given results, with 2.0% of them testing positive for HIV. There were 1,420 live births, with 92.6% of them by skilled birth attendant. There were 111 women treated for obstetric complications in the year, with no maternal death. Only 12 of the births were underweight, with all 43 babies exposed to HIV receiving nevirapine to prevent mother to child transmission. There were 1,257 newborns attending postnatal care within the recommended 2 weeks of birth, representing 88.5% of live births. The facility also treated 7.1% of the newborns with complications. Antibiotics were out of stock for over a week 7 times during the year.

4.2.9 Ponekela Health Centre

Structure

Ponekela Health Centre had 1 medical assistant, 1 senior health surveillance assistant (HSA), 9 HSAs, 1 hospital attendant, 1 ground labourer, 2 guards and no nurse. In 2013 the medical assistant, HSAs, hospital attendant and ground laborer received training in data collection, data analysis and data display and reporting. There was no computer, data backup, generator, access to Internet, data storage service outside the site, or fax. There was, however, a regular telephone, a calculator, a facility mobile phone, personal mobile phones and mobile phone network coverage.

Outcomes

Ponekela Health Centre was an outpatient clinic with no maternal and newborn health services. As such, in 2013 the facility only saw 7,497 outpatient patients with no admissions. The facility experienced stock-out of antibiotics for 59 days in the year.

4.2.10 Winstoni Health Centre

Structure

Winstoni Health Centre had 2 medical assistants, 3 nurses, 21 health surveillance assistants (HSAs), 1 data clerk, 4 hospital attendants, 4 maids, 3 ground labourers, 4 guards and 1 HIV counselling and testing (HCT) provider. In December 2012, both medal assistants, nurses, data clerk, HCT provider and some hospital attendants and ground labourers went for training that covered data display and reporting.

Winstoni had 3 computers with the bespoke eHealth system implemented in 2012, all in working condition, but no data backup unit. There were no printers, modems, UPS or generator. A regular telephone existed, in working condition, and a radiotelephone that was not in working condition. There was no calculator or data storage service outside the site. There was a facility mobile phone and access to cellular network. There was continuous electricity supply, with daily interruptions. The room where computer hardware was kept was not air-conditioned. Running water was not available at the facility. There were 13 paper registers at the facility, with stock-outs of registers for malaria rapid test, manual vacuum aspiration, visual inspection with acetic acid for cervical cancer and outpatient department services.

Outcomes

In 2013 Winstoni Health Centre served 37,156 outpatient clients with 948 admissions. There were 2,643 antenatal clients, with 993 new antenatal visits, of whom 8.3% were in their first trimester of pregnancy. There were 1,082 pregnant women tested for HIV and received their results, 1.2% of whom tested HIV positive. There were 850 live births with 92% deliveries by skilled birth attendant. Sixteen women were treated for obstetric complications, 13 with postpartum hemorrhage, but there was no maternal death reported at the facility. Five of the newborn babies weighed less than 2500g and 23 newborns had birth complications. Postpartum care was given to 84.7% (n=720) of

babies born at the recommended two weeks after delivery. Thirteen newborn babies were given nevirapine to prevent mother to child transmission of HIV. There was once stock-out of antibiotics for more than a week.

4.3 Change Management Dynamics

There is prominent literature from Sub-Saharan Africa describing intended and unintended change management processes, where eHealth system implementation brings to light dysfunctional processes and uncoordinated workflows (Jawhari et al. 2016). In addition to leadership and user engagement described in Section 3.4.1, the paper-based system that the eHealth system was to replace is presented in this section to portray the information management process, and issues of workload and staff shortages are also presented to depict the workflow at the health centres.

4.3.1 Description of the Paper Based System

Most of the references in this theme during the post-implementation interviews related to paper registers running out at the facilities, damage or loss of paper registers, people having to use their own money to buy pens for the paper-based system and one reference relating to use of personal money to make photocopies of register pages when they run out.

Early Adopter Facilities

Paper registers were reported to either quickly get damaged or run out without rapid replenishment at the facilities, with eleven people at the three Early Adopter Facilities referring to this challenge during the baseline interviews, and how they had hoped the eHealth system would resolve it (BL001 – BL011). It was observed during the baseline interviews that paper registers were also mostly not well organised (BL001), as they moved from place to place and were sometimes difficult to locate when needed (BL011). Paper registers were also reportedly prone to being stained in a clinic environment (BL005). When using these paper registers, pages were also reported to wear out or get torn as staff flipped through the pages, making the facility lose information. Participants also noted that, because of the damage and loss of paper registers, it was difficult for them to retrieve data from as far back as the prior six to

ten years (BL010). Even more recent data was reportedly difficult for them to retrieve, as the paper registers started deteriorating soon after arriving (PI006).

> *"We do have our own registers of which sometimes they ran out … using registers, sometimes when they ran out, we are always stranded to produce a report since we missed some data and at the end we put false data to produce a report."* – Male HSA, Winistoni Health Centre (BL004)

During the post-implementation interviews, staff at the three Early Adopter Facilities recalled how they would struggle to get registers, how they would go to collect them at the District Health Office and not find any (PI004). They spoke about how the paper registers started tearing even before two weeks had elapsed, and how they would get lost (PI006).

Paper-based resources also required stationery, and three participants at the Early Adopter Facilities revealed how they needed to use their own money to buy pens for writing in the paper registers (PI001 – PI003). Although stationery was provided at the facilities, it took two to three months without being replenished (PI002). Reduced personal expenditure on stationery reportedly allowed the health workers to use the money for other purposes (PI001).

> *"There was also another thing that [the computers] helped, that the money for buying pens was able to be used for other things, because the OPD register uses up a lot of pens."* – Male Ground Labourer (Janitor), Ponekela Health Centre (PI001)

Following implementation, staff at these facilities did not refer to having to use personal funds to buy stationery. However, one interviewee at Ponekela Health Centre did mention that he had to use personal money to travel to Madalo Hospital to photocopy forms when they ran out (PI008).

Late Majority Facilities

There were five references to lost, damaged or unavailable paper registers at two of the Late Majority Facilities during the baseline interviews (BL012 – BL016). With the paper system, even when patients were visiting the facilities for a subsequent time, they were recorded as new patients (BL012). Baseline interview participants also discussed how the eHealth system would help in cases where the paper registers wore out because of time (BL014), or when pages from the paper registers tore out. They spoke about how data could not be retrieved from the two previous years, and how the computers would be able to rectify that.

> *"Sometimes Ministry of Health personnel come and request for 2011 maternity register. It's difficult for us to find it and when found, it happens that it is worn out since it was used maybe from January to August and carried around daily, so some of the pages go missing, so with the computer, when asked to give data for 2011 deliveries, you just click, enter and search 2011 deliveries and immediately you give them the results, than with (paper) register, it is hard to find it."* – Male Nurse, Sauko Health Centre (BL015)

During the post-implementation interviews, there were no references to lost, damaged or unavailable paper registers at the Late Majority Facilities, though a male nurse mentioned that when the pens that they had been given were finished, they took money from their pockets to buy additional pens (PI009).

Laggard Facilities

Five baseline interview respondents from the two Laggard Facilities spoke of challenges with damaged and unavailable paper registers (BL017 – BL021). They also spoke of the anticipated ability of the eHealth system to retrieve information from the previous month or year, unlike the paper registers which wore out. When the pages wore out, particularly the top page, they would have to stick it with plaster tape, although they would still get removed or wear out, such that they would lose the data

on that top page (BL017). Apart from the paper registers, participants also spoke about HIV master cards that wore out, such that they were not able to identify antiretroviral therapy (ART) defaulters, and they hoped that with the eHealth system they would be able to easily identify those patients and their drug replenishment schedules (BL017).

Some staff who were custodians of data would reportedly take the data with them when they left the facility, leaving those remaining behind with no data when needed, or urgent data could be found later than needed, and the eHealth system was also seen as a solution to that problem (BL018). Further, computers were anticipated to resolve records that could not be accessed because they were misfiled or destroyed by a leaking roof (BL019). During interviews after implementation, there were no references to changes to these situations at the Laggard Facilities.

Summary of Description of the Paper Based System

Although staff at all facility groups spoke about the unavailability, damage or loss of paper registers during the baseline interviews, only Early Adopters mentioned it as still an issue during the post-implementation interviews, while Late Majority staff and Laggards no longer made mention of those issues. Staff at all facility groups described during the baseline interviews how they were unable to retrieve historical data from the paper registers, and how they hoped the eHealth system would resolve this. While use of own money for pens was mentioned only in the baseline interviews with Early Adopters, the issue was mentioned during post-implementation interviews with Late Majority staff. Data custodians leaving the facility with the facility's data was mentioned during baseline interviews with Laggards.

4.3.2 Workload and Shortage of Staff

There was a total of thirty-seven references to issues of workload and shortage of staff during the post-implementation interviews. While only three references cited

reduced workload, only at Ponekela Health Centre, six references were made about increased workload. Sixteen references were made to shortage of staff. Dual entry of data (into the paper registers and computer) was cited twelve times.

Early Adopter Facilities

Staff at the three Early Adopter Facilities projected a reduction in workload during the baseline interviews (BL145 – BL147). They also expected to have more passion for their work with the coming of eHealth system (BL148). However, there was concern from others that their workload would increase if the power cuts persisted, since they would have to enter data into both the paper and electronic systems, as well as their unfamiliarity with the computers (BL150). Baseline interviews also revealed the challenges with shortage of staff (BL152 – BL154), as at some facilities there was only one staff member to provide various services to clients as well as enter data into the eHealth system (BL152).

During the post-implementation interviews, some staff at the three Early Adopter Facilities indicated that the workload had decreased, as they were able to quickly register over 300 clients a day (PI313). Staff found the computers to be less labour-intensive than the manual system (PI314, PI315, PI325). However, others found that the workload had increased (PI316 – PI318). This was due to what they perceived as "hidden knowledge" about the computers which was not imparted to them during the training (PI317). This was also a result of having only a few computers working at a time, such that registration, diagnosis and treatment were being entered on the same computer by the same staff member (PI318, PI321, PI323). Another contributing factor to the perceived increase in workload was the entry of data into both the paper as well as the electronic systems (PI319).

> *"Let me just speak on behalf of my colleagues like the (Medical Assistant). When they write – When it seems like those things are delaying. By themselves they have to write in the little book (health passport), by themselves again they have to transfer that*

information they have written in the little book, they have to enter it again into the computer. So it makes it to be – maybe things to be delaying." – Male Data Clerk, Dalitso Health Centre (PI139)

There were no specific staff given the responsibility to be entering data into the computers, but rather various cadres of staff were trained and given the responsibility, including ground labourers (janitors) and guards. This led to some staff to feel that they were taking on added responsibility without compensation (PI320).

There were some patient flow changes that were developed by the staff at the Early Adopter Facilities to speed up service delivery in entering the data into the computers (PI322, PI327), as well as dividing work among themselves (PI324 – PI327).

"That system that you brought of having two computers, where one would print – one would be booking and one recording diagnosis, I think that system was good. It made there to not be congestion inside there. Because inside the medial assistant prescribes, and some drugs we administer right inside there, and then you have to record in the computer, that becomes difficult." - Female Medical Assistant, Winistoni Health Centre (PI322)

Late Majority Facilities

There was optimism about the system's ability to reduce workload and make the work faster at the four Late Majority Facilities during the baseline interviews (BL155, BL157 – BL160), even though some expected the computers to increase their workload due to their slow use of the computers (BL156).

Post-implementation interviews revealed a less optimistic view of the system's ability to reduce workload at the four Late Majority Facilities. Staff felt that the computers had increased the workload (PI329), as the lower level staff had to add data entry into

the eHealth system on-top of their normal duties (PI324, PI328).

> *"What has changed is that we are forced, because of shortage of people, to work there as the data clerk, in that we are forced after we have done our work, when we are done there, we are forced to assist the data clerk because there is only one."* – Male Ground Labourer (Janitor), Sauko Health Centre (PI328)

It was noted that the increased workload was mainly because of the dual data entry into both the paper and electronic systems (PI330 – PI338). As a result, staff defaulted to just entry into the paper system and not the electronic system (PI330). It was reported that sometimes junior staff would register patients into the eHealth system, but when the patients went into the consultation room the clinician did not enter their diagnosis and treatment information into the computers because of high patient loads (PI332) of up to six hundred patients per day (PI334), and their slow typing speed (PI323).

> *"Maybe there, if there was – I don't know how they would do it, let's just give an example of Baobab. The computers that Baobab installed, they – You can come early in the morning and register a patient, they go in and the clinician assists them. Or if not like that, they didn't find you and just went to the clinician, they come [afterwards] and you assist them. Everything is done right here. You can be at the desk, there would be one data clerk, but you are able to manage the whole crowd the way it is here. But here because that work is, you come, six o'clock I have arrived, six or before six sometimes. Registration. I have finished all of them properly. But for one to record diagnosis and treatment, for that one patient you have to write in that register, the manual one, the same one you enter into the computer so they can go receive drugs. So here we can see maybe, during this season, four hundred, three hundred, when we go fast even six hundred (patients), I find it to be difficult."* - Male Data Clerk, Sauko Health Centre (PI334)

Some Late Majority Facilities deferred entry of diagnosis and treatment data to the junior staff when the clients had exited the consultation room, which the junior staff also expressed increased their workload (PI328, PI335, PI336, PI344). Staff implored that there should be a printer that would print out the diagnosis and treatment data to be attached to the health passport, instead of typing into the computer and then writing with a pen in the health passport (PI330, PI336 – PI338).

> *"There was more work. This is a negative effect, there was more workload. If there was a print-out, workload would have reduced. Because we have to type in the computer at the same time we have to write in the health passport, of which it costs a lot of time. That is why we sometimes use it and sometimes we do not use it."* – Female Nurse, Malilika Health Centre (PI336)

At these Late Majority Facilities, shortage of staff was a challenge that made it difficult for the staff to use the computers consistently (PI331, PI339 – PI344). This shortage of staff was compounded by electricity and network cuts (PI341). Only a few people were trained and could use the eHealth system, and those few people were not enough to cover the different departments at the facilities (PI342), particularly as data entry was not their primary responsibility (PI343, PI344).

Laggard Facilities

During the baseline interviews, none of the Laggard Facilities anticipated reductions in workload, but rather only an increase in workload reportedly due to shortage of staff (BL162) and their low computer skills (BL164). They also spoke about the difficulty in entering data into both the paper and electronic records, making them register only up to five patients on a good day (BL164).

Dual entry of data also came up during the post-implementation interviews (PI345 – PI348), where the clinicians would have preferred to print and staple the patient's diagnosis and treatment information into the patient's health passport (PI346). With

dual data entry, they could be with a patient for up to fifteen minutes, given their slow typing skills (PI346). Staff shortage was also discussed as a challenge at these Laggard Facilities, where there would often not be anyone to spare to be entering data into the eHealth system (PI350), particularly during weekends when many staff were off-duty (PI349).

Summary of Workload and Shortage of Staff

Although some Early Adopters and Late Majority staff anticipated during the baseline interviews reduced workload as a result of eHealth system implementation, other staff across the facility groups expected workload to increase, all due to slow typing speed. Only Early Adopters reported during the post-implementation interviews reduced workload as a result of eHealth implementation, while all the facility groups reported increased workload mainly due to dual entry of patient information into the paper and electronic systems. Late Majority staff and Laggards additionally mentioned staff shortage as a cause for increased workload, and high patient load was reported by Late Majority staff.

4.4 Organisational Dynamics

eHealth systems require appropriate infrastructure, and these are discussed in this theme. They include availability of reliable power, networking and security at the facilities to support the eHealth system. Researchers have recommended specific solutions for limited-resource settings, such as installing various multiple power supplies when implementing eHealth systems so that hardware and software function can be maintained (Jawhari 2016). These are discussed below, as well as challenges encountered with continuous power and network availability.

4.4.1 Infrastructure and Unintended Consequences

How the eHealth system's implementation brought infrastructural development to the facility was cited nine times during the post-implementation interviews. Four of these references were about the introduction of continuous electricity at Bisitoni, Jedawako and Ponekela health centres, while three participants referred to improvements in the security resulting from implementation of the system at Jedawako, Ponekela and Winistoni health centres. There was one reference each for general modernisation of the facility and use of the computer for other functions apart from health information.

Early Adopter Facilities

Winistoni and Dalitso health centres had power supply from the national grid, and backup batteries were installed with the eHealth system since power supply from the national grid was intermittent, although staff had intended to back-enter data into the eHealth system in times of electricity cuts (BL053). Ponekela Health Centre was not connected to the national power grid, and solar power was installed with the eHealth system.

During the post-implementation assessment at the health centres in 2016, Winistoni

and Dalitso health centres were still connected to the national power grid, with power cuts reportedly occurring once a month at Winistoni Health Centre and twice a month at Dalitso Health Centre. Ponekela Health Centre was still using solar power, and they reported no power interruptions.

Staff at Ponekela Health Centre reported an unintended consequence of the installation of power supply in that previously, when a patient came at night, staff were taking their small torches to use during the time the patients were being served. When the eHealth system was implemented at the facilities, they also put one bulb inside the consultation room that was able to be used when serving a patient at night. When another organisation (Concern Universal) saw the one bulb, they decided to extend the coverage of the electricity to other parts of the facility (PI084). Another unintended consequence of the eHealth system implementation was the electricity being used for other purposes, such as powering fridges used for keeping vaccines (PI085) and drugs, although drugs kept in parts of the facilities not connected to the backup power still expired due to challenges with the installed power supply system (PI086), as will be discussed in Section 4.4.2 below.

At the Early Adopter Facilities, baseline interviews revealed staff's appreciation of the improved security as a result of implementation of the eHealth system, as they had fears of theft of equipment at the facilities (BL049 – BL052). Staff remarked during the post-implementation interviews how security had improved as a result of implementation of the eHealth system (PI081 – PI083). Every door that had a computer was fitted with metal bars, and the equipment was stored safely (PI083). Security extended beyond just the computer equipment, to other assets at the facilities (PI081), which was reportedly overlooked during the design and construction of the facilities (PI081, PI082).

Another unintended consequence of enhanced security was that implementation of the eHealth system was seen to have made the security guards at the facilities to

become more alert (PI081), and that security extended even to the safety of the women who were admitted in the maternity wards.

> *"On top of that, the security at the women's place has also been updated because of the coming in of the computers. Because anything strange that they hear outside, they are alert. So the security of the women has been upgraded because of the computers and also protected, because when they hear anything, then one or two guards are outside knowing what is happening, unlike previously where without the computers the guards were just aaaaah, they were relaxed a lot, sleeping, and find that something has happened to the woman and when they find out, it's too late. But with the coming of the computers, it has made security to be very updated."* – Male ART Clerk, Winistoni Health Centre (PI081)

Installation of power supply and enhanced security brought the unexpected result of perceived modernisation of the facilities (BL054 – BL063, PI090), with staff comparing themselves to facilities in town (BL054, BL057), or the perception by the communities that the public facilities would be like private ones (BL050). They expressed that the facilities looked smarter (BL061, BL062), and that the district health office would be proud of the facilities (BL062), as the facilities became more technologically advanced (BL063). Early Adopter Facilities were even expressed by the staff to be superior, unlike any other facility in the district (PI088). They also recalled a time when there was internet at the facilities, which helped them to gain information (PI087). Other uses of the computers included people who would come with their memory sticks and be able to process information or listen to music (PI089).

Late Majority Facilities

Electricity from the national power grid was available at Jedawako and Malilika health centres, and backup batteries were installed there, while Sinelia and Sauko health centres had solar power. These Late Majority Facilities did not express any changes in electricity supply during the post-implementation interviews, and there

was no mention of enhanced security. However, during the baseline interviews, eight participants at Sinelia, Sauko and Malilika health centres anticipated the unintended consequence of how the facility would be modernised as a result of eHealth system implementation (BL070 – BL077). During these interviews, they expected the facilities to look smarter without papers and files lying everywhere (BL070, BL076), bringing pride to the district health office as high standard facilities. They also believed clients at the facilities would have more confidence that they will be well-assisted at the modernised facilities (BL071, BL077), and the facilities would be more technologically up-to-date (BL073). The staff also felt pride that they would be going to a "real" office with computers, looking like executive officers (BL075).

Laggard Facilities

There was electricity supply from the national power grid and a backup generator at Filipi Health Centre. Bisitoni Health Centre was not connected to the national power grid, and solar power was installed with the eHealth system. At these Laggard Facilities, there were no expectations concerning improvements in security or electricity supply during the baseline interviews. Post-implementation interviews only mentioned the installation of batteries and solar power, and the clients' saying that there are strange things coming to Bisitoni Health Centre (PI090). Post-implementation interviews at Filipi Health Centre revealed challenges with the network to the server, which would take three to four days without working (PI288). However, they also had anticipations of the unintended consequence of facility modernisation. They anticipated that clients would experience the same service as at the referral hospital, Madalo (BL078). They also expected the system to make the facility more urbanised (BL079).

Summary of Infrastructure and Unintended Consequences

Implementation of the eHealth system ensured access to continuous power supply at all the facilities by installing backup batteries at facilities connected to the national power grid, and installing solar power at facilities not connected to the national

power grid. There were positive unintended consequences of the electricity supply at Early Adopter Facilities, such as expansion of the electricity supply to other parts of the facility not connected to the eHealth system, and perceived modernisation of the facilities. Security at the facilities was also strengthened, with positive unintended results of improved overall security at the Early Adopter Facilities, while this theme was not mentioned at the Late Majority and Laggard facilities.

4.4.2 Infrastructural Challenges

In this theme, challenges with network and power supply were referenced twenty-two times. None of these challenges were mentioned during the baseline interviews, except at the Laggard Facilities.

Early Adopter Facilities

Electricity was a problem at the three Early Adopter Facilities (PI228, PI237). Although backup batteries were installed, they were not long-lasting and soon depleted (PI230), with the batteries not lasting up to an hour (PI236). Backup power was also only made available to certain parts of the facilities and not the whole facility (PI239).

> *"Like here, at the maternity ward, because there is one at the maternity ward, it is also there. So when the electricity goes off there, access to power is not there because the backup power is at OPD (outpatient department) only. (**Interviewer**: Backup is where?) At OPD only. (**Interviewer**: OPD? Nowhere else?) No. That means only the computers there are the ones that work, while those on the other side do not work."*
> - Male HSA, Dalitso Health Centre (PI239)

Some of the problems with the system were as simple as a blown out extension cable, unresolved by both the health facility and the IT team (PI259, PI260). As will be further discussed in Section 4.6.2, staff found it frustrating that they were not

provided with the knowledge to resolve some of the simple problems. However, batteries were changed, and their performance improved and could stay for over twenty-four hours working (PI263). This was also due to the improvement in the power supply on the national power grid.

Network to the server would also frequently get disconnected, making the staff unable to continue using the system for long periods of time (PI231, PI234, PI235, PI238), sometimes using it only for about three days in a month (PI233). This led to the staff reverting to using paper registers (PI235), demotivating the staff from adopting the eHealth system (PI232). It seemed even the IT team from Madalo Hospital got frustrated with the frequent loss of network connectivity to the server, and their visits to fix the problem soon became less frequent (PI233, PI235).

> *"The issue of unstable network has made my expectations not to be met. I was expecting that once we start using the computers, we will not go back to using the [paper] registers, because everything will be in the system. But now we are going back because there is no network, batteries are off, electricity is not there, what will we do? For the IT support to come it takes time. Previously, when we told them they would come quickly, within three days, and fix it quickly, and it is working well. In the first days, network was not unstable. There was a big computer, an extension and another computer at maternity, so it seemed that if there is no network here but because of the other computer it was spreading network to other computers and they were working. But when they removed the registration computer, things started going bad and network problems got worse."* – Male Hospital Attendant, Jedawako Health Centre (PI235)

Late Majority Facilities

At the four Late Majority Facilities, there were also power and network challenges experienced (PI255 – PI264). This made the staff revert to the manual system, thus discouraging them (PI255, PI264). Even during the times that there was power, there

were challenges with the network to the server cutting off (PI256, PI260, PI261). As such, the staff would spend several days without entering data into the computers, confusing clients who had gotten used to having their details entered into the computers (PI255, PI258).

> *"You find that sometimes the people are already on the queue because they have gotten used to it. As soon as they arrive they know that they will arrive at the computer. You find that sometimes there is no or little power. So you find that the computer, for you to use it, it is not possible. So for those people it is now like what they knew, you have now confused them. So you also have the job of explaining to them that, 'Ah, we will go back to the old (paper) system. You will be doing this, you will be doing this, you will be doing this'. So it is like it is disrupting like that."* - Male Hospital Attendant, Sinelia Health Centre (PI258)

Laggard Facilities

Post-implementation interviews at the two Laggard Facilities revealed challenges with the network to the server, which would take three to four days without working (PI288).

Summary of Infrastructural Challenges

Even though continuous electricity supply was attempted to be ensured by the eHealth system implementation, interviews at the Early Adopter and Late Majority facilities revealed challenges to supply power continuously, with the backup batteries depleting, particularly at the Late Majority Facilities. Challenges with connectivity of the client computers to the server were also observed at all the facilities. These led to the eHealth system being used only occasionally, contributing to lack of successful migration from the paper-based system to the electronic system.

4.5 Technological Dynamics

Health facilities in limited-resource settings require eHealth system software that is well-designed and easy to use, as well as easily customisable to the needs of the facility and staff (Jawhari et al. 2016). This section describes the technological challenges encountered and other uses of the eHealth System at the facilities to improve end-user engagement.

4.5.1 Technological Challenges

In this theme, challenges with the design and functionality of the bespoke eHealth system were referenced twenty times. Beside programme design challenges, there were also other challenges with the software cited six times, while problems that could be traced to the hardware were cited three times.

Early Adopter Facilities

Staff at the three Early Adopter Facilities reported that some aspects of the software were not easy, straight-forward or logical (PI240 – PI251). For instance, when recording drugs one had to record one prescription at a time for a patient, instead of having the whole list available and selecting the ones prescribed before saving (PI240). This slowed the amount of work that could be achieved in a given period of time. Other challenges with the design of the software were as follows:

- It was not possible to make corrections to wrong entries (PI241)
- There was a limit in the number of patient numbers that could be allocated to patients (PI242)
- Inability to prescribe different dosages of drugs (PI243)
- For HIV testing, the system could not indicate whether one was found to have HIV or to be HIV negative (PI244)
- Passwords expired, and the staff did not know how to renew them (PI246)

- Some drugs were not in the system (PI247)
- Registered clients could not be stored past midnight for their diagnosis and treatment data to be entered the following day (PI248)

At Malilika Health Centre, the server was located in a room that was locked at night and during weekends because it contained other valuable items. This made it difficult for the system to be used during these times (PI286, PI287).

> *"Our setup is different from Madalo Hospital. Our buildings are scattered like here, there and there. So for the computer at the maternity to switch on, it requires the ART computer to also be on. So if it is at night or weekend, it is locked there, and there is no one who can open, so that means there at the maternity you cannot use it, it will be off. Unless someone goes to open. And someone cannot go to open, because if they forget to close again they will be answerable. That's how it is. Maybe if it was independent at the maternity, it should be switched on independently. When we switch it on, then we will see ourselves what to do and not have to be connected to the ART. Because that is a challenge. And the maternity report is really good, if all the data were entered it would be so easy to just release it."* - Female Nurse Midwife Technician, Malilika Health Centre (PI287)

Late Majority Facilities

There were also challenges with the design of the eHealth system's software at the four Late Majority Facilities (PI265 – PI283). The major problem mentioned with the software was to do with passwords (PI265, PI266, PI268, PI269, PI281, PI282). Passwords expired after ninety days and staff could no longer login into the system (PI270), and it took an IT technician from Madalo Hospital to come and restore the passwords.

> *"About the passwords, everything was indeed done, we were logging in perfectly. And then … in the middle of it we just heard from our colleagues that, 'Iiih they came*

again, such that we have reset the passwords', which is indicating that even now we fail to login, because we are waiting for when they come again, they will create new passwords for us again." – Male HSA, Sinelia Health Centre (PI268)

It was also reported that at other times, the software would pull up information for the wrong person even when the correct patient number had been typed in (PI271). Some records were also reported to disappear from the system, even after searching for them (PI272, PI273, PI283). There would also be disconnect between registering a client and entering their diagnosis and treatment information, with the client 'disappearing' from the system between the two processes (PI274 – PI276).

Another challenge with the design of the system was that it did not capture all the indicators that were needed by the Ministry of Health, making it not possible to produce complete reports (PI277). Further, the software did not have all the drugs that were prescribed at the health facilities, and the essential drugs list of the Essential Health Package (PI277).

*"Like when you have gone on the drugs part, there are some drugs that in the system, they are not there. But also the other challenge that I have seen is that the one who was designing other programmes and taking into consideration the reports that are needed by the Ministry of Health, some places they differ. For example, antenatal – do you say antenatal? (**Female:** Yes) – antenatal was different. When I take the manual register and how it has been designed in the system, they are different, so it becomes difficult in that if we stop using our registers here, then [data for] these other indicators, where will we be getting them?"* – Male Data Clerk, Sauko Health Centre (PI277)

At patient care level, there were problems with the doses that were set in the software, where the dosage could not be tallied with the actual dosage that was prescribed to the patient (PI278, PI279). At the Late Majority facilities, staff also mentioned how

unintuitive the software was, particularly how it took time to go from registering a patient in one part of the system to entering diagnosis and treatment data for that same patient in another window without a logical and systematic flow between the two processes (PI280). This was the case because the software was designed to have patient registration information entered by clerks, and diagnosis and treatment information to be entered by the health worker providing patient care.

Apart from the difficulty with using the software, staff also had challenges with its mouse-and-keyboard design, and would have preferred using touchscreens as they had seen at other facilities where electronic systems had been implemented, particularly the Baobab Health Trust's electronic health record (PI284, PI285).

Beside software problems at the Late Majority Facilities, there were also challenges with the hardware, where the first set of equipment was working well but their replacements were defective (PI252, PI253). Computers each with its own central processing unit (CPU) were removed and replaced by nano-computer units to conserve electric power. However, staff reported these to be defective and preferred the older computers.

> *"The system that was there at first and the one there now, it seems things have been changed. At first there were computers that (inaudible), you can hear by our statements that at first things were good, but then we saw that things started changing, like with the network. The computers that came at first, things seemed to be very good and we didn't see any problems like now. But it happened that all the computers, there were almost three, right? They took them away, saying they want to go and repair them. Then we just saw that they told us that, 'Those computers are not suitable for here as they have many problems, we'll bring you other ones'. And these are the ones that they brought. (**Interviewer:** So you are able to differentiate? (**All**: Yes.) **Interviewer:** Between the ones that had a box and these ones? (**All**: Yes.))"* - Male HSA, Jedawako Health Centre (PI253)

Laggard Facilities

At Bisitoni Health Centre, it was mentioned during the baseline interviews that the software was unable to enter multiple diagnoses and treatment for the same patient during a single encounter (BL142). When the first version of the software was found to have problems, a second version was installed, but it still had problems which never got resolved (PI290).

> *"At first, the [eHealth system software] that came seemed to be different for maternity and registration. It was found that it would – There were several things that were different. So they told us, 'Ah, wait a bit, don't use it yet'. Then when they brought it, the new one was found that they were failing to open it. To download it well was difficult so they said, 'Wait a bit'. Then phone calls and then all these other things happened."* – Male Clinician, Filipi Health Centre (PI290)

Summary of Technological Challenges

There were 24 problems with the eHealth system identified during the interviews across all the facility groups. Most of the problems were revealed at the Late Majority Facilities, and they had in common with the other facility types problems with use of different windows for registration and diagnosis/treatment entry, prescribing to patients, passwords and the installation of nano-computer units. There were also challenges at the Early Adopter Facilities with the system's database not having all the required drugs and indicators for prescribing and reporting, respectively.

4.5.2 Storage and Retrieval of Information

There were thirty-three references to the use of the system to store and retrieve information during the post-implementation interviews. In particular, there were twenty-four references to retrieval of information, with nine references each of retrieval of general patient information and retrieval of information from lost,

damaged or wrong paper health passports. There were six references to retrieval of information from lost or damaged paper registers. The ability of the system to safely store information was cited nine times.

Early Adopters

During the baseline interviews, many staff at the facilities that adopted the system spoke about the system's ability to safely store information (BL194 – BL209). They recognised that by law, information is supposed to be kept for seven years, and that the system would be able to do that, and even more permanently, without being changed (BL196). They gave an example of a woman who tore off the page in her antenatal book that indicated that she had HIV (BL199). They also anticipated that it would be easier to provide old information in their reports, as well as provide old reports (BL200, BL203 – BL205). That would enable them to track progress in epidemiological cases, such as malaria (BL203). They anticipated that information would be kept safely ((BL206, BL207).

> *"Adding on that, like the way it is in antenatal, if we send the client to (HIV testing), because she has been found HIV positive, and sometimes women deliberately took off the page 6 where it indicates that she is HIV positive and they even throw away the green card, so if we had computer, even if she took off the page or we forget to write in register, the computer will still show that the patient is HIV positive. For example, we had a case where a woman took off the page and when asked why, she said it's a child who tore off the page when the child was playing with it. Then I wondered how can a child just go straight on the middle of the book and tear off the middle page? Lucky enough, I indicated in the register book, so when I checked, I found that the patient was HIV positive, that's why she took off the page and she bought another book, as we already said that patients change health passports. But with the computer, the information will be permanently stored and cannot be changed."* – Female Nurse, Winistoni Health Centre (BL221)

Apart from storage of information, easy retrieval of that information was also mentioned as a benefit at the facilities that adopted the system, during the baseline interviews (BL210 – BL2220). They anticipated not having to go to different departments to collect data, but all could be retrieved from one computer (BL210, BL212, BL220). Further, information could be retrieved even when the custodian of that data was not available (BL211, BL213). At individual patient care, they expected that it would be easier to track patients when they come for a subsequent visit (BL221), or in case they lost their health passport (BL224 – BL234), or when more than one patient uses the same health passport (BL223, BL224).

> *"Yes, there will be a change. It will be easier to retrieve information for a patient. If they lose the health passport page or cover and register, we will still be able to retrieve the information from the computer."* – Nurse Midwife, Jedawako Health Centre (BL229)

Post-implementation interviews indicated that the system had achieved storage of information that was entered (PI497 – PI504). Staff were able to see how many patients had been entered on a daily basis (PI497). Information was also kept permanently in the computers (PI498 – PI501, PI503, PI504).

> *"Storage of information was fulfilled, even though my colleague, the data clerk, was complaining that to go to some place to find some information, he is having difficulties. But the information is really in there. So, on storing information, all is well."* – Male HSA, Dalitso Health Centre (PI404)

Retrieval of stored information was also made possible by the system, according to post-implementation interviews at the facilities that adopted the system (PI505 – PI515). However, some staff could not retrieve reports from the system due to lack of training (PI505, PI508). For those with the knowledge, they testified that it took them far less time to retrieve reports or patient information from the computer than from

the paper registers (PI506, PI507, PI509).

> *"When we just go, 'Oh! The one you want is for when?' Even when it's for the past four months, we can ask it and it tells us that, 'Ah, in the four months you had these and the person who you are looking for, you can find them at such and such'. While when we use the registers, we are still supposed to see how many registers have we filled here, we check where they are supposed to be found, which takes us a bit of time. That's why the use – The results are the same, but the time to receive those results is different."* Male Ground Labourer (Janitor), Ponekela Health Centre (PI509)

Apart from general service information, specific patient information was also found to be easier to retrieve. When patients lost the cover of their health passports which contains their details, staff did not need to ask them details about their demographics, but they could just retrieve it from the computers by entering their patient number (PI510). When the whole health passport was lost, their history and previous diagnoses and treatment could be retrieved from the system (PI511). Even when the patient did not remember their patient number or their patient number was lost, they could be searched for in the system and their health information made available (PI512). Data from damaged or lost aggregate paper registers were also retrieved through the computers (PI514, PI515). Using the computers, they were able to retrieve information from previous months to compile reports, such as the ART cohort report (PI513), even though they were not accurate as discussed above.

Late Adopter Facilities

At the transition facilities, baseline interviews with staff revealed that they anticipated the system to improve safe storage of data (BL235 – BL244). The other expected advantage was that the data would be kept in one place, unlike with the paper system where data was kept in disparate paper registers (BL239), which often got misplaced (BL240).

Staff also anticipated improved retrieval of health information after the installation of the system during the baseline interviews (BL245 – BL262). This would improve supervision of the work being done, which was difficult to do by going through the paper registers (BL245). Information could also be retrieved even when the custodian of that information was not present (BL247). Compiling reports would also be easier than when using paper registers since they get damaged or lost, particularly for data from previous years (BL249).

> *"Sometimes the Ministry of Health personnel come and request for 2011 maternity register. It's difficult for us to find it and when found, it happens that it is worn out since it was used may be from January to August and handled and carried daily, with some of the pages missing. So, with the computer, when asked to give data for 2011 deliveries, you just click, enter and search 2011 deliveries and immediately you give them the results, than with register, it is hard to find it."* – Male Nurse, Sauko Health Centre (BL249)

Baseline interviews also showed how staff at the Early Majority Facilities believed the system would enable tracing of patient data when they have lost their health passports (BL256 – BL259). During these subsequent visits, staff would be able to review the previous diagnosis and treatment, and make necessary changes, without having to register that patient again (BL260, BL261).

Post-implementation interviews at the Late Majority Facilities indicated that the system had improved retrieval of information (PI516 – PI524). Staff could retrieve data that could have been lost through damaged or misplaced paper registers (PI523, PI524).

> *"When I heard, I thought it was very good news because the information cannot get lost. Because sometimes the registers can get lost or get torn, and when it comes to the report it is not enough as if you did not do any work, while the work was done and*

because the information is lost it looks like you didn't work enough. So, if the computers were doing both sides, like the people are saying, the information would be kept well and we would write good reports with what we have really done, because those papers are difficult for us to keep. The registers get torn, they get worn out by the work that they do, so other pages tear out, get removed and get lost." – Female HSA, Sauko Health Centre (PI524)

It was particularly found helpful in retrieving patient data when the patient had lost their health passport (PI518 – PI522).

"There is indeed change because, maybe previously a person would come this time and buy another card and then would not take care of it. Another visit they buy another one. But now when they write it there and say, 'This is your number, you should take care of it', so they do their best to take care of that number and when they come to the facility they will just show the same place and then they are entered in the system again, then help them with what is needed. So, if others have misplaced the book, that, while they took care of it, some people's houses get soaked and the book has gotten soaked, they are able to remember that, 'No, they told me that my number is such and such'. So, when they say that number and we search in the computer, we find that that's their number." – Female Security Guard, Sauko Health Centre (PI520)

Laggard Facilities

At the facilities where the system failed, baseline interviews indicated that the staff viewed the system as coming to improve the storage and retrieval of data for patient care and reporting (BL263 – BL273). This was due to the problem of the registers wearing out, getting damaged or getting lost, making the staff fail to retrieve prior health information (BL263, BL265). This was to assist in compiling reports. This was particularly acute at one of the facilities where the system failed, as it did not have staff for long periods of time, being extremely rural, and information was not being handed over from one staff to the next (BL266). Before the system was removed, it

was reported that it was indeed keeping information safely.

The system was also anticipated to be able to retrieve general patient information (BL267 – BL273). They expected the system to be able to provide data for reports (BLBL269 – BL271, BL273). At these facilities, it was revealed that indeed staff could easily retrieve information from the system for their use (BL272). Post-implementation interviews revealed that, at these facilities, health information could be retrieved for lost or damaged paper registers, and for lost, damaged or wrong health passports (PI526 – PI528).

> *"There was change, because when that information is needed, you were able to access it easily. Within five minutes you have accessed that, 'I've seen how many patients? And for malaria, how many were there? For pneumonia, how many were there?' within maybe five minutes, which is not possible to go to the register and start prrr prrr prrr prrr (sound of pages flipping). That was not possible."* – Male Clinician, Filipi Health Centre (PI526)

Summary of Storage and Retrieval of Information

Staff at all facility groups anticipated improved storage and retrieval of data with eHealth implementation, for up to seven years (Early Adopters), particularly improving the paper-based system's disparate registers that got damaged and lost (Late Majority and Laggards), as well as lost patients' health passports (all) or when one was used by several people during subsequent patient visit (early), and limited handover of data among staff (Late Majority and Laggards). Staff at all facility groups reported improved storage and retrieval of data for lost or wrong health passport and paper registers. Only Early Adopters reported use of the eHealth system's search function.

4.6 Social Dynamics

Socio-technical dynamics are interactions between patients, health workers, implementers and their digital environment, and are often featured as one of the most powerful determinants of eHealth system implementation, adoption and outcomes (Jawhari et al. 2016). This section explores how the system was introduced to the facility leaders and staff, how training and supervision was done, staff's reported computer knowledge and competence with the eHealth system, IT support provided and patient experience as perceived by the health workers.

4.6.1 Leadership and User Engagement

Awareness-raising and orientation refers to how the system was introduced to management and staff at the facilities, and was the second-most referenced theme with sixty-eight references in the post-implementation interviews. Staff at all nine facilities discussed how awareness-raising and orientation was done at the facilities. Almost half (N=33) of these references cite generally positive expectations that the staff had about the system when it was introduced. There were thirteen references to how facility leadership was engaged and how awareness and orientation was – and was not – done, with eleven references to negative interaction with facility leadership (Late Majority and Laggard facilities), and only two references to positive interaction with leadership at Malilika Health Centre, an Early Adopter facility, and Sauko Health Centre, a Late Majority facility. Staff also expressed fears they had about the eHealth system, referenced nine times across all facility groups. Of the seven references to feelings of sense of ownership of the system, six were negative and only one person referred to having a positive sense of ownership. There were four references to partnerships with other organisations, and one person at the Early Adopter Dalitso Health Centre referred to monetary incentives.

Early Adopter Facilities

There were no references, positive or negative, about approach to facility leadership at the three Early Adopter Facilities, both during the baseline and post-implementation interviews. During baseline interviews, participants displayed a positive outlook to the implementation of the eHealth system (BL022, BL023). They were particularly looking forward to the system making work faster (BL023). However, there was also a fear about the staff's inadequacy and inability to use the system due to insufficient training and unfamiliarity with computers (BL024).

At the beginning, all three Early Adopter Facilities provided input into its implementation (BL025 – BL034), such as where the computers should be placed within the facility (BL025, BL027, BL030), and how they would enforce security to protect the computer equipment (BL026), as well as how they would take care of the equipment in general (BL027). Facility staff were also consulted about the electricity situation at the facilities since at that time there was an acute problem with electricity (BL028). However, three staff disclosed that they were not provided a chance to give input (BL029, BL033, BL034), and some staff at Jedawako Health Centre and Ponekela Health Centre felt that not all the input given was taken. For instance, requests for photocopiers and printers was not honoured (BL031).

> *"We were not given a chance to provide input, but they just told us that the computer system will be at booking and treatment point, and when they were conducting training here we had four computers at pharmacy, HCT, treatment and booking point. But at the end we had only two computers: at booking point and treatment point."*
> Male Medical Assistant, Ponekela Health Centre (BL029)

Recalling their impressions of the system at the beginning during the post-implementation interviews, staff at the Early Adopter Facilities spoke of their anticipation of new knowledge to be gained and how that could advance their careers (PI011, PI013, PI018, PI019, PI021). They also recalled how they expected the system

to make their work easier, for instance when quickly producing a report on HIV testing services at the click of a button (PI012, PI013). Most of the staff had only seen computers in other people's offices, particularly when they visited the district health office, and did not have any opportunity to handle a computer (PI013, PI016, PI017), and this was their first opportunity.

> *"What I was expecting was that because it's a computer, it will be only the seniors who will be using them and not a security guard having a chance to use the computer. I was not expecting that (laugher from others). And so, to see that a security guard is also using it, then (continuous laugher from others) what I was expecting did not happen. (Laughter and comments of agreement from others). So, for this I would like to thank Madalo Hospital for not being selective of a person's rank. Yes."* – Male Security Guard, Winistoni Health Centre (PI014)

Participants also recalled some fears that they had when the eHealth system was being introduced at the Early Adopter Facilities. There were fears of retrenchments, since it was assumed fewer people would be needed as the computers replaced some of the work (PI023). Others also feared that since the system would reduce workload, they would be transferred to other facilities that have heavier workload (PI025). There were also fears that people who were skilled in computers would be brought to the facilities to replace the workers (PI026). This led to some "jealousies" among the staff, people suspecting that perhaps their colleague will remain while they themselves get retrenched (PI023). On the other hand, this led to staff endeavouring to know the eHealth system even more, in order to secure their jobs (PI023). None of these fears were realised, and they were glad that the project did not make anyone lose their job or get transferred, and staff of all positions had the opportunity to learn to use the computers.

> "*There was a bit of fear that, this computer, sometimes you know that sometimes people get retrenched. Will they not come and say that 'No, we will need only a few*

people'. So it became like a little burden, that what will happen? Maybe the people who will be trained in computer will be two or five. So there was like some jealousy, jealousy that how will work be organized because the computer will only need one person, or two. So we were saying, 'Maybe they'll take me, maybe they'll take this one, maybe they'll take that one'. So that brought some jealousy at work. But all in all, it was very welcomed and everyone was saying that, 'I should learn it, I should learn it, I should learn it'. That's why when you will go there you will see that there are many people who are using that computer." – Male ART Clerk, Winistoni Health Centre

Some staff at the Early Adopter Facilities expressed lack of ownership of the system (PI027 – PI030). More attention was perceived to be paid only to those staff who seemed to use the system more frequently, disenfranchising non-frequent users who may otherwise have eventually developed an interest to start using the system (PI027 – PI029). As a result, some of the staff did not get involved with the system, as there was perception that there were "owners" among the staff (PI027).

"They prioritize people who maybe like to frequently stay on those things. For example, this other day I had an interest in it, to learn those things. But it was found that I was not being given appropriate attention, unlike the people who seem to already frequently use these things. They just – They came to change – I don't know what they came to change this other day. They just briefed the people who seem to do those things frequently, such that even my interest was gone that, 'Ah, I think these things have their owners who can do it, let me just leave it'." – Male HSA, Ponekela Health Centre (PI027)

These "owners" were also said to not be willing to share their knowledge with other staff. For instance, as all staff received passwords, when the passwords for other staff expired, the "owners" were called to fix the problem, but they did not share how they could fix it themselves (PI030). Nevertheless, one participant alluded to reluctance by some staff to attend meetings and activities organised by Madalo Hospital because

there are no monetary incentives provided for attending such activities, money he noted could perhaps be used in case their bicycle got damaged on the way to the activity (PI032). At facility level, however, staff were pleasantly surprised at how a mission hospital such as Madalo Hospital could provide such a system to public facilities (PI031).

> *"Many times I have been hearing whispers about things from (Madalo Hospital), because us Malawians it's become like something we are born with, that when we have been invited then there should be a little something that when we are on our way back we can be able to get our bicycles fixed. For example, we HSAs do not stay here, we stay at the field (communities). So you think, 'They have invited me, but my bicycle is broken-down. So there, what does (Madalo) do? They don't give anything'. So you think, 'Mmmm – Let me not go there'. I wanted to ask that maybe they should consider like a little lunch allowances that can give a person courage that the things are important, let me go there indeed, because if my bicycle gets broken down anywhere, I can manage to get it fixed. At least it can be given to us like motivation to attend (Madalo Hospital) activities. True."* - Male HSA, Ponekela Health Centre (PI032)

Late Majority Facilities

Late Majority Facilities had positive perceptions at the beginning of implementation, and staff at the four facilities were generally happy with the opportunity to learn about computers (PI040 – PI058). There were some fears, though, particularly about whether they would be able to adequately learn about computers, which was considered advanced knowledge, and the difficulties they may have had to master them (BL035, BL036).

At the beginning, staff at the Late Majority Facilities were provided with an opportunity for input. This included input into the need for the system at the facilities and discussions about its potential benefits (BL037, BL039). They also provided input into which staff could go for training (BL038), and where the various equipment could

be located within the facilities (BL038 – BL042). However, not all recommended departments received a computer, as will be discussed later.

During the post-implementation interviews, there were three references to these fears, and how they had been overcome as the staff got trained to use the eHealth system (PI059 – PI061).

> *"At first when we heard that, 'Aah, they say they will bring computers', we truly had a lot of joy. But then worries were there, especially because it's something that you don't know. But then I just said, 'Ah aaah is this not something that you need to be taught at the beginning?' Because with these modern things, you enter somewhere where you don't know, causing problems. But when they came I saw that the worries that I had, ah now I can say that it is gone, such that I can use it properly without any problem. So aah! I am very happy that it went well."* - Male Hospital Attendant, Sinelia Health Centre (PI059)

Staff at these Late Majority Facilities also acknowledged how unusual it was for a mission hospital to support other un-related facilities with such technology (PI063 – PI065). Participants revealed some positive steps taken by the eHealth system implementers to gain buy-in at the facilities, with senior facility members being invited to the change management High Level Workshop to discuss the project (PI033). This reportedly led the senior staff to help the rest of the staff to learn how to use the computers at the Late Majority Facilities, and encourage them along the way, giving them some training in preparation of the expected eHealth system (PI034).

However, there were references to negative leadership engagement at some of these Late Majority Facilities (PI035 – PI038). A ground labourer (janitor) narrated how he would fear for his job when his bosses found him working on the computers, thinking that he was neglecting his core duties (PI035). For public facilities, this was more difficult as the facilities changed In-Charges frequently, bringing ones who were not

aware of the eHealth system and sometimes withheld their support (PI036).

Other staff, who were meant to be system user champions, were sent to be oriented on the eHealth system before its implementation, during the change management's Implementation Level Workshops, but there was reportedly inadequate feedback to some facility in-charges upon return. As such, the in-charges at those facilities would not be happy when the IT team would come to the facility for supervision or trouble-shooting, since the IT team would contact only the system user champion and not the In-Charge. This made some of the In-Charges to not be supportive of the eHealth system and its use (PI037, PI038).

> *"... Everything that is happening concerning the computers, [our bosses] know about it more than what we think. They know a lot about these things. So I wanted to ask, with the coming of these computers, are the people from [Madalo Hospital] doing research or it's a program to just come and help us at [Malilika Health Centre]? I'm asking this because at this facility I was put as the administrator of the computers, such that when people meet problems I am able to help them that do this and do this. But then it would happened that the people from [Madalo Hospital] would come, those guys, they would come and touch here and there, then leave. So that was affecting … our bosses. They were very annoyed about it, that the people would just show up, maybe without notice and do their things and leave. And then when they are communicating with them, it was bringing confusions, especially on my part, because it would appear like I am communicating with the people from [Madalo Hospital] to come and do this and that and then they would go, while the bosses do not know anything about it."* - Male Laboratory Technician, Malilika Health Centre (PI038)

Despite these challenges, most staff at the Late Majority Facilites were very excited about the coming of the eHealth system (PI044, PI051, PI054 – PI056), how it would provide them with computer skills (PI041 – PI043, PI045, PI048 – PI050, PI052, PI053,

PI057, PI058) and how information would be kept securely (PI046).

> *"When I heard that computers are coming, I was very happy, because ever since I had never used a computer. I was just hearing from our friends that they are using computers. So, I saw that it's my opportunity that maybe I can know it. I was just envying my friends clicking it. So I saw that no, my opportunity has found me, I should also click it, and saw that it is happening. Ah it's a very pleasant thing. (**Interviewer:** So it happened that you learnt how to click?) It has happened indeed! I know [the bespoke eHealth system]."* – Male Hospital Attendant, Sinelia Health Centre (PI042)

Laggard Facilities

Staff at the two Laggard Facilities expressed good prospects of the eHealth system during the baseline interviews (BL043 – BL045). They were happily anticipating how the system would ease storage and retrieval of information at the two facilities (BL043), and access to internet (BL044). They were also happy about the new knowledge to be gained (BL045).

Staff at the Laggard Facilities had input into the eHealth system implementation, by acknowledging the need for the system at the facilities and where the equipment should be located within the facilities (BL046 – BL048).

During the post-implementation interviews, there were no recollections of positive engagement with leadership at these two health facilities where the eHealth system was abandoned and removed. On the contrary, staff spoke about implementers' ineffective engagement with their facility in-charges (PI067 – PI073), noting that the process followed at Filipi Health Centre was not proper (PI067). The in-charge was reportedly unaware of the benefits of the eHealth system to the facilities (PI068), which was said would have made the in-charge welcome the eHealth system at the facility. Implementers relied on trained system user champions at Filipi Health Centre

to explain the system to their in-charge, which was said to not carry as much weight as it would have if the eHealth system implementers had approached the in-charge directly (PI068). Participants emphasized how good and reasonable their in-charge was, and that she would not maliciously sabotage the programme, but would encourage the staff to implement the system if it was demonstrated to her at Madalo Hospital (PI069, PI070).

> *"There is an approach where you meet face-to-face and making a phone call. Two things. These things are different. If you made a phone call, then my in-charge, let me not lie to you, is a person who is busy pondering about projects. And making a phone call, she sees that as nonsense. She just answers with a calm heart. Maybe she just answered you to pass the time. But you were supposed to come straight and meet her face-to-face, tell her first the advantages of the system. She should know. Because if you just tell her, 'We'll remove it', she'll tell you, 'Remove it' (laughter). 'Remove it', that's it. But firstly, you should teach her, 'Ah we have come, we want to explain to you this and that, and there are these challenges. So how can we help each other, you as the in-charge?' So, she will take it from there that, 'Oh those people have come to me as the senior person'. They maybe – Maybe there to me you wouldn't have reached that far (removing the eHealth system hardware from the facility). Because she received an email, and she said to me, 'I have received an email. They say they will take back those things from you (laughter). So, they say I should respond, tell me what I should answer'. She announced it in here, showing that she doesn't know those things. 'Those of you who went (laughter), (unclear)'. You see? But we want her as – Her things should go well. The facility should go well. She should know. Because me as a person, I wanted it a lot, because I know the goodness of those things. But her, she saw that ah! it's useless … She's a very nice person, and if you had approached her … if for these things you had approached her, you would have seen – She would have just made a command herself. She's a person that if – aaah if – When you go with juvenile things, like us – Let's not lie, if you just go with juvenile issues, she will just say, 'That doesn't concern me. Go! You are delaying me, I have things to do'."* – Male

Clinician, Filipi Health Centre (PI070)

At Bisitoni Health Centre, the in-charge was not so accommodating, and did not provide reasons why he disliked the eHealth system (PI072). Participants narrated days he would allow them to use the system, and other days he would stop them from using the system in the middle of the day (PI072).

Nevertheless, staff perceptions and expectations at the two Laggard Facilities were positive at the beginning (PI074 – PI077). Communities were even wondering whether Madalo Hospital had bought Bisitoni Health Centre, as it was not expected that a mission hospital could help a non-related health centre (PI080). The staff were excited about the new computer knowledge they would gain (PI075), despite the challenges with engagements with the in-charges. This was further reflected in sentiments of lack of ownership of the system, as there was need for the in-charge to know what it was, the reason it was coming to the facility, and how it would be working (PI078, PI079). They recommended that it would then be the in-charge who would have told the staff the advantages of the eHealth system, and instruct the staff to be using it, adding more training if necessary, as it would have been seen to be a benefit to their facility. The system was seen to be for Madalo Hospital, and not for the Laggard Health Facilities (PI078).

> *"It was like the things are for [Madalo Hospital], they are not for the facility. That's how it looks. Because they said, 'It's for (Madalo Hospital)', everyone was saying it's for [Madalo Hospital], but not knowing that [Madalo Hospital] has given them to us, it's ours to use, to be keeping information."* – Male Clinician, Filipi Health Centre (PI078)

Summary of Leadership and User Engagement

Staff at all the three facility groups had generally positive outlook for the eHealth system, citing computer knowledge as a transferable skill (all facility groups), and

data management and internet access (Laggards). All the facility groups had input in the eHealth system implementation, particularly location of the equipment (all groups); security, care for the equipment and electricity situation (Early Adopters); and the needs for staffing (Late Majority facilities) and having the eHealth system at the facility (Laggards). Staff at all the facility groups also appreciated the partnership between Madalo Hospital and the health centres. There were fears of retrenchment and transfers at the Early Adopter Facilities and fear of inadequacy using the eHealth system among staff at the Late Majority facilities. Those fears were resolved after the training. There were strong opinions about the ineffective engagement of in-charges at Late Majority and Laggards, with no mention either way by the Early Adopters. Surprisingly, staff at both Early Adopter and Laggard facilities reported lack of ownership of the eHealth system, where it was manifested (a) as some staff being considered "owners" of the eHealth system by other staff at the Early Adopter Facilities and treated as such by the implementers, and (b) as most staff not considering the eHealth system as belonging to the Laggard facilities but rather to Madalo Hospital.

4.6.2 Training and Supervision

Training and supervision was the largest discussed theme, with ninety-one references from all facilities during the post-implementation interviews. A third of the references were about the need to train more people, while twenty references were about the limitations in the adequacy, content and scope of the training received. Thirteen participants cited peer training. There were twelve references about the need for adequate follow-up training, mentoring and supervision following the initial training. The way training was conducted was referenced sixteen times, particularly about training length, its style and logistics, and timing of training and supervision visits.

Early Adopter Facilities

During the baseline interviews, six staff at the Early Adopter Facilities spoke about limitations in the number of staff trained (BL080 – BL085). Only a few number of staff, chosen to be system user champions, were invited to the training, two to seven from each facility, and they were encouraged to train their peers upon return to the facilities, and the trainers would follow to train the rest of the staff at the facilities (BL080). Some of those system user champions trained transferred from the facilities soon after the training, leaving few formally trained staff (BL085).

Training scope was also seen as inadequate during the baseline interviews, with staff asking for training in the reporting module of eHealth system (BL086) and some basic troubleshooting (BL087, BL088). Initial training for system user champions lasted four days and was off-site at Madalo Hospital and Mamba City (BL089), and was supplemented by one-day training sessions for other staff, which was viewed as inadequate, particularly for beginners and those not familiar with computers (BL090, BL091). The four-day training was scheduled for afternoons, and the training sessions would start at 4pm and would reportedly last for thirty minutes, and staff would have preferred to be trained on days they were free, such as Saturdays (BL092). System user champions trained went on to train their peers at these facilities (BL096).

During the post-implementation interviews at the three Early Adopter Facilities, most participants expressed concern that only a few staff had been trained to use the system (PI091 – PI109). Despite only a few people being invited to the initial system user champion training, other staff at these facilities developed interest and learnt from their peers (PI092, PI129 – PI132).

> *"At first the people who were trained to use the computer were very few. But because everyone is eager to learn the computer, that is why now many people are using the computer. As I've already said that at first there was a clerk, Soulos, right? But everyone who showed interest to learn how to use a computer – As [Madalo Hospital]*

you came in as a programme for the whole facility, right? And all of us were trained and there is no one who did not learn." - Male ART Clerk, Winistoni Health Centre (PI092)

However, the appeal to increase the number of people formally trained came as a result of the heavy workload put on the few individuals who were formally trained (PI093, PI094, PI096, PI107). As these system user champions were more senior, they were busier, and training more junior staff was seen as an ideal way of spreading out the work (PI099, PI102, PI103, PI106, PI108).

Content and scope of the training was also of concern to staff at the Early Adopter Facilities during the post-implementation interviews (PI110 – PI116). They did not learn about important aspects of the eHealth system, such as the reporting modules (PI112). Lacking especially was knowledge on troubleshooting and attending to problems that were deemed minor (PI111, PI113, PI115, PI116) and the system user champions trained reported not having adequate knowledge of the system (PI110, PI114, PI115).

"You can see that the smallest troubleshooting, we have to report to [the IT team], 'Can you come and fix this! What should we do?' The smallest thing, 'Can you tell us how to do this?' You did not tell us [how] we should do this and this and this. So we have the impression that the computers are giving us problems. But in fact, the computer here is fine. If you release your knowledge so that we know about the computer, then we will do the work properly. There will not be any more confusion, or to – ummm – Our interaction with the patients to be problematic? No! Everything will go well. But the issue here is that, the information that you have, when training us, was hidden from us. Because the training was very short." - Male HIV Counsellor, Winistoni Health Centre (PI113)

Training was seen to be too short (PI121 – PI124), particularly since most of the staff

had not used a computer before (PI121, PI122), and the trainings were described as "superficial" (PI123). Planning and logistics for the training was also a challenge (PI125 – PI128), where numerous varied information was crammed into the staff (PI125), without detail or explaining the rationale for functions on the computers (PI126), and no user manual provided to the trainees (PI128).

> *"The time that they come, they have to approach us in an orderly way. Not just – You can give an example of a teacher. Today they teach malaria. Then they include malaria, diarrhoea, bilharzia, at the same time! You find that the student at the end is bewildered, because they will not know what is the difference between this and this? And when I get here and get here, what will be the difference with that there and there? So, when our friends come, they do all those things in a short period of time but also very quickly. So, for a person who is unfamiliar with that thing, you find that you are just bewildered. Maybe also even to have an interest that, 'Ah, I should also go learn about – It will just waste my time. Maybe those people are doing that because they don't want me to (really) know that thing'."* – Male HSA, Ponekela Health Centre (PI125)

Following the initial formal training of system user champions, there was inadequate follow-up training that took place, according to post-implementation interviews with staff at the Early Adopter Facilities (PI133 – PI141). Since the initial training was inadequate, some slow learners were reportedly not able to grasp the whole content and needed follow-up training (PI133, PI134, PI137, PI140).

Supervision by the programme implementers was also seen to be inadequate (PI135, PI138, PI139, PI141). This affected the motivation of the staff, and also their ability to resolve teething problems as they learnt to use the eHealth system (PI135, PI136). On the few supervisory support visits that occurred, the timing was also reported to be inappropriate. There would be rapid explanations of what needed to be done, for up to twenty minutes, without investing time to make sure the staff have understood

(PI142). These visits were also taking place in the afternoons, when most of the staff had left the facility since there were no more clients, and they did not receive notice that there would be a support visit (PI143).

> *"Your colleagues who come to train us, maybe if they would have time to observe. But also, messages maybe should be that when they are coming here, the one who is over there should know, and the one who is at another place should know, so that perhaps when they come, all of us should be together. Adequate time, if it can be maybe an hour and a half. Because the way it is done, let's just compare the time we have been here, the time we have been here (interviewing) maybe is longer, they would have already taught us and left. So it seems to be transitory, really just short-cuts. So then, the time that they teach us should really be quite adequate so that we should also be able to understand. (**Male participant**: Often it is maybe ten minutes – (**Another male participant**: Twenty only, just fifteen. Do this, do this. That's it.) But it is also quick, following it is difficult. (**Male participant**: So for slow learners like us to get it, considering that since birth we have never touched it (a computer) before (laughter) it was quite difficult for us. So it's a request. Yes.)) A computer is not something that you can just flip flop."* - Female HSA, Ponekela Health Centre (PI142)

Late Majority Facilities

During the baseline interviews at the four Late Majority Facilities, some of the staff who used the eHealth system were not among those chosen to go for the initial system user champion training (BL098). Although the training targeted more senior staff, it turned out that it was the junior staff who actually used the system because the senior staff were too busy and too mobile (BL099). Onsite training was suggested as a way of making sure everyone at the facility is included in the training (BL103). The scope of the training was also reported to be limited, particularly with no training in basic troubleshooting, as they had to wait for IT support from Madalo Hospital for small issues that the staff felt they could easily resolve with some training (BL102). Continuous training and supervision was minimal, according to the baseline

interviews, limiting the staff's confidence to use the system (BL105 – BL108).

Post-implementation interviews at the four Late Majority Facilities revealed a sustained lack of training by many staff (PI144 – PI153), despite promises by the implementers to train more staff (PI144, PI145). Although higher level staff were trained as system user champions, many of them had left the facilities by the time the post-implementation interviews were conducted. Others had been transferred to other facilities (PI147, PI148) or to other departments within the facility (PI149).

> *"For me, I would have really loved it if our colleagues who went to learn about computers, we have already heard that other people who were here have left, and now there are a few people remaining. So, I would have loved it if this programme, everyone should know it at this facility, especially us who work at public health office. The person who, like my colleagues have said that ground labourers (janitors), you find that they go and do other work. So, at the time that they have been sent somewhere, that means the work will not be done. So, for us, we would have loved if maybe almost every department, they should know the job, two or three, two or three, whether it's among us loving each other and teaching each other, or you take part. I think that would be good."* – Male Hospital Attendant, Sauko Health Centre (PI148)

However, system user champions were reported to be resource persons at these facilities, troubleshooting wherever they could (PI094, PI096, PI106). Nevertheless, the implementers had thought of training mostly senior staff as system user champions, who were thought to be more influential. It turned out that it was the junior staff who ended up using the computers mostly, as the senior staff were more mobile and more likely to be transferred (PI098 – PI103).

> *"Most times – Of course it is not a problem of (Madalo Hospital) but here in Malawi, that the one who gets the training is – (**Interjection:** The seniors) – the senior person, who will not use that on the ground. This is a Malawi problem. So, this is something*

that needs to change. We are not saying that training a senior is wrong, no, but the process is what we see that the channel is wrong. Like at this facility for example, had it been everyone was trained in these things then we would have made advances in this area. But because it was only a few who were trained, maybe three, but when we observe those three, all of them are not settled here for a long time, but the ones you find here are those who were not trained in these things. That is what is contributing a lot to the situation where for the computers there are jitters." – Male HSA, Jedawako Health Centre (PI101)

It was also revealed during the post-implementation interviews at the Late Majority facilities that the scope of the training was limited, such as lack of knowledge on how to care for the equipment (PI154) or basic troubleshooting (PI160). Further, training was mainly about how to use the bespoke eHealth system, with minimal basic computer training, especially for the low-skilled staff (PI155 – PI157, PI161). Lacking especially was knowledge on troubleshooting and attending to problems that were deemed minor (PI117) and the system user champions trained did not have adequate knowledge of the eHealth system (PI119).

"There are also other things that there are problems with the computers that are very minor such that if someone was trained we would not be calling people from (Madalo Hospital) that, 'Come, come, come!' as they are very minor. For example, they could be loose cables that are causing the problem and they come and tell us that this is the problem. So, if two or three people were trained that if there is this problem then do this, it would help. If there is such a person here, I doubt it." – Male Hospital Attendant, Jedawako Health Centre (PI117)

Not only was there no training in basic troubleshooting and fixing common problems with the eHealth system software, but also problems with the power backup system, such that they had to call the IT staff from Madalo Hospital every time there was a minor problem (PI158). There were even problems that did not need an IT person to

handle, but rather someone with administrator rights, such as allocating passwords to users. None of the people trained were given administrator rights, making it difficult to resolve simple problems that did not require an IT technician to come from Madalo Hospital (PI159).

> *"There is one problem that even when we went for training we did not learn. For that person to have password they come and set it for us individually. They have not trained us that, 'On your own do this, do this, do this, do this' until the person learns. They did not train us in that. We look like we are stingy, while for the passwords, even if we were to tell our colleagues, we didn't learn at all about passwords. Even our colleagues would have been able to log in, but we have to wait for the people from (Madalo Hospital). When they come as these guys have said, you hear, 'What is your name?' 'This and that', 'Ah come, this is your password'. If they had told us, everyone's password would have been in. But now we have to wait for people from (Madalo Hospital) to come and train us. So this thing I think can be simple, training someone to know it that we go through here, here, here and find that the person's password is set … So I think that maybe if they train us that a person should go into the system so that their password should not give problems, it should be in there, we go through here, through here, we do like this, like this, they didn't teach us that. So if there can be such an opportunity, that they train us, so that our colleagues can find that chance. Because the computers can just come, you install them everywhere, but for the password you have to wait for people from (Madalo Hospital) again to come and assist us. Or even for us, when it expires, the password expires (laughs), of course I know how to go about it, take it there, there, there, until it comes and I can log in. But how can we train our colleagues? It's difficult for someone to immediately go into the system and be stable. So my request is for those guys to train us there so that we can assist our colleagues. We should also know those things."* Male Ground Labourer (Janitor), Sauko Health Centre (PI159)

Nevertheless, at these Late Majority Facilities, those who did not go for the formal

training were trained how to use the system by their peers (PI162 – PI167). There was a lot of interest from staff from different departments to learn how to use the computers and the system (PI165). Peer training, however, was not seen to be effective, as there was no one with the expertise to train others (PI166). For some of the Late Majority Facilities, those trained at the facilities did not undergo basic computer training but went straight to learn how to use the bespoke eHealth system (PI152), and very few received training in how to manoeuvre the whole computer (PI119), even after the follow-up training sessions at the facilities (PI120). Staff at the Late Majority Facilities also reported the inadequacy of the training (PI117 - PI120). These were expressed as needs for more in-depth training, as quoted from a male HSA at Jedawako Health Centre:

> *"What they are trying to mean is the trainings, like what I said before that our expectations were that we shall be trained in computers. We thought that there would be a special training concerning what? (**Interjections from other participants**: Computers!) – computers. But you just came here, this is a mouse, this is (inaudible), for [the bespoke eHelath system modules] this is where you go. Issues about putting in drugs or reports they were telling the seniors, the juniors were not there."* (PI119)

Leaders at these facilities actively encouraged the staff to learn how to use the computers and the system (PI167). Staff were, however, discouraged by the lack of supervision from the implementers (PI168, PI169). While others learnt from their peers (PI129, PI132), there were still some staff who were not willing to share their knowledge with their fellow staff (PI130, PI131).

> *"There are some problems which are simple to resolve which some members know how to fix them but the few people who were trained do not share the information and when you call them they do not give you instructions on how to go about it. This is the disadvantage of providing training to one group of people."* - Male HSA, Jedawako Health Centre (PI130)

Laggard Facilities

During the baseline interviews, both Laggard Facilities expressed other staff members' lack of training in using the system (BL109, BL110). They also expressed concerns that the training was too short, as it would start from 2pm and finish by four (BL112). Post-implementation interviews revealed that some staff at the two Laggard Facilities were not willing to use the system, even after being trained (PI171).

> *"Please if we receive a new in-charge, please come and discuss with them about training so that he can also give you the recommended people who are willing to use the system rather than getting the whole team with people who are not willing to use the system, because the ones who were trained did not avail themselves frequently. It was only me and my friend who used the system."* - Male Ground Labourer (Janitor), Bisitoni Health Centre (PI171)

Skills and knowledge on troubleshooting and basic maintenance were also not shared with the staff (PI172). As training was for one week with two hours per day, it was reported to be inadequate for staff to gain the required skills and knowledge (PI173 – PI177). It was described more as a "briefing" than a training (PI177). The training was viewed as even shorter because they had to commute and only remained with an hour or two for the training (PI178, PI179). Once back at the facilities, there was reportedly some peer training (PI180 – PI182). Nevertheless, lack of a formal "refresher training" was seen as a barrier to system adoption by the participants (PI183).

Summary of Training and Supervision

Limitations in the number of staff formally trained was seen as an inhibitor to eHealth system adoption across the facility groups, as well as limitations in the scope of the training, particularly training in eHealth system maintenance and basic troubleshooting. All facility groups also reported peer training taking place, but lack

of follow-up formal training to support that peer training. Early Adopters and Late Majority Facilities expressed challenges with off-site training and that staff trained as system champions were senior and thus busier and more mobile, leaving the junior staff, who were not formally trained, to be using the system mostly. Although system user champions were provided with initial training at all the facilities, Laggard Facilities reported that most staff trained as system champions did not use the eHealth system consistently, while Early Adopter Facilities reported lack of a user manual.

4.6.3 Perceived Computer Skills and Digital Enablement

Twenty references from seven facilities discussed computer knowledge gained as a result of the training during the post-implementation interviews, while issues about confidence using computers were cited twenty-three times, with the majority (N=16) expressing lack of confidence using computers and only seven references to using computers confidently.

Early Adopter Facilities

During the baseline interviews, staff at the three Early Adopter Facilities were positive about the computer skills gained (BL113 – BL116). They knew how to use it and could retrieve information from the past (BL113). They were upbeat about their confidence in using the system, and even described those who would have difficulties using the system as "lazy" (BL117). They were also slightly apprehensive about the adequacy of the training they had received, but were optimistic about their ability to learn to confidently use the eHealth system, and that their work would eventually be faster after the early steep learning curve (BL115, BL118, BL212).

Post-implementation interviews with staff at the three Early Adopter Facilities indicated satisfaction with the computer knowledge gained, and considered the knowledge gain as personal achievements (PI184 – PI189). Some even witnessed that

they had gained technical knowledge where they could perform basic maintenance that no longer needed someone coming from Madalo Hospital (PI186).

> *"I should admit that I am thankful for bringing the computers. I was ignorant, without knowing what a computer was, so because of these computers I have known how a computer works. I was just hearing, 'mouse, mouse, mouse', I thought that I now have to be knowledgeable (others laugh) that this is how it goes. So firstly I should say that it has enlightened me on other things like what is a computer."* – Male Security Guard, Winistoni Health Centre (PI183)

However, only a few staff at these facilities claimed to be confident with using the eHealth system (PI190 – PI192). They reported having the basic computer knowledge, but they faced challenges with many aspects of the eHealth system (PI193 – PI200). Of particular concern were older staff, who had difficulties using the computers (PI193, PI195). This was compounded by lack of knowledge of some medical terminology, particularly in the maternity department, which made it difficult for staff from other departments to go and assist with the data entry (PI193). Those who were fast learners were thus burdened with more work as there were many more who were not confident using the eHealth system (PI197), some fearing they could damage the computers if they tried to use them (PI198). Others were concerned about their slow typing speed (PI200).

> *"To say that this one has become settled on the computer, we have a challenge in the maternity that we have old mamas who are unable to use the computer. Also, to say that there they have their own vocabulary, so for another person to go, they don't know their vocabulary (**Male participant**: They don't know it) so it becomes a challenge. But for those who are trained, they can be capable as they have been trained for a long time. Those things that appear there, they can be translated one by one by one by one by one. Now when you take them to maternity to enter maternity data, I think they can make it that simple."* - Female Medical Assistant, Winistoni Health Centre

(PI193)

Late Majority Facilities

During the baseline interviews, staff at the four Late Majority Facilities were happy to have gained computer knowledge (BL129 – BL131), many of them for the first time. They had confidence that with practice they would be able to use the computers well (BL135, BL137), although some of them felt they needed more training ((BL132 – BL134, BL136).

This was reflected during the post-implementation interviews (PI201 – PI208). Staff at the four Late Majority Facilities initially had concerns about whether they would be able to use a computer, but after training, those concerns were reportedly gone (PI203). The eHealth system was said to have brought job satisfaction as the staff's scope of work had increased to also using computers (PI206). Staff were pleased with the new knowledge that they had gained, which they could use elsewhere (PI202, PI208).

> *"For me, the coming of the computers has helped me a lot … It's our good fortune that when I go to another facility, because I know this, I will be an expert there. So I see that in my life it has helped me a lot, because those things, I was far from them. And with that good fortune, I can take it even abroad or somewhere, and they ask, 'Do you know a certain program, (the bespoke eHealth system)?' I will be able to use it because I know this thing, unlike when you don't know these things (laughs, others laugh)."*
> – Male Ground Labourer (Janitor), Sauko Health Centre (PI202)

There was also confidence among the staff with how they could use the computers (PI209 – PI212). There were other staff at these Late Majority Facilities who were considered by their peers as experts in computers (PI210). Some staff even self-reported that it was easy to use computers, and they were proud of that knowledge

(PI211, PI212).

However, some staff raised concerns about the other staff who had not learnt how to use the computers (PI213 – PI215), and how that led to only a few of them being burdened with the work (PI213). There were also concerns about the lack of knowledge beyond using the computer, such as how to connect it, where they had to wait for the individual who had that knowledge to come and connect the computers before they could start using them (PI213). Some staff also expressed a steep learning curve, where they went straight into using the computers even while their typing speed was still very slow (PI214).

> *"Like on the side of maternity, the computers are there so now the people who went for proper training, there is only one person. So the way it is there, there are quite several parts that one person cannot manage. So some of us they just picked us from here and told us you will be doing this here, doing this here, but we don't really know computer. Right now I can say that all the nurses that are there, they also don't really know computer. So it's really a difficult thing. It can appear like the person does not want to do that work, while if there were two or three people, when one is stuck they can ask their colleague that, 'What did they say we should be doing it like here?' Because even when the computer was removed and needs to be reconnected, then if the person who went to do [the training], that, 'On the computer we take this here and put this here, this we put here like this', if that person does not come, then that's it, we will not work, we will be waiting for that person to come and connect it for us. Because some of us know this thing when it is already on, that we click here and continue."* - Female Security Guard, Sauko Health Centre (PI213)

Laggard Facilities

Staff at the two Laggard Facilities indicated that they had gained advanced knowledge during the baseline interviews (BL138), and considered it a privilege (BL139). During these interviews, they also expressed concerns about how slow they

were in using the computers (BL140, BL141). These sentiments were also reflected during the post-implementation interviews (PI216 – PI222). Staff took the computer knowledge as a distinct benefit (PI216, PI217), as some of them had no prior computer knowledge (PI220), yet it was easy for them to learn it (PI222).

> *"Positive things that came, we got some knowledge there when we learnt about the computers, because we were just hearing about computers. So when they came, we said, 'Oh! Now we will know how to use them, how to press the buttons'.* - Female Patient Attendant, Filipi Health Centre (PI220)

A ground labourer (janitor) at Bisitoni Health Centre noted that once they had gotten used to the system, they were able to work faster on the computers (PI223). However, others found the training to be inadequate for them to confidently use the computers (PI224 – PI227). This led them to provide slower services (PI226, PI227).

Summary for Perceived Computer Skills and Digital Enablement

Staff at all facility groups were happy about the computer knowledge gained. Most staff at the Early Adopter and Laggard facilities expressed lack of confidence using the eHealth system, especially at Filipi Health Centre and the older health workers at Winistoni Health Centre, while staff at the Late Majority Facilities expressed confidence using the eHealth system. Staff at Late Majority Facilities also acknowledged the steep learning curve and reported improved job satisfaction as the scope of their work increased.

4.6.4 IT Support

IT support was discussed in three aspects during the post-implementation interviews. Firstly, there were eight references to how accessible IT support was, mostly good IT support accessibility (five references from Late Majority Sinelia and Jedawako health centres) and three references to poor service accessibility. Secondly, IT service speed

was referenced eleven times, with ten references to slow speed of IT response and only one reference to quick response speed at Early Adopter Ponekela Health Centre. Thirdly, in terms of the effectiveness of the IT service, there were four references to poor effectiveness, that is, the problem not actually being resolved.

Early Adopter Facilities

During the baseline interviews, IT support was reported to have declined at the three Early Adopter Facilities (BL143). This got worse by the time of the post-implementation interviews, as IT support was reported to take a long time to arrive, and telephonic support was not effective (PI291). Accessibility to IT support was still a challenge during the post-implementation interviews, with the level of support from the IT team at Madalo Hospital having further deteriorated (PI291 – PI293, PI297, PI300 – PI302, PI304), unlike soon after implementation (PI294, PI301).

> *"Previously, we had another person there at [Madalo Hospital], he gave me his number. When the smallest thing happened on the computer, I was calling. Immediately, he would come. Sometimes when some small information disappears, just calling him, he would come. But recently, let me not lie, we were abandoned a bit."* – Male HSA, Dalitso Health Centre (PI191)

It was often difficult for the IT staff from Madalo Hospital to find a vehicle to go to the facilities for support, making the facility staff revert to the manual system (PI292, PI295). This was partly because the project vehicle was not suitable to carry ladders and the IT team had to wait for an available suitable vehicle, often the Land Cruisers. Some problems would be minor, such a trouble with passwords, but they would have to wait for IT support from Madalo Hospital, which came very late (PI296). Other challenges were major, such as needing to change batteries, which took a long time to get resolved (PI298, PI299). Other times the IT staff would take a computer from the health centres for repairs, and six months would pass without the computer being returned to the facility (PI293, PI303).

"They (IT team) told everyone in thirty minutes, because they said, 'Oh there are some things that need to be changed, this is not there', as they were reminding each other with the [HCT] counsellor at that time. So they said, 'When we fix this, we will fit in the computer so it can be used'. Since then they haven't come again." - Male Ground Labourer (Janitor), Ponekela Health Centre (PI293)

Late Majority Facilities

Some staff at the four Late Majority Facilities reported positive IT support from Madalo Hospital (PI305 – PI307, PI309). They were happy with the communication from the IT team about changes to the system (PI305). They were also happy about the support they received from their system user champions, despite their abilities being limited as discussed earlier. However, there was one respondent at Malilika Health Centre who explained the difficulty in getting IT support, particularly when it came to training and resolving password problems (PI308). Another respondent at Sauko Health Centre raised the issue of the need to have local support by training some staff at the facility to resolve minor issues, as it would take several weeks for a computer to get fixed (PI307).

"They would say to us, 'We'll come to train you in this and that', then they don't show up. Then they would come as if maybe they were just passing by and say, 'Let's go through (Malilika) to see how it is going', and say, 'We came, now we're leaving, we're leaving, we're leaving'. So it happened that we had many people who don't know computer and many have questions. Even reactivating accounts and all that, they were relying on those sirs to come and see how to proceed. These computers, these small printers that came here have many problems. Sometimes they would work, then nothing, it's gone. Then many problems, and we would say, 'Who will we be reporting to?' Then we would take those worries to our bosses that, 'If you have a chance to phone them, then please phone them'". - Male Laboratory Technician, Malilika Health Centre (PI308)

Laggard Facilities

IT support at the two Laggard facilities was reported to be poor. Not only was the support ineffective as the problems would sometimes not get resolved (PI312), but they would also take a long time for support to arrive (PI310, PI311). Further, there was no transfer of knowledge to local staff so that the issues could be resolved locally in future (PI311).

> *"Then say, 'Ok, we'll come tomorrow'. Then it would take two months, or maybe even one month, before coming. When they come, they would come with a strange thing, then they would manage. So for us that strange thing was difficult, they have just done it secretly, now what do we do here? So I wanted to say that our failure, maybe you also contributed (laughter)."* – Male Cashier, Filipi Health Centre (PI311)

Summary of IT Support

IT support was reported to be poor at the Early Adopter and Laggard facilities. At these facilities, response by the IT team was said to be slow and ineffective, and the IT team was thought to be called for minor issues as there was no transfer of skills from the IT team to the health facility staff, even system user champions. At the Late Majority facilities, however, IT support was perceived positively, with reported good communication and support for the system user champions. This may have been due to the shift at that time of concentration by the IT staff to Early Majority Facilities, away from Early Adopter and not yet at Laggard facilities.

4.7 Outcomes

Desired outcomes from eHealth system implementation vary in limited-resource settings, from simply implementing unique identifiers to clinical decision support and patient outcomes (Jawhari et al. 2016). This section presents reported outcomes of implementation of the bespoke eHealth system at the nine health centres.

4.7.1 Additional Requirements and Desired Supplementary Technologies

There were various demands created for the eHealth system during the post-implementation interviews, with forty-seven references to the need of the system or additional aspects of it at all the facilities. Most of the references (N=20) cited the need for computer accessories that did not come with the eHealth system software. There were four references to the need for other software in the computers.

Early Adopter Facilities

Staff at the three Early Adopter Facilities recalled that at the beginning, there were barcode printers and scanners which the staff found very useful and eased their work (PI367). However, these were removed due to difficulty in procuring supplies by the facilities, Madalo Hospital and the district health offices. There was also demand for computer accessories, such as photocopiers (PI366) and printers (PI368, PI370), including label printers for printing diagnosis and treatment data to be attached to the health passport, instead of writing it in there with a pen (PI369, PI371).

> *"It looks like the clinician is having several jobs: we ask the person how they are feeling, we write in their book, we type on the computer. So, it's like maybe we are able to guide each other about things more than this, if there was an arrangement of maybe finding a printer so that the work of writing in the book should not happen, we should just be asking the person how they are feeling, write on the computer and then print and stick it in that book. Maybe we can save time. But to write in the patient's book –*

We ask the patient, we examine them, because we need to examine them physically and check them, time is going there, we write on the computer, still time. So, if it were, for writing on the computer, we should just write and instead of writing again on the paper, we should just be sticking what we have written on the computer like the way other facilities do, if that is possible. To save time. Yes, it can go well like that." – Female Medical Assistant, Dalitso Health Centre (PI371)

At the Early Adopter Facilities, there were suggestions for additional functionalities of the system. For instance, staff wanted there to be established a communication system between the computers at the facilities and those at the district health office (PI372), similar to how there was earlier voice-over-internet-protocol (VOIP) connectivity with Madalo Hospital and the other health centres. They also asked for internet access, which was available at the beginning of the programme but was disconnected later after damage to the tower that was connecting wifi between the hospital and the health centres (PI373).

When the nano-computer units were installed, they did not have Microsoft Office, and the staff could not use programmes like Word or Excel to do their work, which would have improved their computer and typing skills (PI374, PI375). The nano-computer units also did not allow one to access the internet using their own dongle, as all the computer units were connected to one server and did not have their own central processing unit (PI375).

"When I came here I saw that aaah! It's not the same computer, you only have one processor over there connecting a lot of computers. So, naturally at a place when you hear that there is a computer, then you have access to do other things, maybe you want to write a letter, you can just write it on the computer without the trouble of going to have it typed by someone else, no. You can just type it yourself. For example, I [admire] the nutrition office. There is a computer, there are two of them, and each has its own processor, and [if] a person has an interest, maybe you want to browse ...

Because other people have dongles, they have an interest to use the internet, but they have no access to use the internet because at the facility there is a computer, but they can't access an activity of using the internet. Yea. So my thinking that there is a computer, I was thinking that if I want to search for something, if I want to write something, maybe I will be able to do it. Maybe create presentations – because like people have meetings, even at this facility. You want to write things. Elsewhere they want reports, presentations, we can just create it there, since the monitors have those graphs, you just write them then you just take it to print out. But those things here, I see that aaah! With these computers, it's also a challenge. But it's something that indeed ..." – Male Medical Assistant, Dalitso Health Centre (PI375)

Late Majority Facilities

At two Late Majority Facilities, post-implementation interview participants spoke about the need for computer accessories (PI386 – PI393). There was an outcry after the removal of barcode printers and scanners, whose removal made the work to be more difficult for the staff (PI386, PI387, PI394). Staff also expected that the system would have touch-screen, as they had seen at other facilities, which was easier than the mouse-and-keyboard system (PI388). At these facilities, staff also asked for printers, both to print diagnosis and treatment data to attach to the patients' health passports (PI389, PI391, PI394) and also printing facility reports (PI390, PI393).

Laggard Facilities

Access to internet was requested during the baseline interviews at one of the Laggard Facilities (BL348 – BL353). During the post-implementation interviews, both Laggard Facilities asked for the system to be restored at the facility (PI395, PI396). The removal of the system reportedly came as an unpleasant surprise to the staff, who felt that it was done too soon and they should have been given more time to get used to the system (PI399 – PI401).

"It was taken away quickly. So somehow it was like we were left up in the air that ah

ah! there is a dance and then they remove the drum, so you don't continue with the dance, you just stand. Yes. But those things made us very happy." – Female Patient Attendant, Filipi Health Centre (PI399)

They also wanted the barcode printers and scanners to be returned with the eHealth system, as this made their work much easier and faster (PI397, PI398). They were also disappointed that the computers did not provide access to internet (PI403) or programmes such as Microsoft Excel (PI402). They felt that if the computers had those programmes, they would have been motivated to stay on the computers for long periods of time and gotten used to them, becoming more proficient in their computer use.

Summary of Additional Requirements and Desired Supplementary Technologies

Other uses of the eHealth system were explored during the interviews, and all facilities made various requests for the system that would have improved end-user engagement. Removal of the barcode system was seen as a major drawback by all the facility groups. Early Adopter and Laggard facilities shared the need for Microsoft Office programmes to improve their computer use and skills, and internet connectivity. Late Majority Facilities requested touchscreen hardware, while Laggard Facilities requested the eHealth system to be re-installed at the facilities.

4.7.2 eHealth System Desirability

There were four references to staff members' satisfaction with the eHealth system, as expressed by their desire to have access to the system at other parts of the facilities along with additional software.

Early Adopter Facilities

Staff at the three Early Adopter Facilities expressed the need for the system to extend to other departments of the facilities during the baseline interviews (BL344). This

need was reiterated during the post-implementation interviews (PI351 – PI364). The most need was at the public health department (PI355, PI357 – PI360, PI362, PI363), including the maternal and under-five clinic (PI351, PI352, PI354, PI357, PI360), and the dispensary (PI353), malaria testing room (PI356), ART clinic (PI361) and the maternity ward (PI364).

> *"We need a computer at the dispensary. Because sometimes I write the prescription here but maybe they didn't hear and they just pass through. So I need to know that, 'Now that I have written a prescription, has the person received their drugs?' Instead of the person coming out and wondering, 'Ah, have they not started dispensing? Have they not started dispensing? Have they not started dispensing?' But when I search on the dispensary, I should be able to see that they have started dispensing – (**Male participant:** The drugs) – the ones that I have prescribed, and the drugs that I have prescribed to those people, are they there or they are finished? (**Male participant:** Or even when people come from the Ministry [of Health headquarters], they should find things are alright). Yes. Because when the drugs are finished they will not leave their place (at the dispensary) and come to say that – They will see that they are finished, and I will know that the drugs are finished and I need to go and take out some more."*
> – Female Medical Assistant, Winistoni Health Centre (PI353)

Late Majority Facilities

At the four Late Majority Facilities, post-implementation interview participants spoke about the need for the system in all departments (PI376 – PI385). Participants were not specific about which departments most needed the system, but they had expectations that all the departments would have the system. They expressed that having the system in all the departments would facilitate their learning and getting used to the computers. There was clearly a large demand at these facilities from staff in all departments to use the computers.

> *"There was a burden that now there were few [computers]. People would come from*

maternity [ward] to come learn here, from general ward to come learn here, because of the few number of these things. So just because this is our chance, grace has found us, if it was possible and there were many then maybe our learning would have been much quicker. But it is difficult because these things are very few and we scramble that, 'If you are done with (the bespoke eHealth system), I'm on the queue'. So, it would be, 'Let me use it this time because someone else is coming'. If in all the departments there were several, then if we have spare time we would sit down and do some things, because it is not all the time that you can be trained. But when you are doing it yourself, because you say we learn through corrected mistakes, so through that we would have now been at a good mile that we now have an attempt of how to use [the computers]." - Male Cashier, Malilika Health Centre (PI384)

Summary of eHealth System Desirability

Early Adopters and Late Majority staff expressed the need for the eHealth system to be extended to other parts of the facilities, indicating user satisfaction. These issues were not discussed by the Laggards, as the eHealth system hardware had been removed from the two facilities.

4.7.3 Data Quality

Of the thirty-one references to data quality in the post-implementation interviews, twenty-two cited factors that led to incompleteness and poor accuracy of data, while nine references were about the staff's reverting to the manual system when the electronic system failed. This theme was supplemented by quantitative analysis of data quality, which compared reports from the eHealth system to those from the paper registers as reported in DHIS2.

Quantitative Measure of Data Quality

Registration and diagnosis data was obtained from the bespoke eHealth system at four facilities: Early Adopter Facilities Winistoni and Ponekela health centres and

Late Majority facilities Jedawako and Sauko health centres. Number of patients registered at the facilities between January 2014 and December 2015 were compared to OPD registration in DHIS2 over the same period. Relative completeness of data entered in the bespoke eHealth system was found to be 82.4%.

Bland-Altman analysis was used to determine the agreement between data entered in the bespoke eHealth system and that entered in DHIS2 from the paper records. Normality of the differences between the values in the bespoke eHealth system and DHIS2 was analysed using the Shapiro-Wilk test, since the sample size was less than 2,000 (Landau and Everitt 2004), as shown in Table 10 below. Since the test returned a value that was not statistically significant (p=0.125), the alternate hypothesis that the data did not have a normal distribution was rejected.

Table 10 Tests for Normality

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Difference	.093	70	.200*	.972	70	.125

Differences between values in the DHIS2 and the eHealth system were plotted against the mean of the two values on a scatter diagram shown in Figure 12 below. As can be seen, there was negative bias in the eHealth system data capture, with the eHealth system registering an average 1,271 less clients than paper-based records in DHIS2 per month. Since the line of equality (y = 0) was within the confidence interval of the difference between the eHealth system and DHIS [-4,000 – 1,459], it can be said that the bias was not significant. Further, only one of the 81 differences between the eHealth system and DHIS2 was outside of this confidence interval, though marginally.

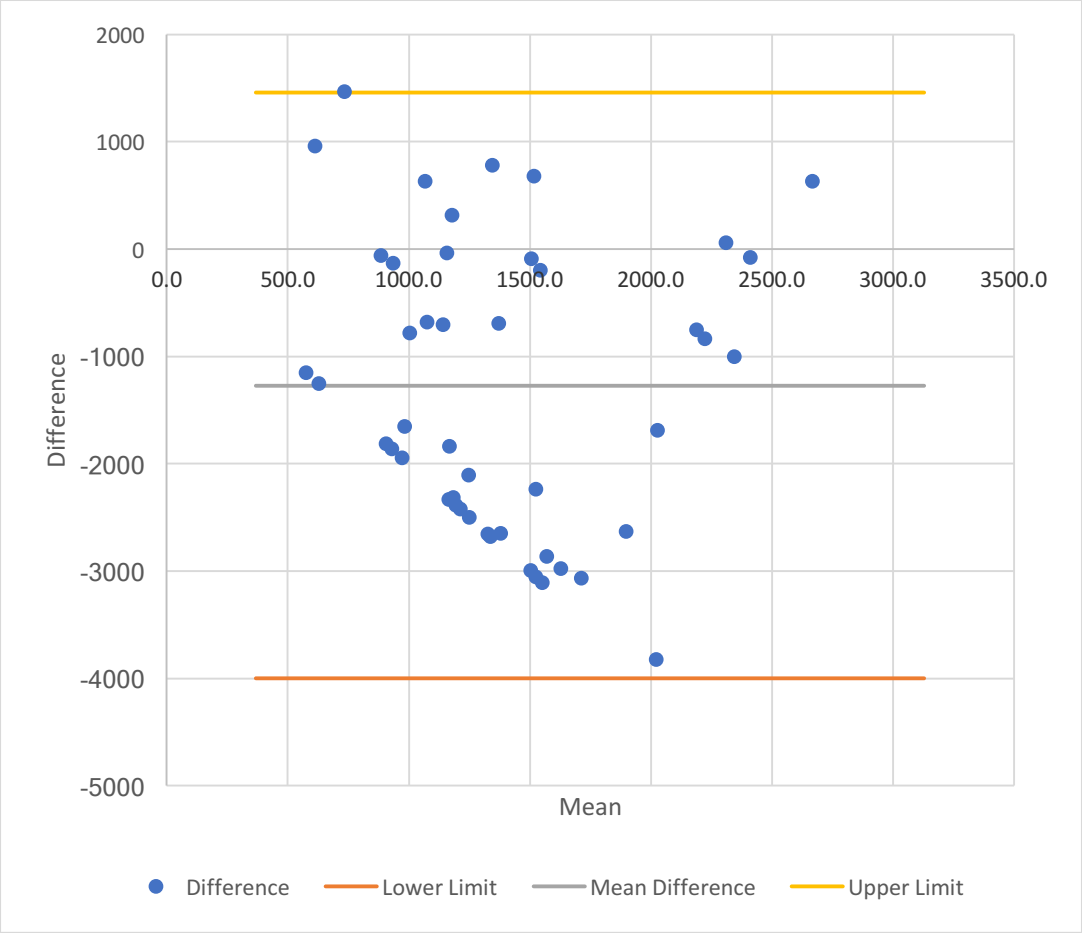

Figure 12 Bland-Altman Plot for Four Facilities

When interpreting the Bland Altman charts, from the literature 95% confidence interval is just a guide; one needs to decide what difference is acceptable or not – the difference between statistical significance and clinical or organisational significance. Human judgement is needed. Graphing the percentages over months to see if there are events that could explain variations would be helpful. As such, in the following graphs for the Early Adopter and Late Majority facilities below, instead of having the same x axis there is the calendar month to see if there is a temporal pattern. There are the percentages and the actual numbers in two different axes of the plots.

The lower number of entries in the eHealth system were not affected by duplications in the paper based records for repeat visits, since each patient visit was recorded uniquely, similar to the eHealth system data. Some of the reasons for the poor data

quality were explored during qualitative interviews at the health centres, and are presented below.

Early Adopter Facilities

Baseline interviews with the staff at the three Early Adopter Facilities indicated that there was incomplete and inaccurate data recorded (BL275 – BL277). Staff explained that the computers would help in that a patient would have the same number even when they lost their health passport, unlike with the manual system where a new patient was provided a new number at every visit (BL275, PI276). The system was to help deter that, so that there would be no duplication of patients, with no patient having more than one number.

> *"Yes, there will be a change, every patient in ART (antiretroviral therapy) does not want to be an old patient but new, for example if today they have been assisted with a sister, that means next time that patient would want to be assisted with another medical personnel and sometimes could bring a new health passport, so the medical personnel has no time to check the register, he will just register the patients as a new ART patient with a new number. But with the new system, if the patient has been given a number, there will be no any other number when the patient revisits the facility, because we will be checking in the system if the patient is registered or not, because every ART patient, when they come, wants to be a new ART patient. Whether patients lost their numbers, in computer if the number of patients is 10, they will be 10, because there will be no duplication. That has been a challenge and causes us to request new registers quarterly, so with this computer system it will end this problem … With this new system, it will be easier because if one master card is entered in the computer, it is guaranteed that it's permanent, if you want to update that the client is dead, you just enter the information in the system, and if someone wants to use the same number, it won't be possible. For example, with our current system it happens that one person is given three death dates deliberately so that when they produce quarterly reports, that patient should not appear in the last quarter, but in the current*

one. So, with this system it will make us to forge ahead not going backwards and it will help us to have clean data." – Male HCT Counsellor, Winistoni Health Centre (BL276)

However, post-implementation interviews revealed that the staff still reverted to the paper system, making the data in the eHealth system to not be accurate. This happened when the computers malfunctioned and IT support did not arrive quickly enough (PI529, PI539), for instance, when the batteries needed to be replaced (PI530) or lost network to the server (PI536 – PI538).

"When (the bespoke eHealth system) was working, we were using the computers. But you find that (the bespoke eHealth system) is not working. So now what do we do? We go back to the registers, take that, put it in the register, and do everything well. So, the person wanting to collect data goes to the computer for the days it was put in the computer and combine with the days for the register." - Male Hospital Attendant, Jedawako Health Centre (PI531)

One of the key causes to poor data quality was the frequent loss of electricity, which made the staff revert to the manual system (PI532). It was also revealed at the Early Adopter Facilities that data was not always entered in the computers because some of the staff were unable to do so, particularly the elderly staff (PI534).

However, there were also some reports of factors that may have improved data quality. It was reported that earlier, patients would skip having their diagnosis and treatment information entered in the eHealth system, but when they got used to the electronic system, the patients reportedly made sure that their information was entered into the eHealth system (PI533).

"By then people would just exit from there and we guide them to the collection of drugs and where they write in the register, maybe they would just pass it and go

straight to the window to receive their drugs and we would call them, 'Come so that we can enter your details in here (the eHealth system)!' But now they are used to after being registered they go and meet the clinician, they cannot just pass without coming back to the computer. It means information is being captured well and there is good interaction. And even the patients themselves say, 'I have not been entered! You need to enter my prescription into the computer'." – Male HSA, Winistoni Health Centre (PI533)

Quantitative assessment of data quality found completeness at the Early Adopter Facilities to be 100.0%. Visual inspection of Figure 13 below shows a downward trend in the difference between paper-based DHIS2 data and data from the eHealth system. This may indicate a maturation effect of the eHealth system, where data quality improved over time, as shown by the linear trend-line.

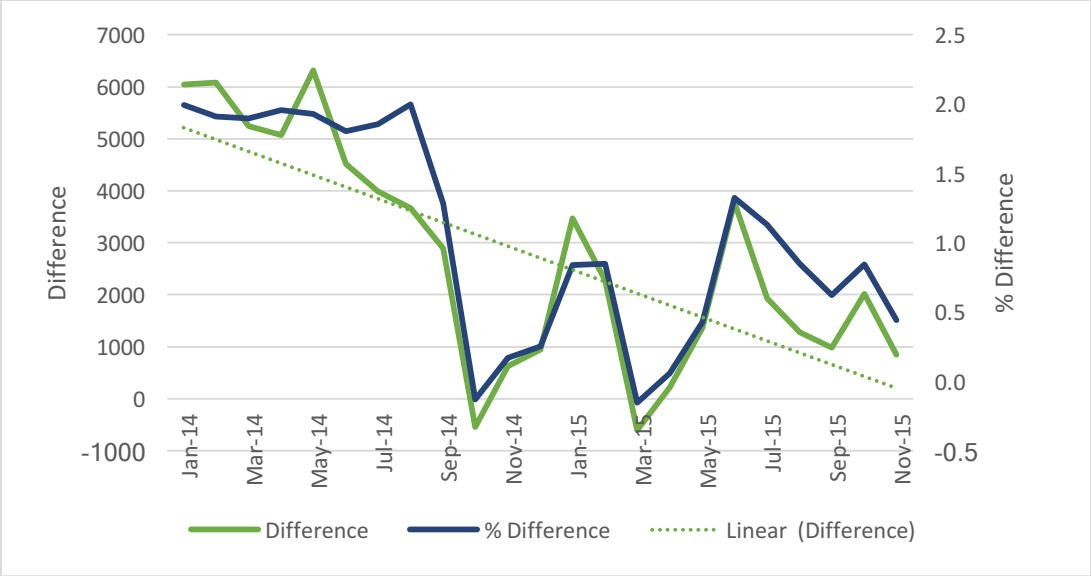

Figure 13 Difference Between Paper-Based DHIS2 Data and eHealth Data: Early Adopters

Late Majority Facilities

There were no predictions of how data quality would change at the Late Majority Facilities during the baseline interviews. Post-implementation interviews revealed that the staff were reverting to the manual system away from the eHealth system,

affecting data quality in the electronic system (PI450 – PI454). This was reportedly due to their unfamiliarity with the computers and slow typing speed, which made the queues to be too long and the patients to be complaining about the delays (PI540), particularly on busy days (PI542), or when there was disrupted electricity or network to the server (PI543).

Quantitative assessment of data quality at the Late Majority facilities found data completeness to be 73.9%. As shown in Figure 14 below, the difference between the paper-based data (as represented in DHIS2) and eHealth system data remained constant over the time of the assessment. However, it appears that the difference increased in the months of December to May, which are the peak malaria months where the facilities are overwhelmed with patients. However, longer-term data is needed to clarify this trend.

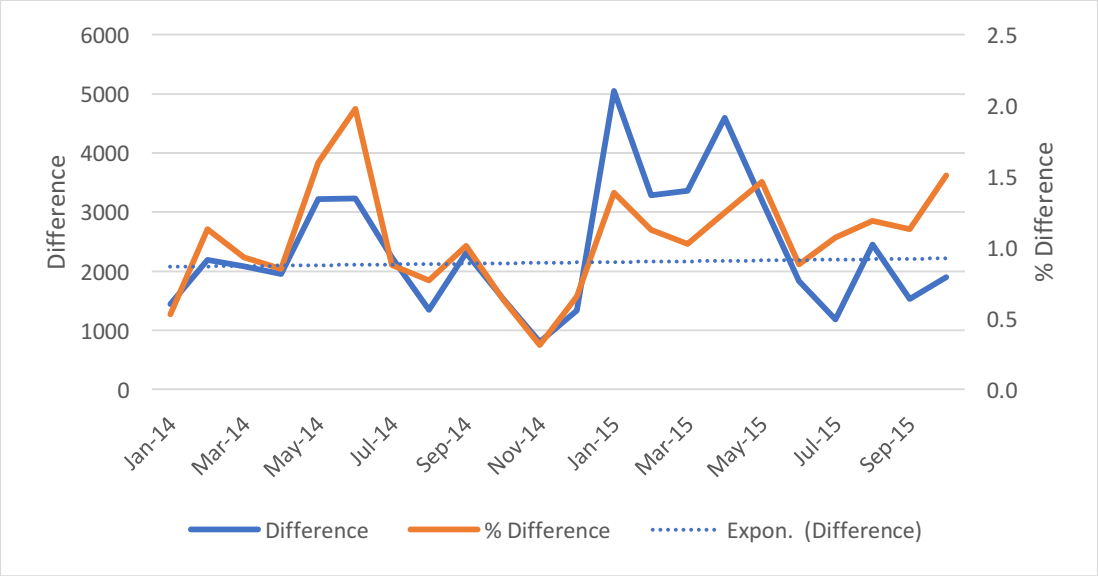

Figure 14 Differences Between Paper-Based DHIS2 and eHealth System Data: Late Majority Facilities

Having to enter patient data twice, into the paper register and electronic system, made the staff at the Late Majority facilities to prefer entering into the paper system, since the eHealth system could not print the data to be stapled onto the paper record,

making the staff do double the work (PI541), and they were not motivated to enter data into the computers since they could not get some reports from it, like the financial report (PI544). Even though other reports were available in the system and some staff could compile their reports from the eHealth system, they were not confident about the accuracy of the electronic data because they did not consistently enter the data into the computers (PI545, PI550, PI554), making the data unreliable for reporting (PI550).

> *"To see if the patient came, what were they suffering from, oh this one came, what were they suffering from, when I go on the computer, if I entered into the computer when they came, it's good because it instantly shows how many times they came, when they came that time what illness did they have, what medication did they receive, it's good. But now because the computers have not started working well, that now it is incomplete. But if they were working completely, then even the reporting system would be easy and very good."* - Male Data Clerk, Sauko Health Centre (PI550)

Staff admitted that at some departments, the number of days that data had been entered in the eHealth system over the previous four months did not exceed ten (PI547). Reasons for not entering data into the eHealth system ranged from challenges with electricity and network to the server, difficulties to work with the system (PI551), low confidence in using the computers (PI552), to shortage of staff (PI546), as the staff who entered the data into the eHealth system had other responsibilities and could only start entering data into the computers when they were free, which was sometimes too late (PI548).

> *"The problem is [with] the nurses, who have to enter in the book and in the computer, which takes time. So, to avoid delay [when] there are too many people, we just leave putting in the computer and just do the manual entry. So that is the main problem: the printer."* – Female Pharmacy Attendant, Malilika Health Centre (PI553)

It was also revealed at the Late Majority Facilities that data completeness was poor because changes to the eHealth system by the IT team were reportedly not always communicated to the staff who actually used the system, but rather to the senior staff, mostly system user champions, who would not always relay the message of the changes to the junior staff who actually used the eHealth system. This also made the data to not be entered, as the users would not be able to operate the eHealth system with the new changes (PI535).

> *"Sometimes when things have been changed, (they) just sit on that information and [we] do not know what things have been changed in the computers. So, because we do not know anything, we end up not doing anything. We are told too late that, 'Yes, those things have been changed', and so during those days no data has been entered. There are things that have been changed recently and we do not know about it and hear, 'Yes, we went for training and they have changed this and that', but we don't know anything about it. We try to do this and that, entering the password but it refuses, things have been changed on the computer, so you end up not doing any work."* Female Ground Labourer (Janitor), Jedawako Health Centre (PI535)

Laggard Facilities

Staff at the Laggard Facilities anticipated during the baseline interviews that they would have to revert to the manual system due to challenges in coping with large patient numbers, particularly at Filipi Health Centre where paying patients expected faster service (BL279). They did not appreciate the fact that they had to enter information into both the paper and eHealth systems, and admitted that on a good day they would only register into the eHealth system five patients (BL280). Staff at Filipi Health Centre were sensitive about perceptions of clients about the speed of the service, as patients would reportedly spend up to three hours at the facility and could not differentiate it from a public facility (BL280). As such, they resorted to recording most of the patients in the paper registers only.

"The other problem is that it's tiresome to write two times, in health passport book and register book. So sometimes when we have passion, per day we can register five patients or none in the computer. But if the computer could produce a barcode that could be put on the health passport book it would have been simple. And fastness comes when we use the computer often. The other thing is that our community is very sensitive in the sense that when they come, they expect to receive treatment very fast, so when we are slow they start talking to each that it is just the same as going to government health centre because they are spending three hours before receiving treatment like government facilities. So as we know this is a CHAM facility that we depend on the same patients that means if they are complaining like that here, they are also speaking like that in the community, 'Eee! Now at (Filipi) Health Centre we are spending three hours to receive treatment which is the same as government facility'. So for us to maintain our integrity that patients should continue saying 'We receive treatment fast at (Filipi)', we try our best to balance. Like some patients could be registered in the computer and some not, to make our transactions fast. So that when they go to the community, they should continue speaking good of our facility and that the number of patients we receive may increase." - Medical Assistant, Filipi Health Centre (BL280)

Providers spending up to 15 minutes with a patient due to the eHealth system and ensuing entry of information in the paper system only were also reflected in the post-implementation interviews (PI555). This led to the staff admitting that the data between the paper and electronic systems was not equivalent (PI556). This was also attributed to the facility in-charge at Bisitoni Health Centre, who stopped the staff from using the eHealth system (PI557), such that data was not entered consistently (PI558), with up to three months of information gap (PI559).

*"For us we were just doing that since we are servants, so when he said, 'Today we shall use the computers', we would listen and use them, when he said, 'We will not use the computers today', what then can we do? (**Interviewer:** Would you know the*

*real reason why he was saying some days you should not to use them?) There the real reason I cannot know. (**Interviewer:** Perhaps they were delaying things, or …?) There, there is no real answer. Delaying the work, no I don't think so. They were his own reasons. Sometimes when we want to use them, when we come early in the morning and do our work, we would get the keys, open and start registering the patients, and sometimes he would just say, 'No, today no computers'."* – Male Ground Labourer (Janitor), Bisitoni Health Centre (PI557)

Summary of Data Quality

All three facility groups reported poor data quality in the eHealth system, mainly due to dual data entry into the paper and electronic systems, where staff defaulted to use the paper system only. This was reportedly aggravated by power and network problems at the Early Adopters and Late Majority facilities, and facility in-charge stopping staff from using the eHealth system at a Laggard facility. Late Majority Facility staff reported data completeness to be affected by communication breakdown between system user champions and other users about changes made by the IT team, and no relevant reports from the eHealth system to encourage data entry. Overall data completeness in the eHealth system was found to be 82.4%, with Early Adopters having 100.0% completeness and Late Majority facilities having 73.9% completeness. Although the eHealth system recorded an average 1,271 less clients than DHIS2 from the paper-based system per month, indicating a negative bias, the line of equality in the Bland-Altman plot was within the 95% confidence interval of the differences between the eHealth system and DHIS2 [-4,000 to 1,459].

4.7.4 Use of Data for Service Delivery

Use of the eHealth system information for patient care was referenced twenty-five times during the post-implementation interviews. Ten of the references referred to use of the system for continuity of care and patient follow-up, while four referred to, respectively, use of the system to identify the correct patient and for maintaining

patient confidentiality. Three references cited use of the eHealth system to keep health workers alert and refer patients to specialised care, and one person spoke about the usefulness of the system to follow clinical care protocols.

Early Adopter Facilities

During the baseline interviews, many staff at the three Early Adopter Facilities expected the eHealth system to improve patient care at the facilities (BL310 – BL326). It was anticipated that the eHealth system would be able to identify HIV-positive patients who did not return for laboratory tests when they next visited the facility (BL311, BL312).

> *"Adding on that, if the client is found HIV-positive, currently we give him or her a referral letter to bring on Wednesday for CD4 count, since we have ART services on Wednesdays. It's easy for the client to throw away the referral letter, and we will not know if we referred the patient. But with the computer, things will improve because whether he runs away or not, as he has already said, he will be identified when he revisits the facility for HIV test, because the client will say, 'I have come because I am sick,' and yet they were supposed to be tested for CD4 count before and be helped. When they see that they are not sick and they don't have any sign of sickness, they just stay home and leave the referral letter. After some time, when they feel that they are having some pain, they come back and are referred to HCT for a test, and the computer will show that the client had an HIV test before, because of the client number, so it will be easy to detect patients who run away and the follow up of patients will be easier."* – Male HSA, Winistoni Health Centre (BL312)

Staff also contemplated the possibility of their ability to follow up any other patient who had come for a revisit (BL313, BL321). Even at the dispensary, the staff would reportedly be expected to know which drugs have been prescribed by the clinician before the patient arrives (BL318). The system was expected to make referral easier as they would know which patients needed further treatment (BL315, BL321).

Post-implementation interviews indicated that the eHealth system was used for patient care. It reportedly made it easier for staff to trace patients who were supposed to come for follow-up services, such as those on ART (PI590), children for immunization (PI589) or those with venereal disease (PI591).

> "*Right now, it is difficult for the patient to lie to the clinician. What used to happen previously is that when the patient has been registered here and has been found with venereal disease, they would get recorded here and when they are outside they would tear that and throw away the book. When they come back, they would buy another book and get recorded again so that those ones should not be seen. But now because of those numbers that are being given, when they give their name and it is not in there, when I search for them and the village they are coming from, I find that it's that same person who came and tore their book and the number is confirming that. So even if that book was torn, the person didn't sneak through, it's the same person and I catch them. While previously when the person has torn it, it's torn and when they come after two days, for one to know that they came at such and such time and was treated with such and such, they would not reveal and I would not know, they would come like it's a new person. So, with this system a person will not trick the clinician and will receive appropriate care.*" Male Hospital Attendant, Winistoni Health Centre (PI591)

The eHealth system was also reported at the Early Adopter Facilities to be able to inform the health workers about patients' previous visits and their prior diagnosis and treatment (PI592). This enabled the health workers to know where they stopped, and where to proceed with the patient's treatment (PI593). However, some staff observed that the system was deficient in that it did not provide laboratory results (PI594).

Another reported advantage of the eHealth system in terms of patient care was its

ability to keep health workers alert, for instance at the maternity ward (PI597). Also, the staff would reportedly leave the facility as soon as the last patient had been attended to, regardless of the time (PI595). With the eHealth system, health workers were reported be found at the facility at any time during working hours, as they were busy on the computers, even playing games (PI596).

> *"We were not dosing when we were with a patient, right? We were not dosing. There weren't moments when people would be calling the doctor and you would be asleep when you are at maternity. We would wait for the patient until they have delivered. We would be on the computer, play a bit of Zooma (a computer game). We would not dose, let me not lie, or sleeping. We can just sit here and someone says 'Hey!' while we are dozing."* Female Hospital Attendant, Jedawako Health Centre (PI596)

The eHealth system was also reported to be useful in identifying the correct patient. Since clients would have similar names, the entry of the village would enable the correct patient to be identified (PI598). Further, some patients were reported to borrow each other's health passports for various reasons, such as not having the money to buy their own health passport, and the eHealth system was able to identify that the health passport belonged to someone else (PI599, PI600), although it was sometimes difficult to find the correct patient (PI601).

> *"You find that the card (health passport) belongs to the husband, and the wife is using the same card, and the child also the same one. So, since the husband was the first one to come to the facility, he was given a number there. And then it is taken by the wife, especially the general ones. Yes, so they come and ktktktkt teee! (Sound of typing) It's the wife who has brought the book. We tell them, 'Now, there is Mr Moyo's name', 'No, we just use the same one', 'No no no, you should have your own'. So, they are forced to buy their own, and they are given their own number. So that's what the guy is saying, that tracing the woman is found to be (inaudible)."* Male Security Guard, Winistoni Health Centre (PI600)

Maintaining patient confidentiality was also seen as one of the advantages of the system. This was especially for HIV patients, as they reportedly did not need to be asked their sero-status or other information at the ART clinic since all the information was displayed in the eHealth system (PI602, PI605). It was also relevant for general patients, as staff observed that patients' diagnoses could be kept safely in the computer and no-one untrained and without username and password could retrieve that data, unlike the paper registers where everyone could see the patient details (PI604).

> *"Where I was, there were problems that sometimes people would monitor someone going for the [HIV] testing. Then they really wanted to capture the person's information. As someone working there, you didn't know. So, it would happen that it's open, it's been left unlocked (the HIV testing room). People would go into the register and trace the name of that person, and just be saying that that person's results are like this. So, my expectation was that where I am going, if I will be using a computer, I will have my secret code number that no one else will see them. Because when the person hears outside that, 'They are saying I have the virus', they will suspect that it's the counsellor who has revealed it, while we don't [reveal] anything."*
> – Male HSA, Ponekela Health Centre (PI605)

Late Majority Facilities

At the four Late Majority Facilities, many staff anticipated the system to improve patient referral during the baseline interviews. They expected there to be the ability to transfer data between the health centres and the referral Madalo Hospital for improved referral outcomes (BL339 – BL340). They also anticipated linkage of information between the different departments within the facility to avoid duplication of work, and for continuity of care among the health providers (BL341). Staff also hoped that the system would improve patient care by making it easier to identify the correct patient and see their history, and track their progress (BL332 –

BL334), even when they had a new health passport (BL335 – BL327), as patients often preferred to just buy a new health passport (BL328, BL330). This was said of OPD patients as well as ART clients, where they would be able to see their appointment dates for ART refill (BL329).

One of the issues that came from the post-implementation interviews at the Late Majority Facilities was the eHealth system's requirement to follow protocols, which the staff found useful for patient care (PI606).

> *"We can say it is good because when we are making a prescription, small things that you would have forgotten when writing in the book, it reminds you, some assessments you are reminded on the computer that I did not ask this, I did not do this. It is quite good."* – Female Nurse, Malilika Health Centre (PI606)

It was further mentioned in the post-implementation interviews that the system enabled the healthcare provider to see which medication the patient had received the previous time, and whether there was need to change treatment, when the patient had lost their health passport (PI608). Staff also observed that the computers made it easier to find the patient's information during a subsequent visit (PI609), improving patient experience as it indicated that the clinician was paying attention during the previous visit.

> *"The advantage is that the people, as has been said, have been entered into the system, so their information needed to assist them is not difficult. They are able to follow those people, so it gives hope to the people who are being treated as they are able to receive the information from earlier, so it shows that the clinician was paying attention, which makes the communication to be good because if the person realizes that they were understanding each other during the previous visit because of the information from prior visit that is kept securely, because searching from the register would take time, it makes the people feel that there is good communication because it makes them realize*

that everything that they explained was well understood." Male HCT Counsellor, Sauko Health Centre (PI610)

Use of the system to facilitate patient referral was also noted during the post-implementation interviews at the Late Majority Facilities. Health workers would notice from the eHealth system that the patient kept coming with a recurrent problem, and sent them to a referral hospital for further tests and treatment (PI611), where they could potentially use their patient numbers for the clinicians at the referral hospital to retrieve their records and provide appropriate care (PI612). There was confusion about the sharing of patient data across facilities, with the project initially intending to enable patient data exchange among the facilities, but some of the staff mentioning that this was only to be exchanged between the health centres and Madalo Hospital (PI613).

Laggard Facilities

There was little anticipation of the eHealth system's ability to affect quality of care at the Laggard Facilities, during the baseline interviews (BL342, BL343). One participant mentioned how the eHealth system would ensure that the patients' demographics and vital signs were captured, which was not always the case with the paper system (BL342). Another participant anticipated that the system would assist in identifying the correct patients when their health passport cover had worn out or was missing (BL343). There was no response during the post-implementation interviews regarding any effect of the eHealth system on patient care.

Summary of Use of Data for Service Delivery

Early Adopters and Late Majority staff anticipated and reported improvements in service delivery, while the Laggards neither expected nor reported any service delivery benefits from the eHealth system. Early Adopters reported the eHealth system resulting in tracing patients, treatment continuity (though no lab results), identifying the correct patient and patient confidentiality, and the unintended

consequence of keeping health workers alert. Late Majority staff reported improvements in following clinical protocols, identifying the need to change prescription for (or refer) a recurrent patient, and the unintended consequence of reportedly showing the patient that the provider was paying attention.

4.7.5 Perceived Patient Experience

Service speed and patient experience, as perceived by the health workers, was the third most frequent theme emerging from the post-implementation interviews (N=65). Most of the participants referred to patients' positive experience with the eHealth system and its faster speed (N=37), while some (N=21) remarked that it was slower and provided patients with negative experiences. Five reported observing no difference in patient experience and speed of work between using the electronic system and the manual system.

Early Adopter Facilities

During the baseline interviews, staff at the three Early Adopter Facilities were hopeful that patients would have positive experiences with the system (BL165 – BL170). Staff at Winistoni Health Centre reported that they were receiving more clients since implementation of the eHealth system because many community members wanted to be registered into the computers (BL165). During that time, patients were not taking a long time to be treated, as the system was fast (BL166, BL173). Clients were even proud to be memorising their patient numbers (BL168). They anticipated that the clients would not differentiate the health centres from district or central hospitals (BL170).

> *"Others were saying, 'There are computers at the health centre, I will go there so that they can register my name in the computer', and since at first there was barcode sticker, when we stuck it on their health passport book, they were happy that they have been registered in the computer. Now we are receiving more clients to be registered in*

the computer." – Female Medical Assistant, Winistoni Health Centre (BL175)

However, other staff felt that the eHealth system had made the clients have a negative experience with the services (BL171 – BL175) or expected that the patients would not see any difference, since the services were already slow (BL71, BL172). Other staff anticipated that the work would increase and service provision would be slow as the clients were being registered into the system, to improve once most of the people in the community had been registered (BL174). It was reported during the baseline interviews that indeed some clients, especially in the antenatal clinic, were complaining about the delay in service provision after the introduction of the eHealth system (BL176).

Some post-implementation interview participants indicated that there was no difference in the provision of services or client experiences of the services (PI438 – PI440).

> *"The coming of computers didn't – I can't say changed much because for those people we still ask them their names, where they are coming from, when they were born, like at the time of registration. It is happening like before in that, maybe after they get recorded by the clinician, when they are being entered into the register, they still have to be asked their name and where they are coming from. So, I feel that there has not been a lot of change because we are still able to speak with the people. At the register, we still speak with them. At the computer also, we still speak with them."* – Female Clinician, Dalitso Health Centre (PI439)

Other interviewed participants reported that there had been an improvement in service delivery and patient experience after the introduction of the system (PI441 – PI456).

> *"It also helps my work, to write those things is simpler. When asking a person, 'What*

is your name?' all the other details just come and you just proceed without having to ask this and ask that. It has reduced the amount of time you would have spent asking that person or patient or client. I just do it simply." – Male HCT Counsellor, Winistoni Health Centre (PI441)

Patients were reported to be happy to have their details entered into the computers (PI442), and their interaction with staff was described as "optimal" (PI443). Patients were even reported to memorise their patient numbers to avoid delays when registering (PI444, PI455). Staff felt that the system had reduced delays in providing care (PI445, PI447, PI451 – PI454) and the patients spent about twenty-five minutes at the Early Adopter Facilities (PI446). When the batteries started giving problems and the staff went back to the manual system, clients reportedly started complaining that they were being delayed, indicating that the eHealth system was perceived to be quicker (PI448).

"The time that we have been using the computers, people were quite, they were not [complaining] because they had gotten used to that method. But the time that the batteries seemed to have depleted in there, going back to the OPD [paper] registers, that's when we started hearing talks, 'No, these are time-consuming. You are delaying us with these things', showing that the method of computers was fast, unlike that of using the [paper] registers. Such that the people started getting used to that thing. They have gotten used to it. There is indeed a big difference. The computers are quicker, while the [paper] register quite delays." – Male Ground Labourer (Janitor), Ponekela Health Centre (PI448)

It was also reported to have become more difficult for clients to jump the queue, because they would need to be registered into the eHealth system first before being seen by the clinician, bringing more order to the patient flow (PI456, PI466). Clients were also reported to get annoyed for being asked the same questions repeatedly when using the paper system (PI449), and the electronic system avoided that since all

their details were already in the computers and they did not have to constantly provide the same information at every visit (PI449, PI450).

> *"The relationship was good with the clients. Because there are some questions that a person finds themselves asking them, but they have forgotten. So, when they say they have forgotten and you continue asking them, it seemed like somehow you would even make each other angry, with the (paper) registers. While here, if they have forgotten you just go to that computer, it will give you information, you will not ask them again, you will not continue asking them, which makes your interaction with the clients to be quite good."* – Male HSA, Ponekela Health Centre (PI449)

There were also reports of negative experiences by clients after the introduction of the eHealth system (PI457 – PI467). This was partly because the electronic system required more fields to be filled than the paper registers, slowing down the service. For instance, while the eHealth system required the full address, that is, village, group village and traditional authority, the paper register only asked for village (PI467).

Further, those who were being registered only in the paper system seemed to move faster along the queue than those who were being registered into the computers when the two systems were being run in parallel (PI462 – PI464, PI466). Also, since the facilities used both the paper and electronic systems, two extra processes had been added to the patient flow: being registered into the computer before meeting the clinician, and having their diagnosis and treatment data entered in the computers after seeing the clinician and before collecting their drugs (PI457, PI459).

> *"With the coming of computers, my interaction with patients, sometimes it seems like we are confusing them, because we can differentiate with the amount of time. When they come, I tell them to go and do booking, I book them there, and from there they go to the clinician for recording. When they come from there, the same patient has to come to the computer for their diagnosis to be recorded, then that same patient needs*

to be recorded into the OPD register, the same patient we send them to receive their drugs. So, it seems that we are confusing them. That's how I see it, that somewhere it seems it is difficult because before computers came, when we recorded them and stamped for them (in the health passport to indicate that they had been registered), they would go and meet the clinician, from the clinician they come to the OPD register, from the OPD register then immediately they go and receive their drugs and then they are on their way. But now there are two things that seem to have added effort for one patient instead of (inaudible). The way I know it is that it has added for the patient two places: they should be booked, and the same patient has to come back to the computer to record everything that the clinician has written, and the same patient should go to the OPD register, now manual. After manual, they should go receive their drugs and be released to go. So, I feel that the work there has quite increased." Male Hospital Attendant, Winistoni Health Centre (PI457)

This challenge was compounded by the slow typing skills of the staff and their inexperience with computers (PI460), although this could improve over time. Some clients were reported to feel that the computerised system was slower than the manual system, and were reported to spend as long as six hours at the facilities (PI462).

"That challenge that we see that people are on the queue for a long time. So, since you hear when you are passing by, 'There came their Western things that they are entering in there. Those are what are delaying us'. But now, since when something is starting, it takes time for people to get used to it, maybe slowly they will know." Female Nurse, Dalitso Health Centre (PI463)

Late Majority Facilities

Baseline interviews at the Late Majority Facilities indicated that staff anticipated patients to have positive experiences with the system (BL177 – BL181). Already the system was seen to be making the work faster than the paper system (BL177 – BL179).

Although they had expected the workload to be heavier because they were not used to the computers, they found that the work was actually faster (BL179). They expected the clients to spend less time on the queues (BL180), and that the clients would be excited to get a patient number (BL181).

> *"Every patient will be excited to get numbers and that their names have been registered in the computer."* – Female Nurse, Sauko Health Centre (BL181)

However, some staff anticipated that patients would take a long time to be served (BL183 – BL185) because the staff was slow in typing and using the computers (BL183), high patient load (BL184) and dual data entry into the paper and electronic systems (BL185).

After full implementation of the eHealth system, some staff indicated that the computers helped to improve the speed of serving clients in comparison to the paper system (PI469, PI475), and they were able to serve more patients in a shorter period of time (PI470, PI473). They could pull the patient's record without having to ask the patient many questions, as all the health information was already present in the computer (PI471, PI472).

> *"This manual system delays quite a bit because it happens that at the register you have the work of asking the person a lot of things: name, maybe where they are coming from, their age and so on. While with that [bespoke eHealth] system, when a person is returning here we don't ask them anything, we just take it (the health passport) and just enter that number. So, then everything that they were asked, it comes out on [the bespoke eHealth system]. So, you just have the job of [only] checking how you are supposed to serve them."* Male Hospital Attendant, Sinelia Health Centre (PI471)

The eHealth system also reportedly attracted more patients to the facilities, as they wanted their names to be registered into the computers (PI474). Patients were

reported to have more confidence in the service they would receive after seeing the computers (PI476). When the clinician was able to relay the previous diagnosis and treatment to the patient, the patients reportedly felt more confident that they had been understood, which was not possible to do with the paper registers (PI477).

Other focus group discussion participants at the Late Majority Facilities felt that the computers had led to clients' negative experience of the services (PI478 - PI487), mostly from the private facility (PI480 – PI487). It was also reported that the clients felt that they were not being paid attention to when the clinician was on the computer during consultation (PI478), and that clients felt the staff were just playing on the computers (PI487). Some staff recommended that the computers be removed from the consultation room and just have a clerk to register and enter diagnosis and treatment data for the client after the consultation (PI479).

The staff's slow typing speed and unfamiliarity with the eHealth system also reportedly led to the clients not being happy with the system (PI480 – PI484). Clients who were coming for the first time and being registered for the first time into the eHealth system were the ones who felt the most delay (PI483). Having to record in both the paper and the electronic system was also reported to lead to the delays in service delivery (PI485, PI486).

> *"The other delay, for us to be not interacting with patients well, we are delaying because we are using two systems at the same time. At the cashier, I have to charge the patient through the (bespoke eHealth) system, but also after charging them I also have to write information in the manual receipt book. Doing two things at the same time, making the queue longer and longer. What I see is that, maybe because we are doing it slowly, that is why we are not really fast. But it seems that when we are writing, one should write in the manual and the other in the computer to speed up the work. But for one person to do both, we receive complaints from the patient that we are delaying."* - Male Dental Technician, Malilika Health Centre (PI485)

Laggard Facilities

At the Laggard Facilities, there were relatively fewer anticipations for improvements in patient experiences after implementation of the eHealth system (BL186, BL187). Bisitoni Health Centre did not record any expectation of positive client experiences, but recorded relatively more anticipation of negative client experiences with the system (BL188 – BL193). At Filipi Health Centre, where there were positive anticipations of client experience, staff felt this would come from the fact that the electronic system forced staff to take demographic data, while the paper system did not (BL187). Clients would also reportedly feel like they were at Madalo Hospital, a more advanced facility (BL186).

However, other staff at the Laggard Facilities contemplated the possibility of the system making service delivery slower (BL188). Since one of the facilities was a private facility, patients expected faster service, and this reportedly would lead to the lowering of their satisfaction (BL191). Staff's limited training was seen as the cause for the slower service delivery. This made the staff enter information for only some of the clients into the computers (BL192).

During the post-implementation interviews, two participants at the Laggard Facilities felt there had been no difference in the care provision (PI489, PI490). However, some staff at Bisitoni Health Centre felt that patient experience had improved with the coming of the computers (PI491 – PI495). This was reportedly due to the fact that when the clients came for a subsequent visit, all their information was found in the computers and they didn't need to be asked many questions (PI492). It was also reported that the eHealth system removed the perception of favouritism among the clients (PI493), as the clients would all follow the queue and no one would be able to jump the queue (PI494).

Other staff confirmed their prediction that the work would be slower, especially with

their unfamiliarity with the computers, and they reported that they would be with a patient for up to fifteen minutes because of the eHealth system (PI496).

> *"But then it is tiresome, for when you see the queue, you write. Then that made you to be with the patient for fifteen minutes, which was not good. So, to avoid that, people would just say, 'Iiih! Let this be on the side a bit, let me do the manual' (laughs).* ***(Interviewer:*** *So, you would be with a patient for maybe fifteen minutes?) Yes. You write in the book. Then you enter in the computer. You should search where 'b' is (laughter)."* – Male Clinician, Filipi Health Centre (PI496)

Summary of Perceived Patient Experience

Staff at all facility groups anticipated the eHealth system to improve service delivery and patient experience, while Early Adopters and later majority facilities reported increased traffic of patients wanting to be registered into the computers. Some Early Adopters and Laggards reported no difference with patient experience and service delivery after eHealth system implementation, while other staff across the facility groups spoke of both improvements and negative consequences. On the improvements, staff at facilities in all groups reported this to be due to no redundancy in entering patient information at subsequent visits, while Early Adopters and Laggards reported better management of queues and Late Majority staff reported that patients felt more understood by the service provider and had more confidence in the services. Negative consequences were reported to be due to the staff's slow typing skills and unfamiliarity with the eHealth system across the facility groups, while Late Majority staff and Laggards reported dual entry of patient information into both the electronic and paper systems as the cause. Early Adopters complained of two extra steps added to the patient flow as a result of the eHealth system, while Late Majority staff reported disrupted patient-provider interaction as a negative consequence of the eHealth system.

4.7.6 eHealth System Use for HMIS Reporting

Use of data from the eHealth system for HMIS reporting was cited twenty-eight times in the post-implementation interviews, with nine references to the positive use of the computers for reporting and eight references to the difficulty using the computers for reporting. There were seven citations to the continued use of the paper registers for reporting, while four references mentioned use of both the computers and the paper sources for reporting.

Early Adopter Facilities

Some of the baseline interview participants at two Early Adopter Facilities reported that they still use the manual register when compiling reports (BL281 – BL286). Others spoke about using computers for reporting, and the prospects thereof (BL287 – BL298). They reported during the baseline interviews that it took a day to compile a report, while with the paper system it took two weeks (BL281, BL287, BL281, BL292). Further, they anticipated that the ART reports would only need one person with the computer system, instead of four people with the manual system (BL287).

> *"ART cohort reports are normally done by four people if we are many or two to handle the four types of master cards. But with the computer, it will be done by one person and it can take one day to produce the cohort report, while with manual system [it] can take two weeks to produce a report. It will help a lot and our work will be easier."*
> – Male HCT Counsellor, Winistoni Health Centre (BL287)

They also had prospects of providing more accurate reports, since with the paper-based system the registers ran out and they would provide false reports (BL288). The eHealth system was also anticipated to be able to provide epidemiological data so that public health interventions could be planned and implemented (BL297).

Post-implementation interviews reported that the staff were still using the paper

system to compile reports. This was because some of the staff had not be taught to use the reporting module of the system (PI560, PI561, PI574), and so did not see the benefit of the electronic system (PI569, PI570, PI572, PI573), and resorted to using the paper registers when compiling reports (PI574, PI575), or a combination of data from the eHealth system and paper registers (PI575, PI576).

> *"When it comes to report, then we start again using the papers or the report books that we use to write, tear out and send. While it could have been a simple job, you want to write an HCT report, you just come to the report part and trrrrr paa! it's out, then you are done. It also means time is reduced. But as of now it is time-consuming because we are still using the old system, writing manually."* – Male HCT Counsellor, Winistoni Health Centre (PI560)

Clients registered in the eHealth system's HCT module as HIV-positive were sent to antiretroviral therapy (ART) services, and an ART Clerk at Winistoni Health Centre reported how he compared that information to his ART paper register to know the accurate number of new HIV cases when reporting:

> *"When compiling reports, I do not use that (computer), but just knowing how, from HCT [module], how many have been sent (to ART services), that helps me, and when I know that I then go to the manual system and from what I have been told from HCT [module] and those I have entered manually, are they the same? So I am able to detect how many were tested. Someone who has been tested there has the freedom to just pass [the ART clinic] and leave, so I end up having a different number from there of, say, women who are positive, and here have a different number. So it helped me to know how many have been found positive from HCT and for me at ART, how many have I registered. So it was helpful in that way."*

Some of the staff were, however, able to retrieve reports from the eHealth system (PI564, PI565, PI566, PI567), for instance for cervical cancer (PI562). Others were able

to retrieve epidemiological data from the system (PI563).

> *"At the time when we are perhaps writing reports, it is not difficult to find the numbers of various illnesses or people who came when writing those reports. That computer helps us in like record-keeping. But also, we see that, like in a month, which diseases are giving us problems in this area. Those are also followed through the same computers."* – Male HSA, Ponekela Health Centre (PI563)

Using the computer system to compile reports was seen to be faster than using the paper registers (PI566 – PI568).

> *"As a data clerk, I can say the coming of computers has changed a lot especially my work of compiling reports. For instance, it used to happen that – Let me just give an example, OPD (outpatient department) register. It would take me maybe a week compiling that information. But now it takes me two, three minutes, I have finished compiling. Work that was taking me a week."* – Male Data Clerk, Dalitso Health Centre (PI566)

Late Majority Facilities

At the beginning of implementation, baseline interviews at the four Late Majority Facilities indicated that staff still used paper registers for compiling reports (BL299). However, they had hope that the eHealth system would make data storage and reporting easier (BL300, BL301), quicker than the two to three days it was taking them to write a report (BL302).

At the time post-implementation interviews were conducted, the Late Majority Facilities were still using the paper registers to compile reports (PI577 – PI579). Some of the reasons for continued use of paper registers when compiling reports were differences between the design of the forms in the eHealth system and the forms required for reporting (PI580), intermittent power supply and network connectivity

to the server (PI581), and shortage of staff to work on the computers (PI582, PI584), leading to poor quality of the data most of the months (PI583).

> *"Real change has not been observed, because when we want to write a report now, then for that we use the manual register. There in the computer I cannot take a report – the right information, because diagnosis and treatment is not done. If it's done then it's maybe only a few people are entered, which cannot give me accurate information … To get from there information, like in this month how many patients came, or reporting, we don't get anything from it, we just register, so we get it by looking at how the OPD register has done. So, it's like that."* – Male Data Clerk, Sauko Health Centre (PI578, PI579)

It was reported that the system did not produce reports (PI585), or some of the staff did not have the knowledge of how to retrieve the reports (PI584). For those who knew how to retrieve the reports, they would get them, but because the data was incomplete, they supplemented the data from the eHealth system with data from the paper registers (PI586).

> *"In terms of patient information, here we still use OPD register as well as the patient's book (health passport). Here at [Malilika], there are times we have few people, we do it (enter patient information into the eHealth system), but when there are a lot of people it is difficult for us. So we are still using the old (paper) system and computer, we are using both. So those who have been entered, when we have searched for them we find them and when they came and how they were served. But we are still using the old system when we are not using the computer. We are still using the register and the patient's book for how they were previously served. But in future I'm sure that when we have settled we will often retrieve information that is in the computer."*
> - Male Laboratory Technician, Malilika Health Centre (PI586)

Laggard Facilities

Staff at the Laggard Facilities indicated during the baseline interviews that they had not yet started using the eHealth system to compile reports, but rather the paper registers (BL304). However, they anticipated that the eHealth system would ease their reporting (BL305).

Participants during the post-implementation interview provided positive feedback about use of the eHealth system to compile reports. They found the work of reporting to have been made much simpler than using paper-based registers, taking less than an hour to compile a report (PI587, PI588)

> *"In terms of reporting, it was very simple, such that you would just go there, three minutes it has given you a report that this whole month you saw this number of people, with malaria this number, under-five this number, over-five this number. So, the work was little."* – Male Clinician, Filipi Health Centre (PI587)

> *"The successes can be like, the people who write reports, the work was simple. Let's say, someone says compile a report for the last five months, how it has gone. You could just go there then maybe within one hour – thirty minutes you have finished. But to have to go through the books, to gather information for five months, it's tiresome work."* – Male Cashier, Filipi Health Centre (PI588)

Summary of eHealth System Use for HMIS Reporting

During baseline interviews all facility types were using only paper registers for HMIS reporting, and all had hopes of the eHealth system easing the work of reporting. At post-implementation interviews, all facility types were still using paper registers to compile reports. This was because some Early Adopters and Late Majority staff had reportedly not been taught the reporting module. Late Majority staff reported challenges with the design of the reports in the eHealth system, in that they were different from the required reporting formats, and disruptions in electricity and

network to the server. Other staff across the facility groups said they used the eHealth system to compile reports, usually in combination with the paper system.

4.7.7 Use of Data for Financial Management

Unsurprisingly, the fewest references during the post-implementation interviews were about use of the eHealth system for finances, since only two of the nine facilities charged user fees: Malilika Health Centre (a Late Majority Facility) and Filipi Health Centre (a Laggard Facility). Of the three references to the theme, two were about use of the eHealth system for financial governance, while one was about fraud prevention. This theme is discussed in more detail in the Madalo Hospital Case Study in the previous chapter, where qualitative interviews were supplemented by quantitative analysis of hospital finances.

At Malilika Health Centre, baseline interviews indicated that the eHealth system was helping to know whether the patient had paid their bill (BL306). It was also expected to enable the cashiers to know which drugs had been prescribed and how much needed to be paid (BL307). They asked for the eHealth system to be deployed in the offices of the administrator and the facility in-charge, so that they could monitor all the transactions at the facility (BL308). At Filipi Health Centre, use of the system for improved financial governance was discussed during the baseline interviews, by showing which clients left a bill from the previous visit, and by the in-charge being able to easily monitor the finances (BL309).

> *"It looks like it is important because of the way our community is, not all clients manage to pay the bill in full amount, they usually have debts, and when they come back, for us to trace them, it's very difficult. So, the computer will help us to trace them because when we enter the client's number, the computer will show the client's previous information. And the Sister-In-Charge to know how things are going, it will be very easy. Even if the responsible person is not around, she can still find the*

information without problems because she will also have a computer account that she can access information while the responsible person is not around." – Male Cashier, Filipi Health Centre (BL309)

During post-implementation interviews, staff at Malilika Health Centre revealed that the eHealth system helped them know which medication had been prescribed and what their bill was (PI615). At Filipi Health Centre, staff reported that the eHealth system used to enable transparency, as the finance staff would just take the cash received to the administrator, who could cross-check the amount with that in the eHealth system (PI616). They also indicated that the system was helping the clients have more trust in the printed receipts than the hand-written ones (PI614).

"It was helping me in that, most times the receipts that we were producing (from the eHealth system) people believed – saw that they are original, while these hand-written ones some people can – What you have written, they can erase and write the figures that they want. Which was giving some impressions that things are not going well. But now with that (eHealth) system, when we produce a printed receipt, it is difficult for a person, maybe they want to go to their office, when they have been sent by their office, to deceive them. Because the receipt was printed, changing anything messes it up." – Male Cashier, Filipi Health Centre (PI614)

Summary of Use of Data for Financial Management

Only two health centres charged user fees and used the billing module, hence it was not a major theme in the Health Centres Case Study. Implementation of the eHealth system helped staff in the accounts department with billing, the facility in-charge with oversight and clients with more trust in printed receipts. More extensive description of the use of the eHealth system in financial management is presented in Chapter 3.

4.8 Key Adoption Factors Inferred from Pattern Matching

Content analysis methodology was described in Sections 1.6.1 and 4.1.5 above. Using that method, a list of the correlations is presented in the Table 11 below, with their two-tailed statistical significance (P) to consider both positive and negative correlations. This analysis tested the null hypothesis that the correlation amongst the quantized binary qualitative themes at the facilities was zero, and the results rejected the null hypothesis that there was no directional relationship between each of these factors and the level of adoption. From Table 11 below, factors that significantly correlated with eHealth system adoption were the organisational dynamic of improved security, the change management dynamic of paper-based system resources, the social dynamic of leadership engagement, and outcomes of both staff satisfaction with the eHealth system and service delivery factors of identifying the correct patient and ensuring patient confidentiality.

Table 11 Correlations for Adoption Quantised Factors

Theme/Code/Factor	**ρ**	**P**
Negative facility leadership	- 0.866	0.003
Damaged or lost paper registers	0.725	0.027
Identification of correct patient	0.725	0.027
Patient confidentiality	0.725	0.027
Need for the system at the facility	- 0.725	0.027
Improvements to facility security	0.730	0.025

Facility leadership had the strongest correlation with the level of adoption of the system by the facility, whereby negative attitudes of the facility In-Charge, or negative approach and engagement with the facility In-Charge by the implementers, resulted in low adoption by the facilities. Facilities that expressed experiences with lost or damaged paper registers tended to have better adoption of the eHealth system. In terms of the use of the eHealth system by the facility, those that showed higher

adoption of the eHealth system expressed using the system to identify the correct patient and appreciated the system's ability to better keep patient records confidential. Facilities that had less or no adoption of the eHealth system expressed a stronger desire for the system to return to the facility. Facilities that had increased adoption of the eHealth system were those that expressed an increase in the facility's security as a result of implementation of the system.

Coded themes were further quantified into how many times they were mentioned at each facility. Based on this, even after quantifying the responses from the interviews, the factors that correlated with the level of eHealth system adoption at the facilities remained the same, with only the addition of the staff's perception of the ability of the eHealth system to safely store information, which had a positive correlation with the level of eHealth system adoption, as shown in Table 12.

Table 12 Correlations for Quantified Adoption Factors

Theme/Code/Factor	**ρ**	**P**
Negative facility leadership	- 0.857	0.003
Damaged or lost paper registers	0.725	0.027
Identification of correct patient	0.730	0.025
Patient confidentiality	0.725	0.027
Need for the system at the facility	- 0.725	0.027
Improvements to facility security	0.730	0.025
Ability of the computer to safely store information	0.802	0.009

These themes are quantified in Table 13 below to indicate the number of times they were mentioned at each of the adoption levels: Early Adopters, Late Majority and Laggard facilities. As can be seen, this analysis is based on 42 statements that had significant differences across the adoption levels.

Table 13 Cross-Tabulation of Themes Across Adoption Levels

Theme	Early Adopters	Later Majority	Laggards	Total
Damaged or lost paper registers	2	4	1	7
Negative Facility Leadership	0	2	3	5
Improvements to facility security	2	3	1	6
Ability of computer to safely store information	1	2	0	3
Identification of correct patient	2	4	1	7
Patient confidentiality	2	4	1	7
Need for the system at the facility	0	4	3	7
Total	**9**	**23**	**10**	**42**

Since the number of participants in the focus group discussions varied across the facilities, the quantified themes were divided by the number of interview participants to correct for participant number. Results of the correlations are shown in Table 14 below.

Table 14 Correlations of Ratios of Adoption Factors

Theme/Code/Factor	ρ	P
Negative facility leadership	- 0.895	0.001
Damaged or lost paper registers	0.730	0.025
Identification of correct patient	0.730	0.025
Patient confidentiality	0.730	0.025
Need for the system at the facility	- 0.730	0.025
Improvements to facility security	0.733	0.025

Factors that correlated with the facilities' level of eHealth system adoption, and the direction of the correlations, remained the same even after adjusting for the number of interviewed participants. In all the assessments, engagement with the facility in-

charges remained the highest factor correlating with the level of eHealth system adoption. Factors that correlated with level of eHealth system adoption are in green boxes in Figure 15 below.

A further exploration was done on these factors that correlated with facilities' level of eHealth system adoption, in order to gain insights into underlying factors, using quantified binary data, as shown by white boxes in Figure 15 below. Negative engagement with facility leadership was found to be significantly associated with facility proprietorship, where there was more negative engagement with facility in-charges at CHAM facilities than government facilities (ρ=0.694, P=0.038); the perceived ability of the computers to safely store information, which decreased with increasing poor leadership engagement (ρ= -0.877, P=0.002); use of the system for financial governance (ρ=0.694, P=0.038); and need for the eHealth system to be restored at the facility (ρ=0.694, P=0.038).

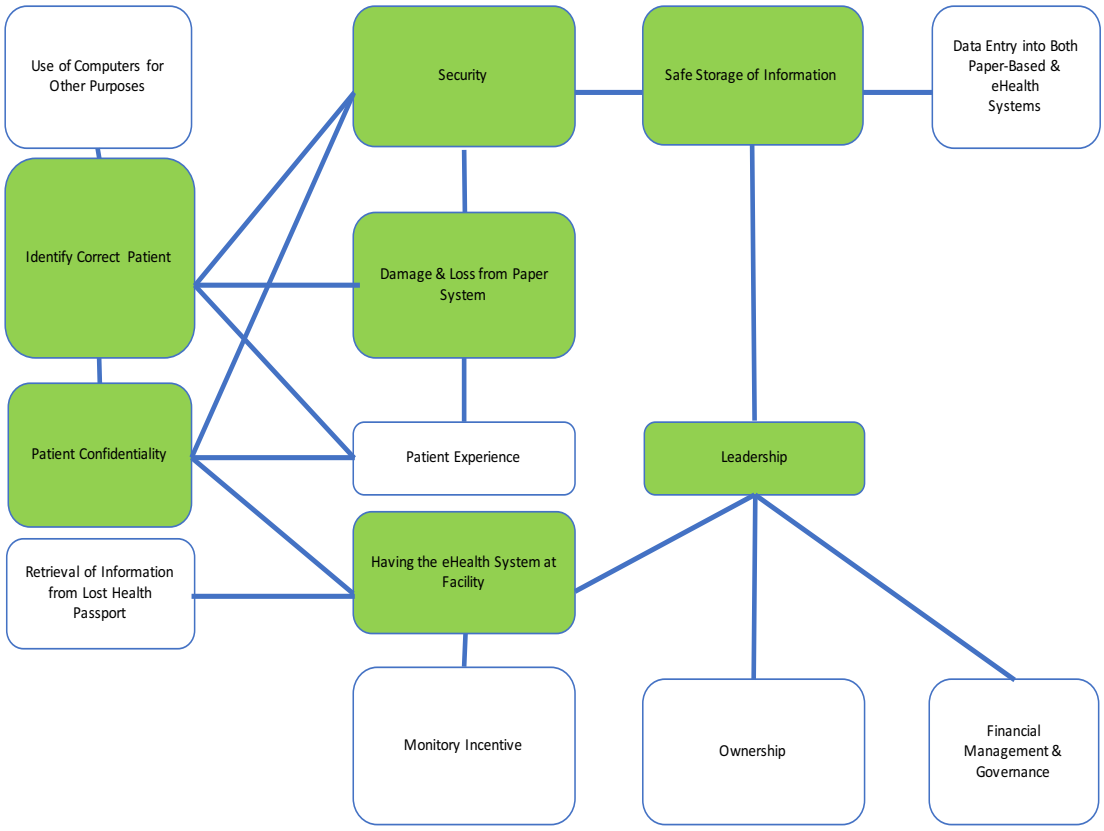

Figure 15 Adoption Factors According to Content Analysis

Ability of the system to safely store information was the second strongest factor correlating with the level of eHealth system adoption. This factor significantly correlated with negative engagement with facility leadership, where perceived ability of the system to safely store information decreased as negative facility leadership engagement increased (ρ= -0.877, P=0.002), while it increased with reported improvements to facility security (ρ=0.732, P=0.025), and decreased with reported increase in double data entry into both paper-based and eHealth systems (ρ= -0.817, P=0.007).

Improvements in facility security correlated with reported damages or loss of paper registers (ρ=0.756, P=0.018), and ability of the eHealth system to safely store information (ρ=0.732, P=0.025), identify the correct patient (ρ=0.750, P=0.02) and ensure patient confidentiality (ρ=756, P=0.018).

On the other hand, the ability of the eHealth system to identify the correct patient was significantly correlated with reported damage and loss of paper registers at the facilities prior to the eHealth system's implementation (ρ=0.992, P=0.000), improvements to facility security (ρ=0.750, P=0.02), other uses of the computers apart from health information management (ρ=0.750, P=0.02), patients having positive experience with the system (ρ=0.676, P=0.045) and the eHealth system's ability ensure patient confidentiality (ρ=0.992, P=0.000).

Patient confidentiality, on the other hand, was significantly correlated with reported improvements to facility security as part of eHealth system implementation (ρ=0.756, P=0.018), positive experience of the eHealth system by patients (ρ=0.700, P=0.036) and enhanced ability by the health workers to identify the correct patient using the eHealth system (ρ=0.992, P=0.000).

Facilities that described the damage or loss of paper registers prior to implementation

of the eHealth system also reported improvements to facility security as a result of the implementation (ρ=0.756, P=0.018), positive experience of the eHealth system by patients (ρ=0.700, P=0.036) and enhanced ability to identify the correct patient using the eHealth system (ρ=0.992, P=0.000).

Lastly, facilities where the system had failed and had been removed expressed a need for the system at the facility, and they significantly also reported wanting monitory incentives (ρ=0.750, P=0.020), an enhanced ability by the eHealth system to maintain patient confidentiality (ρ=0.688, P=0.040) and to retrieve information for lost, damaged or wrong patient-held, paper-based health passports (ρ=0.698, P=0.037).

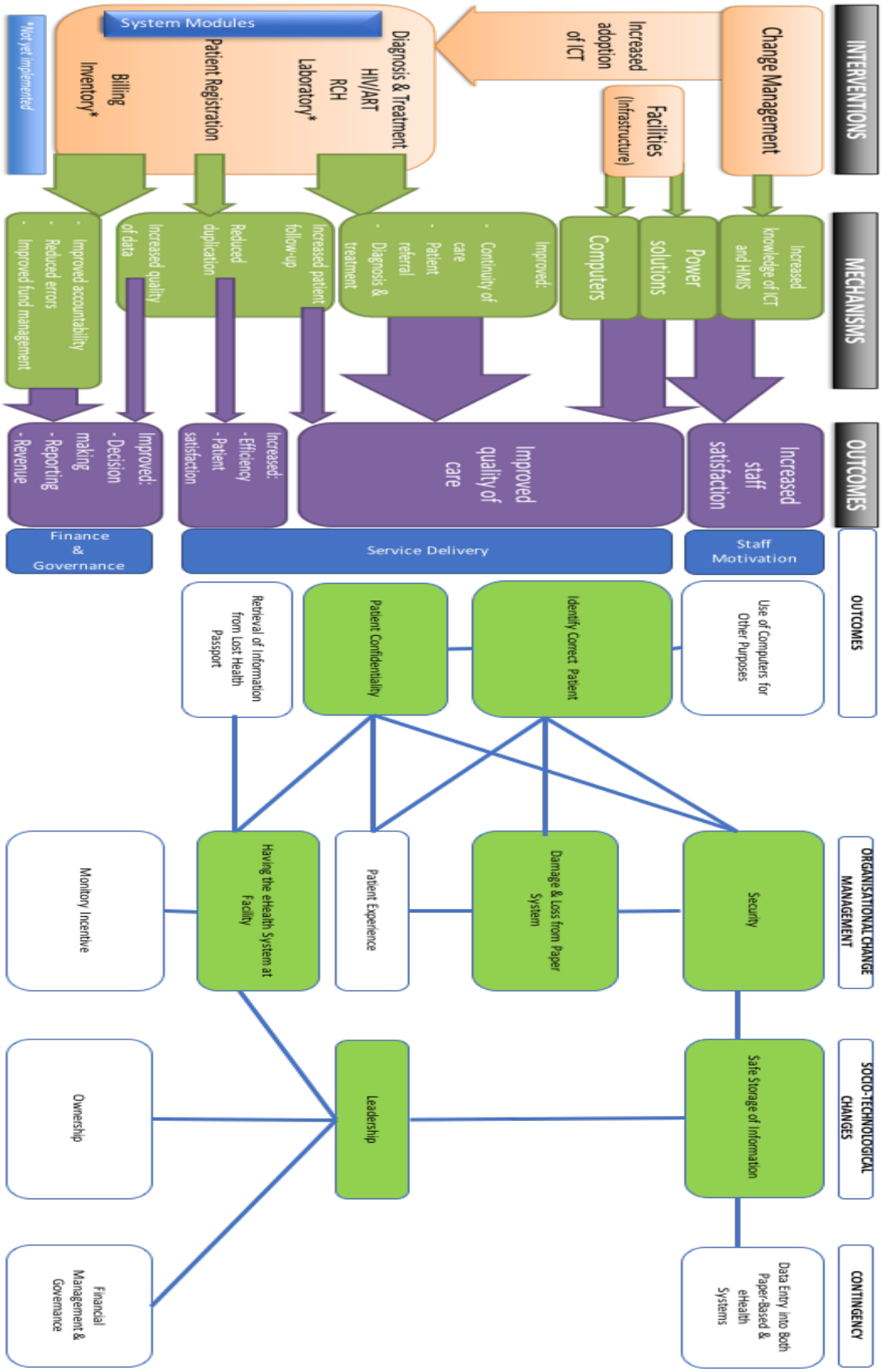

Figure 16 Comparison Between Logic Model and Content Analysis Results

This framework was presented to representatives of study participants for validation. They indicated which categories of barriers and facilitators they identified with, and had the option of adding other factors not presented in the framework. There were hypothetical pathways in the initial logic model relating to the theory of how the system would change practices and then influence outcomes. However, this framework only looked at associations between barriers, facilitators and outcomes. When this new framework was matched against the logic model that was developed for the study, based on project proposals, discussion with its planners and implementers, and literature, the two models matched at outcome level. However, the facilitators and barriers in the new model did not exactly match the study's theorised intervention and mechanisms, though there were similarities. There was a box with "Other" in the framework to indicate whether there were other factors that inhibited or enabled adoption not captured by the framework. Only one health centre had stickers on "Other" and upon enquiry they indicated the eHealth system's inability to produce a report and inadequacy of training as other key adoption factors.

4.9 Summary of Case Study 2

This chapter presented the findings from the nine health centres. Sections 1.5 and 1.6 gave a broad overview of the methodologies used in this study, presenting the case study design and use of mixed methods. Those abstracts were undertaken and are depicted in this chapter in the methods section, followed by results. These results are organised along the theoretical underpinnings of this study (Section 1.4): soft-positivist epistemology, pluralist narrative, and the complex interactions between organisational, change management, social and technological dynamics. Descriptions of how the nine health facilities were structured was given, covering human and infrastructural resources, followed by a description of the processes of patient flow, data management and delivery of patient care, and finally patient load and health outcomes for the year 2013.

Only Early Adopters mentioned unavailability, damage or loss of paper registers as still change management difficulties. They also reported reduced workload following eHealth implementation, while the other facility groups reported increased workload due to dual use of paper and electronic systems, staff shortage and high patient load. Apart from strengthened security, another organisational intervention was access to continuous power supply by installing backup batteries and solar power, with unintended consequences of perceived modernisation and expansion of power to other parts of the facility. Major challenges were backup batteries depleting and frequent connectivity interruptions between the client computers and the server, leading to occasional use of the eHealth system.

Socio-technological factors were also reported. There were 24 problems identified in the eHealth system, covering its design, security protocols, hardware and database. Although staff reported improved backup storage and retrieval of data for the paper system, only Early Adopters reported use of the eHealth system's search function. There were strong opinions about the ineffective engagement of in-charges at Late Majority and Laggard facilities. Limitations in the scope and number of staff formally trained was perceived to be an inhibitor to eHealth system adoption, particularly lack of training in basic troubleshooting and maintenance. Peer training lacked follow-up formal training. Many system champions were senior staff and thus busier and more mobile, most often leaving the junior staff, who were not formally trained, to be using the system. Staff were happy about the computer knowledge gained, but most expressed lack of confidence using the eHealth system. Response to calls for technical support by the IT team was said to be slow and ineffective (except at Late Majority Facilities), and there was no transfer of basic skills from the IT team to the health facility staff. Various hardware and software requests to improve end-user engagement were made by staff.

Outcomes of the eHealth system were quality and use of its data for service delivery, reporting and financial management. All three facility groups reported poor data

quality in the eHealth system, mainly due to dual data use of the paper-based and electronic systems, where staff defaulted to use the paper-based system only, aggravated by infrastructure and leadership problems. Data completeness was 82.4% as compared to DHIS2 (100.0% Early Adopters, 73.9% Late Majority), with on average 1,271 clients less than recorded in DHIS2 per month. Reported service delivery improvements included enhanced ability for tracing patients, treatment continuity, identifying the correct patient, ensuring patient confidentiality, keeping health workers alert, following clinical protocols, identifying the need to change prescription for (or refer) a recurrent patient, and reportedly showing the patient that the provider was paying attention. Perceived improvements in patient experience included no redundancy in entering patient information at subsequent visits, better management of queues, and staff reported that patients felt more understood by the service provider and had more confidence in the services. Perceived negative patient experiences were reported to be due to the staff's slow typing skills and unfamiliarity with the eHealth system, dual entry of patient information into both the electronic and paper systems, extra steps added to the patient flow, and disrupted patient-provider interaction. All facilities were still using paper registers to compile HMIS reports, a few in combination with the eHealth system, because of lack of knowledge of the reporting module, poor design of the system's reports, and disruptions in electricity and network to the server. The eHealth system reportedly helped staff in the accounts department with billing, the facility in-charges with financial oversight, and clients with more trust in printed receipts.

CHAPTER 5 SYNTHESIS AND DISCUSSION

Chapter Aims

- Integrate and discuss the key findings from the two case studies in the context of existing empirical and theoretical literature
- Isolate new insights
- Portray effects of the system on quality and use of data for service delivery
- Discuss the complex and interdependent relationship between technology, organisation and people

Impacts of eHealth on health systems are complex, and this study shows the mixed facilitators, barriers and outcomes of an eHealth system at 10 rural facilities in Malawi. Two main questions guided this study: How do complex organisational, change management and socio-technological interactions affect eHealth implementation and adoption? How do eHealth systems affect quality and use of data for service delivery, reporting and financial management? These questions are discussed in this chapter, reflecting on the case study health centres and referral hospital, in the context of related literature. Studies have shown that facilitators, barriers and outcomes to eHealth adoption apply across varying geographic and cultural settings (Xierali et al. 2013; Aqil et al. 2009; King et al. 2013), hence the determinants of eHealth adoption in other diverse health systems across the globe also apply to the case study facilities. Building on the state of literature on eHealth implementation, adoption and outcomes presented in Section 1.2, this chapter mainly presents the specific contributions of this study to that literature.

5.1 eHealth Evaluation and Complexity

"*Technologies mirror our societies by reproducing and embodying the complex interplay of professional, technical, economic and political factors*" (Bijker & Law 1992). While the original plan for the study was to evaluate the cost-benefit of the eHealth implementation at the ten facilities, discussions with interdisciplinary supervisors quickly revealed the advantages of approaching it as a sociotechnical study, as more was learned about the history of the project and the contextual factors surrounding it, and a priori assumptions about users' work practices, incentives and the role of the system were challenged. Assumptions about linear relationships between interventions and outcomes as displayed in the study's logic model were also challenged during the course of data collection and analysis, leading to a more complex framework as shown mirrored against the outcomes of the original logic model in Figure 17 below.

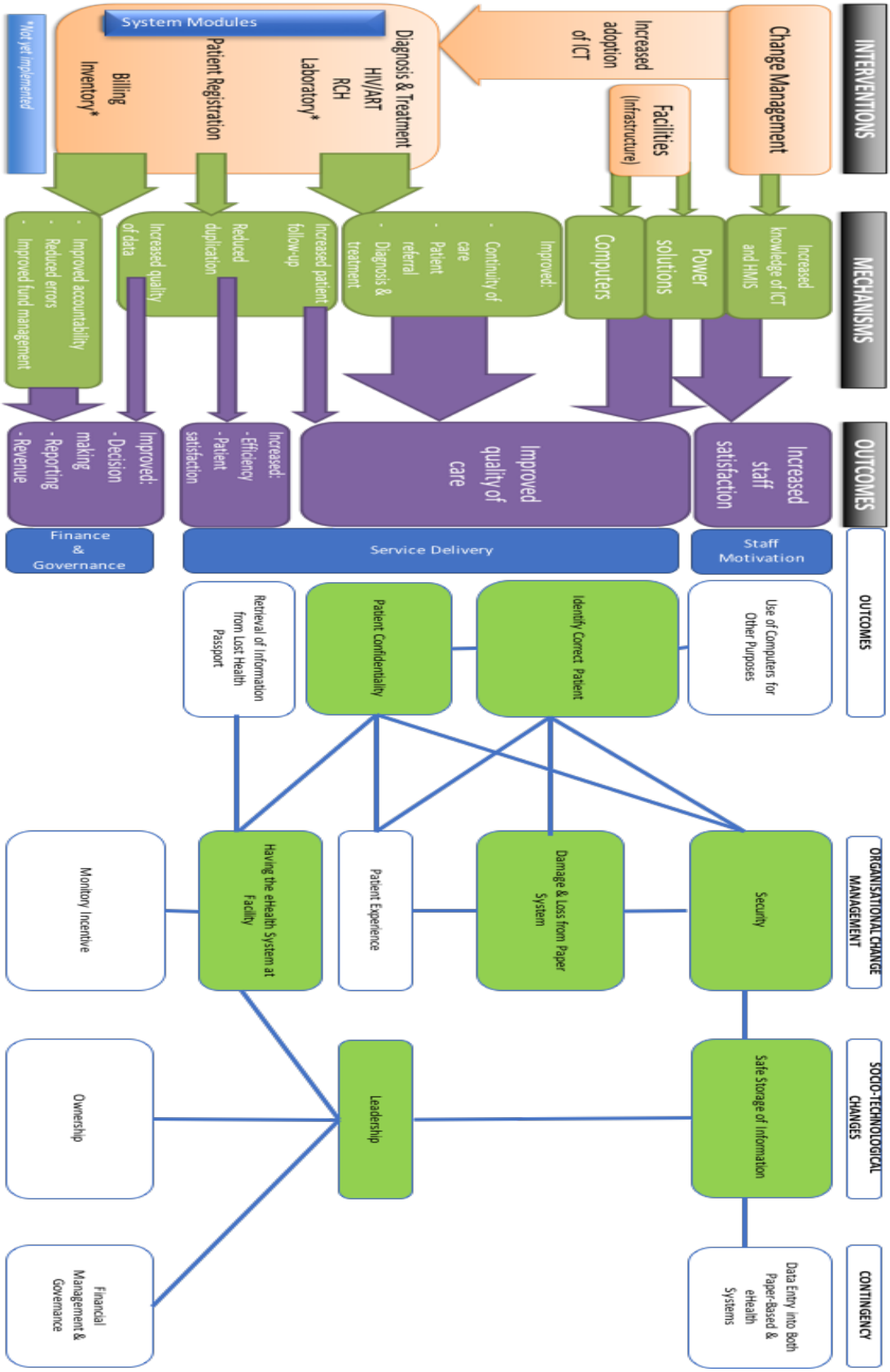

Figure 17 Complex Interactions Between Adoption Factors and Outcomes

Sociologists of technology recognize the co-dependency of information systems and their users and settings within sociotechnical systems, where human and organizational factors influence or 'shape' the technology (e.g. (Williams & Edge 1996)) whilst introducing technology may shape professional roles and work practices (e.g. (Berg 1999)). Such authors therefore argue that information systems projects should be approached as a process of organizational development, taking account of the social context and consequences of implementation (e.g. (Berg 2001)), rather than focusing on the technology alone. In the case studies presented in chapters 3 and 4, the sociotechnical intervention included not only the roll out of an IT system but also staff training and workflow changes, including the recruitment of ward clerks to replace the billing roles of the inpatient department nurses, patient attendants and accounts personnel. In a similar way, the introduction of patient records at the beginning of the twentieth century necessitated changes in hospital architecture and the emergence of the new profession of medical record managers (Berg 1999; Berg 2001). Likewise, researchers in the field of eHealth recognize that introducing such innovations can disrupt existing work processes and often require additional change management and service redesign efforts, which make it hard to disentangle the effects of the technology from the social, change management and organizational processes that surround it (Pagliari 2012; McLean et al. 2013).

This study has shown that eHealth has the potential to strengthen health systems in terms of human resources skills development, service delivery and financial management. However, these improvements are dependent on organisational change management and socio-technical interactions affecting implementation and adoption of the eHealth systems. These are discussed in the remainder of the thesis.

5.2 Outcomes of eHealth Systems

Introducing new health information systems can be complex and demonstrating their impacts without controlled trials represents a challenge for evaluation (Harris et al. 2006). For these reasons, evaluations focused on clinical and cost indicators can have limited generalizability, and sociotechnical studies may be more useful for uncovering unanticipated influences and effects (Cresswell & Sheikh 2014; McLean et al. 2013). Undertaking such evaluations in low income country settings adds an additional layer of complexity, leading some researchers to argue that quantifying hard outcomes may be less important than understanding ICT as an enabler of socio-economic development (Gomez & Pather 2012).

5.2.1 Quality of eHealth Data

Overall quantitative data completeness in the eHealth system was found to be 82.4%, with Early Adopters having 100.0% completeness and Late Majority facilities having 73.9% completeness as compared to paper-based data recorded in DHIS2. Although the eHealth system recorded an average 1,271 less clients per month than DHIS2 from the paper-based system, indicating a negative bias, the line of equality in the Bland-Altman plot was within the 95% confidence interval of the differences between the eHealth and DHIS2 [-4,000 to 1,459]. These are discussed below and compared to other eHealth systems. A 93.6% eHealth system data completeness and 68.9% accuracy of inpatient data at Madalo Hospital are also discussed. Further, qualitative factors that influenced the quality of data at both case studies are explored in context of the body of literature.

In the outpatient department at Madalo Hospital, only patient registration and billing data were entered consistently into the eHealth system. Diagnosis and treatment data was not entered in the eHealth system, but only in the paper-based system. In the inpatient department, ward clerks entered patient registration, diagnosis and

treatment, and billing data into the electronic system. Having an inpatient department electronic data that is 93.6% complete and 68.9% accuracy indicates that the system is maturing. In the early years of implementation of eHealth systems in developed countries, data quality was poorer (Peabody et al. 2004), with completeness being as low as 57% for primary diagnosis 27% for secondary diagnosis. In developing countries, data quality of electronic data at that time was also so poor such that the potential of eHealth was deemed to be unachievable (Williams & Boren 2008). Indeed, in those early years, eHealth systems in developing countries such as Uganda (Ndira et al. 2008) and Tanzania (Maokola et al. 2011) did not establish any change in accuracy of data after implementation.

There are few studies that have found higher levels of eHealth system data completeness than that at the case study facilities. Earlier studies at facilities known to be highly committed to using their eHealth systems found that completeness of the electronic system as compared to the paper records was 82% for diagnoses (Pringle et al. 1995), even after validating with video recordings of patient encounters. Later analyses of eHealth system data found their completeness reaching 97% to 100% for patient identification and test results, respectively (Dixon et al. 2013). Data entered into an eHealth system by trained non-clinical data clerks have ranged from 93% to 100% completeness (Ayoub et al. 2007). eHealth systems such as DHIS2 have reached average data completeness of 100% as compared to an average data completeness of 94.3% for paper-based system (Amoakoh-Coleman et al. 2015).

Nevertheless, eHealth data completeness at the case study facilities was higher than those found by other studies. Indeed, other studies have shown limited improvement in data quality after implementation of eHealth system (Douglas 2009; Gadabu et al. 2011; Maokola et al. 2011; Hahn et al. 2013). Data quality of other eHealth systems have been found to have HIV data completeness between 60% and 80% (Puttkammer et al. 2015) and chronic diseases data between 43% to 80% (Singer et al. 2016). Electronic admission data has also been found to have completeness of only 60%

(Wang et al. 2013), while cancer data only peaked at 93% (Harshberger et al. 2011).

High level of data completeness at Madalo Hospital was attributed to the eHealth system's internal validation rules, and the inpatient departments' recruitment of ward clerks. While these ward clerks collected most of the data from the paper record into the electronic record, their average accuracy was 70.0%. This level of accuracy is lower than those achieved by other eHealth systems, even in the pioneer stages in low-income countries (Ayoub et al. 2007; Ndira et al. 2008). More recently, a comparison between hand-written and electronic dermatopathology case requisitions was made (Kinonen et al. 2017), resulting in an accuracy of 96.1% for the eHealth system as compared to 97% accuracy for the paper record. Other eHealth systems implemented in Sub-Sahara Africa have reported an improvement of data accuracy from 33.5% to 97.9% (Castelnuovo et al. 2012).

Qualitative methods helped to explain some of the drivers of electronic data quality at the study's facilities. All three facility groups reported perceived poor data quality in the eHealth system, mainly due to dual data entry into the paper and electronic systems, where staff defaulted to use the paper system only. These change management factors are discussed in Section 5.3.1. This was reportedly aggravated by power and network problems at the Early Adopters and Late Majority facilities, organisational factors discussed in Section 5.3.1 below. A key challenge to the quality eHealth system data is unstable power supply (Puttkammer et al. 2015). Late Majority Facility staff reported data completeness to be affected by communication breakdown between system user champions and other users about changes made by the IT team. Data quality was also affected by a facility In-Charge stopping staff from using the eHealth system at a Laggard facility. Late Majority Facility staff reported data quality to be affected by lack of relevant reports from the eHealth system to encourage data entry. However, some data completeness is ensured at the case study facilities by not allowing one to proceed when other fields have been completed, like other systems in Sub-Sahara Africa (Castelnuovo et al. 2012). These socio-technological issues are

discussed in Section 5.3.2 below.

Like Madalo Hospital, other factors that predict improved eHealth system data completeness include number of elements to be recorded (Wang et al. 2013), staff satisfaction with the system despite challenges in implementation (Harshberger et al. 2011) and low staff turnover among the Ward Clerks (Singer et al. 2016), and being a fee-for-service facility with higher patient load (Singer et al. 2016). Another strength of Madalo Hospital was the presence of a system champion, which has shown to improve data quality in other settings (Ghosh et al. 2016). Madalo Hospital also conducted regular training for Ward Clerks, which improves data quality (Piette et al. 2012). However, a weakness is the Ward Clerks' insufficient capacity to analyze and use data for decision making, a key challenge to data quality (Mutale et al. 2013). Data quality at Madalo Hospital was also adversely affected by limitations of the software, discussed in Section 5.3.2 below, as also experienced by other health systems (Ghosh et al. 2016).

Although having health workers enter data into the computers is said to improve data quality unlike having data clerks do the task (Castelnuovo et al. 2012), as was the plan at the case study facilities, the heavy workload on the health workers makes it very difficult for them to both attend to the numerous patients as well as enter data (Majeed et al. 2008), particularly when both the paper-based and electronic systems are being used concurrently. There is also grey literature reporting the security risks that can arise if you expect busy clinical staff to be entering data – for example, shared passwords and open screens. Having a dedicated administrator to do this can help to avoid these risks. Nevertheless, data completeness has been shown to improve with time (Häyrinen et al. 2008).

5.2.2 eHealth Data Use in Service Delivery

Quality of data affects its use for clinical and organizational decision-making, which was demonstrated at the case study facilities, and could possibly be used for research (Richesson et al. 2014; Weiskopf et al. 2013). Without improving the information culture of data quality and use from the point of collection, eHealth systems have limited impact (Piette et al. 2012). Clinical decision-making included Madalo Hospital's outpatient physician using the eHealth system to follow up patients' inpatient information, particularly hypertension and diabetic patients. Organizational decision making at Madalo Hospital included use of reports from the eHealth system to procure medical supplies, deploy trained staff, allocate wards and advocacy.

Staff at all health centre facility groups anticipated improved storage and retrieval of data with eHealth implementation, for up to seven years (Early Adopters), particularly improving the paper-based system's disparate registers that got damaged and lost (Late Majority and Laggards), as well as lost patients' health passports (all facility groups) or when one health passport was used by several people during subsequent patient visits (Early Adopters), and limited handover of data among staff (Late Majority and Laggards). Staff at all facility groups reported improved storage and retrieval of data for lost or wrong health passport and paper registers. Only Early Adopters reported use of the eHealth system's search function. At Madalo Hospital, the eHealth system was reported to improve speed of retrieval of patient files. eHealth systems have been shown to reduce time taken to locate patient files from 2.9 minutes using the manual method to 0.09 minutes (Avilés et al. 2008). With this improved record keeping and retrieval, staff can monitor and detect patients who might abandon care, which has shown promise in developing countries (Blaya et al. 2010).

eHealth has been perceived by managers and patients as positively influencing

workplace efficiency and communication (McGinn et al. 2011), and improved the facility's tracking of patients (Butler et al. 2013). At the health centres, Early Adopters and Late Majority staff anticipated and reported improvements in service delivery, while the Laggards neither expected nor reported any service delivery benefits from the eHealth system. Early Adopters reported the eHealth system helping in tracing patients, treatment continuity (though with no laboratory results), identifying the correct patient, and patient confidentiality. They also reported the unintended consequence of keeping health workers alert. Late Majority staff reported improvements in following clinical protocols, identifying the need to change prescription for, or refer, a recurrent patient, and the unintended consequence of showing the patient that the provider was paying attention. Some Early Adopters and Laggards reported no difference with patient experience and service delivery after eHealth system implementation, while other staff across the facility groups spoke of both positive and negative patient experiences. On positive experiences, staff at facilities in all groups reported this to be due to no redundancy in entering patient information into the eHealth system at subsequent visits, while Early Adopters and Laggards reported better management of queues. Late Majority staff reported that patients felt more understood by the service provider and had more confidence in the services. Negative patient experiences were reported to be due to the staff's slow typing skills and unfamiliarity with the eHealth system across the facility groups, while Late Majority staff and Laggards reported dual entry of patient information into both the electronic and paper systems as the cause.

Late Majority staff reported disrupted patient-provider interaction as a negative consequence of the eHealth system. Elsewhere, health workers have also expressed fears that the increasing use of eHealth will result into the depersonalization of healthcare (Lluch 2011), with increased interaction with the technology leading to a loss of both physical and relational contact with patients (McGinn et al. 2011; Noblin et al. 2013). Many health workers report that using eHealth will take more time for each patient to be attended to than using paper (Boonstra & Broekhuis 2010). Health

workers have been reported to be reluctant to adopt eHealth due to fear that eHealth usage would result in more time spent with each patient as well as interference with doctor-patient relationship (Paré et al. 2014). As such, these organizational management issues need to be assessed if eHealth implementations and adoption are to succeed (Lluch 2011; Castillo et al. 2010).

Seamless and reliable clinical information exchange across facilities and eHealth modules is a cornerstone of service delivery outcome (J. Li et al. 2013; Castillo et al. 2010). However, as the implemented eHealth system's modules were not integrated, it could not be used for referral from one department to another within the case study facilities, like other facilities with eHealth do (Noblin et al. 2013), further limiting its potential to improve continuity of care (Gulliford et al. 2006). Only one health worker at Madalo Hospital was using the eHealth system to track patients with non-communicable diseases such as diabetes and hypertension, like other eHealth systems that have improved non-communicable disease care elsewhere (Sidorov 2006; Tang et al. 2007).

Health care data exchange within eHealth system modules and across service delivery points requires use of common terminologies and communication standards between information systems and service delivery (Chiang et al. 2008). One of the objectives of the eHealth project at the case study facilities was therefore to enable sharing of patient data amongst the facility departments, across health centres and particularly with the referral hospital. This would only be achieved if all the health centres and the hospital shared similar diagnosis codes. Since the bespoke eHealth system at had the more comprehensive HL7 list of diagnosis codes, data exchange was possible between the case study health facilities, including their referral hospital. However, at organisational level, vandalism of network equipment made this objective unachievable. At outcome level, this continuity of care was further compromised by the occurrence of the same person existing multiple times in the eHealth system, as few staff searched a patient's record during registration.

5.2.3 eHealth Data Use in Financial Management

Results of the study suggest that the eHealth implementation project modestly increased revenue within Madalo Hospital by helping to reduce intentional and unintentional billing errors. The relationship between the system and these outcomes was far from simple, however, and involved a combination of technological, behavioural and organizational mechanisms. While the key respondents strongly perceived that the system had improved financial governance processes and thus reduced fraud and increased efficiency, the revenue data were far less convincing, albeit generally consistent with this interpretation. By converging quantitative financial data with qualitative interview data, a rich picture was revealed of the macro-environmental factors influencing revenue fluctuations, as well as examining how the eHealth system influenced billing practices and the importance of role separation as a mediator of governance.

The finding of modest increases in inflation-adjusted billing revenue is consistent with the results of a similar study of a similar eHealth system in Tanzania, which reported a 15% increase in revenue at three hospitals after implementation (Leon 2012). Factoring in the cost of employing the four Ward Clerks (MK355,982) reduces the percentage increase in revenue still further, from 15% to 8%. Other studies have similarly found unchanged financial outcomes following eHealth implementation four years after implementation of an eHealth system (Lim et al. 2015; Chiang et al. 2013).

Some health facilities have even reported loss of revenue, particularly in the early years of eHealth adoption (Menachemi et al. 2011). These losses have been projected to be as high as $43,743 over a five-year period after adoption of eHealth at an average health facility, while only 27% of facilities would achieve a positive return on investment (ROI) (Adler-Milstein et al. 2013). Facilities that achieve this positive ROI are those that increase revenue by increasing the number of patients seen per day

resulting from improved efficiency, and improved charge capture and billing that lead to reduced rejection of insurance claims.

Loss of revenue in the initial phases of eHealth implementation are commonly due to disruptions in access to patient data and interference with staff productivity, and such fears lead to low adoption of eHealth (Police et al. 2011). These losses of revenue need to be included in the finance plans for eHealth implementation, which also include additional personnel and utility (electricity and internet) costs (Gleason & Farish-Hunt 2014). Indeed, the financial impact of eHealth interventions depend largely on non-IT costs, including non-IT labour and capital, and time (Ko & Osei-Bryson 2008), similar to the Ward Clerks at Madalo Hospital.

Other studies have demonstrated improved health facility revenue following implementation of eHealth systems (Bardhan & Thouin 2013), usually after 5 years (Abraham & Junglas 2011) or 6 years of implementation (Choi et al. 2013), with the cumulative net present value (NVP) of up to $3,617. Similar to Madalo Hospital, these financial benefits derive not only from the technology itself, but are also mediated by the sophistication of the eHealth system that lead to improvements in collecting outstanding receivables (Smith et al. 2013). Converging the documentary analysis, interviews and revenue data also revealed the co-dependency of the system and its users, shining a light on the introduction of Ward Clerks, which was associated with a steep rise in revenue capture, although this declined somewhat in the following year. However, the study only collected data for 4 years of eHealth system implementation at Madalo Hospital, the point where revenue has been shown to start improving.

eHealth systems such as that at Madalo Hospital facilitate patient billing, as demonstrated in studies showing fewer errors, more effective charge capture and improved cash flow (Sidorov 2006; Choi et al. 2013; Menachemi & Collum 2011; Schmitt & Wofford 2002; Wang et al. 2003). Similarly, key informants at Madalo

Hospital reported a general improvement in the capture of data items for billable services such as patient consulting, admissions and drugs, which they attributed to the use of the eHealth system. Interviewees described that with the introduction of the eHealth system, it was more difficult for patients to skip registration at entry, or payment for drugs, such that their care encounter was being documented, revenue was gathered during their visit, and they could be followed up. Inpatient revenue was also no longer lost through incomplete manual bills, which failed to document all the care or drugs received. Implementation of the eHealth system required every patient be registered on the system before they can receive a physician consultation and pay for a screening consultation before receiving a prescription, although patients could still, if they chose, exit the hospital without purchasing the drugs they had been prescribed.

Converging the financial data with the interviews revealed what is perhaps the most salient observation of this study, in terms of its implications for eHealth adoption in lower income countries. This is that the increase in per patient revenue did not materialize until after the introduction of Ward Clerks in 2012, whose remit was to ensure that all patients and procedures were recorded and patients billed appropriately using the eHealth system. This significantly changed the role of nurses, patient attendants and accounts staff, who had previously been responsible for these activities. Although users and managers saw the eHealth system as contributing to revenue improvements at the hospital, they explained this largely in terms of staff behaviour rather than as a simple effect of the technology itself. The sociotechnical system implemented here consisted of, as one manager put it, electronic as opposed to hand written receipts, separation of duties and closer monitoring of staff managing finances. While most interview participants described the importance of the Ward Clerks in effectively deploying the system, the marked increase in billing revenue immediately after their recruitment may be coincidental and the effect reduced the following year. It is possible that as they became more integrated within local teams, increased social pressure reduced their motivation to report objectively; however as

only two years of data were available, it was not possible to explore these longer-term effects.

There are few studies on financial outcomes of eHealth in low-income countries, since health services in such settings are typically free at public facilities. As such, there is very limited literature on use of ICT to improve financial management and reduce fraudulent practices in the health sector (Holeman et al. 2016), a gap this study aimed to help fill. Most interviewees drew attention to dishonest or unethical practices by staff members using the paper-based system, such as documentation being altered or billing stages by-passed. This included favour-giving to friends and relatives as well as employees receiving fees from patients without recording them. Immediately after the introduction of the eHealth system, the same staff continued to be responsible for data capture and billing processes, on the assumption that the technology itself would lead to improvements. However, staff were simply able to replicate the workarounds previously used with the paper-based system. After the recruitment of the Ward Clerks, many of these loopholes were closed and greater transparency and accountability afforded by the eHealth system, and the people managing it, led to disciplinary actions and noticeably reduced these practices. It is important to note that these changes were part of a wider set of financial management measures instituted by the hospital, such as new training and accounting practices. However, it is noteworthy that issues relating to billing workarounds and lack of transparency dominated interviewees' accounts of the governance-enabling role of the eHealth system.

Implementation of the eHealth system at the health centres reportedly helped staff in the accounts department with billing, the facility In-Charge with oversight and clients with more trust in printed receipts. Similar findings have been reported in a study from Kenya, which managed to combat staff theft of user fees through a governance intervention involving networked electronic cash registers, coupled with more attentive management and the separation of billing and fee collection activities. This

improved accountability through more detailed recording and analysis of activities, including comparisons of actual to expected revenue, and enabled greater transparency through issuing printed receipts to patients. Implementation was associated with a 47 percent increase in patient fee revenue within three months, with no effect on service utilization, and a 400% increase within three years (Vian 2008). Weak financial management represents a major barrier to the delivery of equitable, effective and sustainable healthcare worldwide (Mugo 2013; Joshi et al. 2015; Dasandi et al. 2015). Although the problem is recognized by most global development agencies, it remains a politically sensitive issue and is often lost in the commitment to raise funds and expand services (Lewis 2006b) whilst regulation and enforcement are often ineffective (Vian 2008; Swanson et al. 2015). These problems are exacerbated by institutional factors, such as inconsistent salary payments, and organizational norms that encourage tipping, informal payments, minor theft or favour-giving, coupled with a lack of monitoring and oversight, which enables such practices to flourish unhindered (Muula & Maseko 2006; Lewis 2007; Fritzen 2007).

5.3 Enablers and Inhibitors to Implementation and Adoption of eHealth Systems

Outcomes described in Section 5.2 above were mediated through organisational change management and socio-technical factors described here. There are multiple stakeholders in a health system, with some enabling and others inhibiting eHealth system implementation, making its adoption and outcomes very erratic (Cripps & Standing 2011). Understanding health workers' reluctance to use eHealth is critical for developing targeted strategies to effectively accelerate adoption (Yan et al. 2012). It has been shown in studies that facilitators and barriers to eHealth adoption apply across varying geographic and cultural settings (Xierali et al. 2013; Aqil et al. 2009; King et al. 2013), hence the determinants of eHealth adoption in other diverse health systems across the globe also apply to the case study facilities.

5.3.1 Organisational Change Management Factors

Significant organisational change management factors that affected eHealth system implementation in the case study facilities were workload and patient flow, power supply, and security of the equipment and data.

Workload and Patient Flow

Only Early Adopters reported reduced workload because of eHealth implementation, while Late Majority facilities and Laggards reported increased workload due to dual entry of patient information into the paper-based and electronic systems. Late Majority staff and Laggards additionally mentioned staff shortage as a cause for increased workload, and high patient load was reported by Late Majority staff. Heavy patient volumes seen by clinicians at the cases study facilities did not allow adequate time to update electronic patient records during consultation.

Increased workload has been cited as an important barrier to eHealth adoption (McGinn et al. 2011; Noblin et al. 2013). Parallel entry of data into paper and computer increases the workload of already overstretched health workers (Akanbi et al. 2012). Both manual and electronic practices were being used at the case study health centres, which is a barrier to changing staff roles and workflow (Ancker et al. 2013).

Increased workload is also often associated with lack of integration into the organization's workflow, which is an intra-organization barrier to eHealth adoption (McCullough et al. 2014; Shen et al. 2012; Shank 2012). With the coming in of the eHealth system, workflow was changed to add patient registration into the eHealth system before going into the consultation room, then clinicians would write the patient's diagnosis and treatment into the patient-held health passports as well as entering it into the eHealth system. However, as data entry is an already widely experienced barrier among health workers (Boonstra & Broekhuis 2010), clinicians at the case study facilities did not have time to write diagnosis and treatment into both the health passport and the eHealth system. Instead they gave their password to support staff at the registration desk to also enter diagnosis and treatment data into the eHealth system. After clinicians observed this practice, support staff were given rights to the diagnosis and treatment module, and the workflow changed. At Madalo Hospital, there was a transfer of data entry roles to Ward Clerks in the inpatient department, leading to improved documentation and financial management. Such changes in staff roles and workflow have hindered eHealth adoption in other places (Ramaiah et al. 2012). In a South African private hospital, implementation of an eHealth system was rejected by nursing staff because the nurses perceived a lack of cultural fit between the system and their work, as their commitment to their nursing culture made them unwilling to adapt their processes to integrate the eHealth system into their work (Whittaker et al. 2011).

Power Supply

Even though continuous electricity supply was attempted to be ensured by the eHealth system implementation, interviews at the referral hospital, Early Adopter and Late Majority facilities revealed challenges with continuous power supply, with the backup batteries depleting, particularly at the Late Majority Facilities. Poor electricity infrastructure is a barrier to successful eHealth adoption (Ancker et al. 2013; Lewis et al. 2012; Akanbi et al. 2012). Malawi, like most sub-Saharan countries, experiences acute power challenges with poor electricity supply, especially in the rural areas (Heeks 2008; Amoroso et al. 2010; Tiihonen 2009). Like most developing countries, hydroelectricity is the major source of electricity in the country (Williams & Boren 2008), which suffers from both flooding and drought, making electricity supply intermittent. In rural Australia, frequent power outages and a lack of back-up power meant if the power was out, the staff had to telephone a clinic in another community for patient information (Cripps & Standing 2011). Unlike other health systems in the region (Leon 2012), when the power was out at the case study facilities, staff reverted to using the paper-based registers and rarely back-entered data into the eHealth system when power returned. As a result, case study facilities' electronic data was incomplete.

Three of the nine health centres (Sinelia, Ponekela and Bisitoni) were not connected to the national electricity grid. As such, solar power was installed at these facilities, and backup batteries were installed at the facilities connected to the national grid. Use of these deep-cycle batteries has been reported elsewhere in Malawi (Douglas et al. 2010). Introduction of continuous electricity at health facilities enables not only use for the eHealth system, but also brings other benefits as an enabler of facility development (Gomez & Pather 2012), with case study facility staff using the solar power to charge their phones and keep vaccines, amongst other uses.

Finally, to conserve electricity, low power-consuming nanotechnology devices were

used at the health facilities. Nanotechnology is a growing subject in international health informatics (Vito et al. 2014), and provides an ideal solution for areas that need low power devices, more so in developing countries. While nano-materials open up the possibility for developing new devices in many industrial and scientific areas, they also offer breakthrough perspectives for the prevention, diagnosis and treatment of diseases (Maojo et al. 2012).

Security and Privacy

Implementation of the eHealth system involved strengthening security of assets at the case study facilities. This involved installing burglar bars in the rooms the computers and servers were placed at the end of each day. Security was one of the risks that health facility staff were worried about, and were happy with the enhanced security measures implemented, which also protected other assets. A positive unintended consequence was improved facility-wide security at the Early Adopter Facilities, while this theme was not mentioned at the Late Majority and Laggard facilities. In another eHealth project in Malawi (Douglas 2009) theft of equipment was a serious threat to its success, especially since computers and solar equipment cost more than Malawi's $750 per capita income. However, they found that workstations locked up in rooms to increase security confounded their real-time use at service delivery. Theft of computers also has privacy and security implications if patient data was being stored on the computer (Shovlin et al. 2013). To eliminate this risk, it was decided that no data would reside on the workstations, but instead use client-server architecture, with all data kept in the server and backed up regularly.

Privacy and security issues are very important in countries that are both developing (Shovlin et al. 2013) and developed (Cripps & Standing 2011). Laws that regulate medical record keeping are in place in most settings, though they vary across countries and are sometimes completely non-existent in other countries. However, eHealth projects that collect medical data should strongly consider legal

representation that ensure that the project complies with written or tacit laws relating to patient data keeping (Shovlin et al. 2013). Although Malawi instituted international standards regarding security of patient data, in practice these are not strictly followed or enforced. At Malawian health facilities, manual patient records are written into the patient-held "health passport" by the clinician or nurse, and the patient's encounter is transferred into the facility-held HMIS register by support staff, usually a guard, cleaner, a statistical clerk if available or other low cadre staff. Apart from perhaps the clinician and nurse, none of the other staff handling patient data are oriented in data protection and privacy regulations. When the eHealth system was installed, each staff member was given a password and rights for only limited modules or functionalities. Only the clinician or nurse had access to the diagnosis and treatment module, while the other staff had access to only patient registration module. When nurses or clinicians started getting overwhelmed with the number of clients and could no longer manage to attend to patients and record their encounter into both the paper health passport and the eHealth system, they gave their passwords to the other staff so they could also have access to the diagnosis and treatment module. It is noteworthy that this was not a diversion from the former practice using the manual system, as these support staff already viewed patient data when entering diagnosis and treatment data from the health passport into the paper register.

Although eHealth holds the promise of increased security if used fluently (Noor et al. 2012; Najaftorkaman & Ghapanchi 2014), health workers generally perceive privacy and security as a barrier to eHealth adoption, while managers and patients often present this factor as both a barrier and a facilitator (McGinn et al. 2011). Protecting the privacy and security of patient data should be a high priority for all countries because of the sensitive nature of medical information (Ko & Osei-Bryson 2004; Police et al. 2011; Black et al. 2011); however, the subject is complex and managing access and confidentiality of patient data can be difficult in practice, even in the face of guidelines from the World Health Organization (World Health Organization 2012). Despite these guidelines, there are limited localized clear security standards which

can be followed by those who are involved in the use of eHealth (Boonstra & Broekhuis 2010). As such, security concerns have been barriers to eHealth adoption (McGinn et al. 2011; Isaac 2015; Mason 2015; Williams & Boren 2008; Steininger et al. 2014; Najaftorkaman & Ghapanchi 2014), particularly for health conditions that are associated with stigma such as HIV (Fraser et al. 2005) and mental health (Yan et al. 2012), which health practitioners fear may lead to legal problems (Boonstra & Broekhuis 2010; Yoon et al. 2012).

It has been argued that adoption of eHealth will only be successful if health care providers and the government can assure privacy and security of electronic patient data, and basic legal requirements, particularly in the field of data protection, is a critical area (Cripps & Standing 2011). Besides its direct effect on adoption of eHealth, privacy concerns have been shown to have a negative effect not only on the intention to use an eHealth system, but also on its perceived usefulness (Steininger et al. 2014). There is critical need to put in place measures aimed at preventing unauthorized access to data or data loss (Shcherbatykh et al. 2008; Shovlin et al. 2013).

At policy level, current developments in the area emphasize security issues mainly related to patients' data protection (Lluch 2011), and the need to establish measures that dispel concerns regarding possible breaches of patient confidentiality, such as the NHS Care Records Guarantee in the UK (Black et al. 2011), the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule in USA (Boonstra & Broekhuis 2010) and those included in Malawi's Ministry of Health HIS strategic plan (Ministry of Health 2013). To decrease privacy concerns, clear privacy laws are required, but also adequate enforcement of these regulations in terms of penalties, and there is also need to raise public awareness to breaches and infringements (Steininger et al. 2014).

At implementation level, one of the first steps in the design of the system should be keeping the database on a secure server (Laing et al. 2014), which was done at the case

study facilities and is backed up regularly. It is therefore essential to have a high level of reliability in eHealth server hardware (Devkota & Devkota 2014). Further, health workers at the case study facilities were provided with different levels of access, although passwords were shared amongst the staff as explained above. A second intervention for data protection at implementation level is conducting routine, random audits of the eHealth system for appropriate use (Haughom et al. 2011). However, with the sharing of passwords among staff at the cases study facilities, it would make it difficult to embark on audit trails of personal logins to identify unauthorized entry (Devkota & Devkota 2014), made even more difficult by the fast-paced environment of health facilities which make it is easy for computers to remain logged on and unauthorized access to occur (Black et al. 2011).

A third implementation-level intervention to promote security of patient data is the development of a confidentiality agreement that informs the potential user of appropriate access and use, and advice of corrective action that can occur in cases of violation of the rules (Haughom et al. 2011). In line with this, the project implementers at the case study sites developed an information governance policy that was to be given to all staff for signing at the issuance of their password.

5.3.2 Socio-Technological Factors

Leadership, User Attitudes and Deployment of System Champions

Healthcare systems have been described as silos of individual interest groups, each with their own agenda, and technology adoption needs to run across these interest groups with their individual agenda, making popular support difficult (Cripps & Standing 2011). There were strong opinions about the ineffective engagement of in-charges at Late Majority and Laggards facilities, with no mention either way by the Early Adopters. It was found during interviews with staff that successful adoption by the facilities at the case study facilities was heavily dependent on the facility in-

charges. Facilities that were ahead of the others in adopting the eHealth system had leaders that displayed much interest in the system, and were responsive to changes that the eHealth system demanded, could articulate the benefits that the system would bring to the facility, and actively engaged with the implementation team. Only three of the ten facilities had leadership with these attributes (Winistoni, Dalitso and Ponekela), two facilities (Filipi and Bisitoni) completely did not have any of the attributes and system adoption failed, and the others had these attributes to various degrees and had various levels of adoption.

Prior research on eHealth had largely focused on technical issues but rarely on leadership issues (Lin et al. 2012). Whether the management level supports the use of eHealth, and believes in the benefits of eHealth, has been found to influence the rate of eHealth adoption by health workers (Boonstra & Broekhuis 2010; Kamadjeu et al. 2005). A health facility's success in implementing and adopting an eHealth system will also largely depend on clinicians' willingness to adopt the new technology (Hochron & Goldberg 2014), relevant in the Malawian context where clinicians are mostly in-charges of facilities. Adoption of eHealth systems have been attributed to support from heads of department (Struik et al. 2014). Forcefully implementing eHealth contributes to failure, while adopting a bottom-up approach fosters enthusiasm, dedication and commitment from individuals, thus contributing to successful implementation and adoption (McGinn et al. 2011). Having centralized leadership has been found to be a predictor of successful eHealth adoption, where practices were more successful if they displayed strong clinical leadership (Ancker et al. 2013; Lin et al. 2012), and where clinical and administrative leaders built eHealth adoption into their strategic plans (Silow-Carroll et al. 2012; Bush et al. 2009).

Studies on health workers tend to consider poor organization management practices as barriers to eHealth implementation and adoption, such as a top-down decision-making process (Crosson et al. 2005; Steininger et al. 2014), poor timing of the implementation (Rahimi et al. 2008) and providing inadequate resources to deal with

the extra workload to support implementation and adoption (Greenhalgh et al. 2008). Systematic, dynamic and reflexive leadership approaches (Greenhalgh et al. 2008; Boulus & Bjorn 2007), prioritisation and 'driving' by the management team (Øvretveit et al. 2007), and voluntariness (the absence of pressure forcing individuals to use an innovation against their will) (Aubert & Hamel 2001) are perceived positively by health workers as facilitators of eHealth adoption.

Staff at all the three facility groups had generally positive outlook for the eHealth system, citing computer knowledge as a transferable skill (all facility groups), and data management and internet access (Laggards). It was also observed that there were differences in the reception of the eHealth system by staff. This was interdependent with aptitude in using the system, but there were also others who took longer time to learn the system but displayed interest to be able to use it. Interest in the system was not dependent on cadre of the staff, age or gender; there were some staff who reportedly lost their password almost every time they were visited, particularly at Bisitoni, indicating non-use of the eHealth system.

User attitude towards the systems is a critical factor for adopting eHealth (Castillo et al. 2010; Police et al. 2011). Dissatisfaction with eHealth among health workers remains a barrier to achieving its potential (Buntin et al. 2011). Health workers who are older and likely have established careers might be more resistant to change in workflow associated with eHealth implementation (Yan et al. 2012; McGinn et al. 2011). Professional norm is a key determinant of behavioural intention to use eHealth in the psychosocial and integrated models; the fact that health workers perceive that using an eHealth is consistent with what they consider an appropriate behaviour for a health worker is likely to increase their acceptance of this technology, thus adoption strategies need to present eHealth as an integral part of facility workflow (Gagnon et al. 2014). In addition, many health workers are reluctant to change, making this one of the key change management barriers to eHealth adoption (Scholl et al. 2011). Lack of change of organizational culture required to accompany a switch from paper to an

eHealth system leads to slow adoption of eHealth (Boonstra & Broekhuis 2010; Police et al. 2011). Reward systems of an organization should aim at focusing and influencing individual behaviour (Lluch 2011). Unless health workers see some personal benefit from using eHealth, they will not be motivated to switch and will instead stick to their traditional working procedures (Boonstra & Broekhuis 2010). Apart from the satisfaction of learning computer skills, financial incentive during training, improved access to electricity, and the potential ease of compiling reports at the case study facilities became some of the incentives for them to continue using the system.

Finally, implementers at the case study facilities focussed training on system champions. Such champions were to know their module in depth and be part of the eHealth leadership group. However, system champions were reported to provide inadequate feedback to their peers and facility In-Charges. Further, at some health facilities, system champions were more senior staff who were busier and more likely to be transferred from the health facilities. Nevertheless, they were also reported to be peer trainers, despite their inadequate knowledge of basic troubleshooting. Implementation of eHealth tends to force health workers to face changes, such as more and new workloads, while health workers' incomes do not reasonably reflect their extra effort, leading them to regard such change as the cause of inequality and react in angry resistance (Lin et al. 2012). This is where implementers need champions the most, to motivate their fellow health workers (Boonstra & Broekhuis 2010). Studies have established expert support from peers as a very important determinant of adopting Health (Castillo et al. 2010).

Despite their professional autonomy, health workers' decisions regarding eHealth acceptance could be strongly influenced by their peers, and role modelling and peer support by champions is likely to increase eHealth system adoption (Gagnon et al. 2014). Implementers repeatedly mention positive attitude among staff toward potential benefits of the eHealth as a predictor of successful adoption, and these

positive attitudes are generally associated with a system champion (Ancker et al. 2013). Facilities with successfully-implemented eHealth systems are more likely to report that a local system champion was available and of major or critical importance (Singh et al. 2012). System champions are most beneficial as leaders of the user interphase design team to make the eHealth system more user-friendly to their peers (Scholl et al. 2011). Implementation and adoption of eHealth systems in rural settings have been successful, despite the challenges encountered, mainly due to the system champions who have a determined approach that aims at developing a workable system (Cripps & Standing 2011).

User Training and Mentoring

Limitations in the number of staff formally trained was perceived to be an inhibitor to system adoption across the case study facilities, as well as limitations in the scope of the training, particularly training in eHealth system maintenance and basic troubleshooting. All facility groups also reported peer training taking place but lack of follow-up formal training to support that peer training. Early Adopters and Late Majority Facilities expressed challenges with off-site training and that staff trained as system champions were senior and thus busier and more mobile, leaving the junior staff, who were not formally trained, to use the system mostly. Although system user champions were provided initial training at all the facilities, Laggard Facilities reported that most staff trained as system champions did not use the eHealth system consistently, while Early Adopter Facilities reported lack of a user manual to support training and mentoring.

Significant user training and mentoring was required to improve confidence, reduce errors and improve data accuracy at the case study facilities. The eHealth system implemented at the case study facilities was not intuitive and therefore required considerable familiarity and support for users to become competent. Training would most effectively be given by clinicians and "system champions" as mentioned above.

Training and competences of healthcare professionals as the end-users operating a specific application, particularly training and IT/eHealth literacy, is a key factor in eHealth adoption (Lluch 2011). Many researchers have concluded that health workers have insufficient technical knowledge and skills to deal with eHealth, and that this results in resistance (Boonstra & Broekhuis 2010). Learning a new system may take time, especially when the system is complex and training inadequate (Boonstra & Broekhuis 2010; Police et al. 2011). Before implementation, health workers need to be aware of the capabilities of the system and the training programme must focus on influencing the attitudes of participants toward the system (Gagnon et al. 2012).

In studies where adequate IT support and training was provided, these factors tend to be perceived as facilitators, while studies which report inadequate or no IT support or training tend to conclude that these factors are barriers to eHealth implementation and adoption (McGinn et al. 2011). Poor training is the most important barrier to eHealth adoption (Yan et al. 2012), while the time taken to learn an eHealth system means that often the benefits of the system are not leveraged (Cripps & Standing 2011). Perceived and actual length of time taken to learn an eHealth system is a barrier to adoption (Paré et al. 2014), as it affects perceived ease of use. Perceived ease of use is amplified by health workers' computer self-efficacy. Health workers who feel capable of using information technologies have little difficulty in using eHealth. Through its indirect effect, IT self-efficacy has a significant overall effect on behavioural intention to use. Concretely, training health workers in the use of computers improves their overall perception that using eHealth is easy (Gagnon et al. 2014).

Training is not only by implementers, but also by colleagues, and particularly system champions. Studies define communication among users as a factor affecting the adoption of eHealth systems (Castillo et al. 2010). Lack of support from colleagues impedes health workers in further adopting the system (Boonstra & Broekhuis 2010). Lack of support from other colleagues to help with effective eHealth system usage is

a significant barrier to eHealth adoption (Paré et al. 2014), while support from management and colleagues in integrating eHealth in healthcare professionals' daily practice, their professional role and service delivery is identified as an enabler of eHealth adoption (Lluch 2011).

System Design and Technical Challenges

Since the initial introduction of the eHealth system at the case study facilities in 2009, the system has been under continuous design and redesign; more requirements are identified as others are being addressed. A key challenge is to design a system that was able to deal with the potentially multiple (at times conflicting) requirements of different stakeholders and within different user groups in an environment that is characterized by complexity and variability (Cresswell et al. 2012; Lau et al. 2013). For instance, as elsewhere the primary domain of improvement is preventive health (Chaudhry et al. 2006), the initial design of the eHealth system at the case study facilities was derived from a public health perspective rather than an electronic health care record for patients. This led to an iterative process of redesigning the eHealth system with input from clinical system champions to make it fit for use in a clinical setting, also to make the system user-friendly.

The complexity and usability problem associated with eHealth results in health workers having to allocate time and effort if they are to master them (Boonstra & Broekhuis 2010). In studies where systems are reported as user-friendly, participants tend to perceive eHealth as easy to use and a valuable tool to facilitate work processes; however, when systems are not adapted to the needs or abilities of the users, studies report participants as perceiving the eHealth system as being difficult to use (McGinn et al. 2011). Although staff at all the facility groups reported input into the eHealth system implementation, their input was limited to location of the equipment at the facility (all groups); security, care for the equipment and electricity situation (Early Adopters); and the needs for staffing (Late Majority facilities) and the eHealth system

at the facility (Laggards).

Implementation at the case study facilities has been fraught with technical problems since its start, and six years after its initial implementation there was still no final version of the software suitable for the health system. This contrasts with a typical eHealth system in the US that takes about 25 weeks to implement (Ancker et al. 2013). This is one of the most important barriers to adoption at the case study facilities. There were 24 problems with the eHealth system identified during the interviews across all the facility groups. Most of the problems were revealed at the Late Majority Facilities, and they had in common with the other facility types problems with use of different windows for registration and diagnosis/treatment entry, prescribing to patients, passwords and the installation of nano-computer units. There were also challenges at the Early Adopter Facilities with the system's database not having all the required drugs and indicators for prescribing and reporting, respectively.

Systemic flaws with the technology itself prevent health workers from realising the full benefits of eHealth. Such hardware and software challenges were also experienced during implementation in rural Australia (Cripps & Standing 2011). Even practices in Europe (de Lusignan et al. 2013) and USA (Yan et al. 2012) face technical problems as one of the key barriers to eHealth adoption, such as users not being able to log in as their ID-card software or certificates had not been up-dated.

A systematic review (McGinn et al. 2011) found that the most frequently mentioned barriers were the technical limitations related to software or hardware, and system problems, with concerns that the system would become obsolete also mentioned. One reason why health workers do not adopt eHealth is that they cannot find a system that meets their special needs or that they can utilize to meet their requirements, such that more effort is required from the vendors of eHealth systems to increase their customizability (Boonstra & Broekhuis 2010). Apart from critical technical interventions, there is also need to implement social interventions to support sceptical

users and those lacking IT skills, sometimes independently from the eHealth system vendor (Scholl et al. 2011).

A socio-technological factor that limited adoption was lack of technical knowledge transfer across the social groups. Proprietors of the software were unwilling to transfer information to the implementing IT team, mainly due to proprietary issues, and the implementing IT team did not transfer troubleshooting and minor technical skills to system champions at the health centres. As the eHealth system being implemented at the case study facilities was proprietary, with efforts to make the system open source not supported by the vendor and its funder, the opportunity to have a larger community of programmers improving the eHealth system was limited. To facilitate the implementation of eHealth systems, adoption of open source, standards-based software platforms are needed to make efficient use of existing resources (World Health Organization 2012; Bagayoko et al. 2010). There are trade-offs between proprietary and open systems. It may be that the problem is easily solved by training local technicians, but the point about having to always check with the parent company in another country is going to remain an issue. Some proprietary systems do allow for a lot of customisation, while others do not allow so as they fear it will compromise the integrity of their product and could create risks.

CHAPTER 6 LIMITATIONS, CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY

Chapter Aims

- Describe lessons learned about the challenges of conducting health informatics research in LMIC settings
- Discuss constraints presented by the methodology used and the availability of data for analysis
- Consider limitations of the findings and their implications for interpretation
- Outline recommendations for future research, implementation and policy

6.1 Limitations

Just as with any other research strategy, the case study method has limitations (Benbasat et al. 1987). First is the danger of bias, as the processes of data collection and analysis in case studies are exposed to the influence of the researcher's characteristics and background, relying to a large extent on their personal interpretation of events, documents and interview material (Darke et al. 1998). However, even in the design and conduct of other types of research, bias is unavoidable (Yin 2014). Secondly, case studies are often accused of lack of rigour, particularly if the case study investigator has been sloppy, allowing oblique evidence or biased views to influence the findings and conclusions (Zaidah & Zainal 2007). During the analytic phases of this study there was continuous triangulation of data,

verifying claims with documentary evidence where possible and accounting for missing evidence, and testing qualitative insights against quantitative methods. Thirdly, since case studies tend to focus on particular situations, projects, programmes or settings, and may involve only a single case, as in the study of Madalo Hospital, they may provide little basis for scientific generalisation. However, case studies aim for theoretical and analytical generalisation, and not statistical generalisation (Yin 2014). Further, the Health Centres case study was longitudinal and used two waves of interviews seventeen months apart to enhance the generalizability of the findings (Venkatesh et al. 2016). In addition, although Madalo Hospital was one 'case', it involved many data subjects. Lastly, as was found during this study, case studies are often seen as being very lengthy and difficult to conduct, producing an enormous amount of documentation (Zaidah & Zainal 2007). However, systematic management, organization and secure back-up of the data produced by this study, combined with the use of framework analysis, enabled this large corpus of study data to be efficiently managed and processed.

The in-depth interviews were retrospective, and thus limited by hindsight, although triangulation with historical financial and documentary data helped to validate the participants' recollections and reflections.

The possible confounding role of macro-contextual influences on financial data also requires further exploration. For example, a government reimbursement scheme for maternal and infant health, introduced shortly before the eHealth was first rolled-out, may have raised baseline patient numbers and Madalo Hospital income, while a government anti-malaria programme, implemented in parallel with the eHealth system, is likely to have lowered patient numbers between 2009 and 2011, coinciding with the dip in revenue. Consumer price inflation in Malawi also fluctuated dramatically during the lifetime of the eHealth implementation project, from a record low of 6.3% in December 2010 to a record high of 37.9% in February 2013 (Trading Economics 2015), creating a challenge for interpretation of the CPI- adjusted revenue

figures. Absence of detailed information on unit prices affecting patient bills and actual eHealth implementation costs (hardware, software, training, maintenance) also calls for caution in interpreting the reported revenue changes, and further illustrates the importance of using mixed methods when seeking to understand financial data in these complex settings (Pitt et al. 2016; Venkatesh et al. 2013).

6.2 Effects of the eHealth System

The effects of eHealth on healthcare processes and outcomes can be complex, and this study revealed a mixture of outcomes arising from this bespoke modular system. A main question guiding this study was: *How do eHealth systems affect quality and use of data for service delivery and financial management?* Although firm conclusions about the impacts of the eHealth system on service delivery and revenue capture at the ten facilities cannot be drawn, the study has offered important insights into the importance of managing change, understanding context, and anticipating challenges for evaluation. It also feeds the growing literature on digital good-governance interventions for lower income country health systems (Holeman et al. 2016) and development of theoretical frameworks for eHealth implementation in low- and middle-income country health systems (Jawhari et al. 2016). This study has shown the quality and use of eHealth data in strengthening health systems' human resources, service delivery and financial management building blocks.

6.2.1 Quality of eHealth Data and Its Use During Service Delivery

Reported service delivery improvements at the health centres included enhanced ability for tracing patients, treatment continuity, identifying the correct patient, ensuring patient confidentiality, keeping health workers alert, following clinical protocols, identifying the need to change prescription for (or refer) a recurrent patient, and reportedly showing the patient that the provider was paying attention. Perceived improvements in patient experience included no redundancy in entering patient

information at subsequent visits, better management of queues, and staff reported that patients felt more understood by the service provider and had more confidence in the services. Perceived negative patient experiences were reported to be due to the staff's slow typing skills and unfamiliarity with the eHealth system, dual entry of patient information into both the electronic and paper systems, extra steps added to the patient flow, and disrupted patient-provider interaction. All facilities were still using paper registers to compile HMIS reports, a few in combination with the eHealth system, because of lack of knowledge of the reporting module, poor design of the system's reports, and disruptions in electricity and network to the server. At Madalo Hospital, the eHealth system was reported to have made retrieval of patients' paper files faster as it changed the hospital's filing system, and retrieval of data for patients with lost paper records, allowed linking of an out-patient to their inpatient record, and provided data to measure quality of care. Customised reports for the hospital were created and used for decisions such as allocation of wards, advocacy and funding applications. There is need for further mixed methods implementation research on strategies to improve data use in service delivery.

eHealth data was of poor quality when entered in the eHealth system by staff involved in direct patient care, but perceived to be of better when entered by clerks. Improving data quality in eHealth systems is an area which urgently requires further research (Callen 2014). There would be value in undertaking follow-up studies in this case, to examine the factors influencing the quality of data available in inpatient wards. Evaluating data quality might involve statistical analysis of data from the eHealth system to measure accuracy, determining whether the unique patient identifiers can be used across locations to improve patient-centred care delivery, comparing the findings with research in other similar hospitals to determine their generalisability, and verifying whether death reports are up-to-date and patients can be followed up to measure currency (Shabestari & Roudsari 2013). Other possible research areas include quantitative data quality evaluations in other outpatient departments in comparable settings. In the inpatient department, it has also been

shown that data quality can depend on the diagnosis (Jordan et al. 2004; Gunningberg et al. 2009; Majeed et al. 2008) and may vary across data elements (Puttkammer et al. 2015), and this needs to be considered when performing data quality assessments. Improving information culture has been shown to improve the quality of data in health information systems (Amoroso et al. 2010; Braa et al. 2012; Mutale et al. 2013).

6.2.2 eHealth and Financial Management

This study draws attention to the capacity of eHealth to ameliorate fraudulent practices by reducing opportunities for billing workarounds, improving the recording of chargeable items and increasing accountability. It also illustrates the need to approach such projects with a clear view of the change management, organizational and sociocultural contexts affecting them. Leaders considering such systems should be aware of the importance of blending technological approaches with workflow redesign to overcome entrenched norms or conflicting roles, which may sometimes involve creating new job categories (Bossen & Foss 2016).

It should also be recognized that not all diversions from correct billing are inherently unethical; for example, overlooking charges for a patient who is in great need but is unable pay for treatment may align with a health worker's moral motive even if not within their remit as an employee. Likewise, the strong influence of social obligations should not be underestimated. In a rural area, it is likely that anyone who has advanced in their education and has a good job is known by many people in the surrounding villages, and is expected to assume the role of a benefactor, placing them under considerable pressure to bend the rules.

Separating the roles of healthcare practitioners and administrators may help to address these challenges. Improving accountability, transparency, monitoring and enforcement has been identified as a "grand challenge" for global health governance (Gostin & Mok 2009) and the potential of eHealth to improve health intelligence and

encourage new norms has been recognized as part of wider strategies that include awareness raising and education (Lewis 2006a; Stansfield 2005). Where these factors are not considered, the introduction of such technologies may merely perpetuate poor governance practices or even increase them (Bowman 2013).

This study's findings also illustrate the importance of continuing to analyse staffing needs in the months after information systems are rolled out rather than, as in the Madalo Hospital case, letting years pass before recognizing that personnel changes may be required to realize their benefits. It also demonstrates the importance of taking contextual influences into account when attempting to explain impacts, and the benefits of evaluating such projects as complex sociotechnical systems. A key finding from the study is that, although the pre- versus post-implementation median revenue difference was statistically significant, eyeballing the data revealed that this was largely explained by the up-swing in revenue in the period immediately following the recruitment of ward clerks. This observation was an incidental finding, and yet it makes a clear point about the need for financial 'good governance' (Holeman et al. 2016). Documentary review further revealed various other changing contextual factors and events that had taken place over the years in which the "IT" project was delivered, which were likely to have had effects on hospital finances well beyond any the eHealth system itself may have had. This illustrates that simple quantitative comparisons can be misleading when evaluating complex eHealth interventions in complex settings. LMIC settings add to this complexity, and using mixed methods is therefore vital for interpretation.

Additional research is required to establish longer-term impacts of eHealth on financial management and governance, taking into account the many costs involved in their set-up, roll-out and on-going sustainability (Lewis et al. 2012). Lack of complete and reliable revenue data, inconsistent pricing and unstable inflationary pressures are likely to complicate such research in low-income settings and call for innovative methodologies (Pitt et al. 2016). Mindful of the complexities underpinning

both financial management and eHealth implementation, further interdisciplinary research is recommended to improve understanding of their mutual influences and outcomes.

6.3 Enablers and Inhibitors of Implementation and Adoption of eHealth Systems

One of the two main questions that guided this study was: How do complex organisational, change management and socio-technological interactions affect eHealth implementation and adoption? This study has highlighted the important enablers and inhibitors of adopting eHealth systems in a low-resource setting. These have included (1) security of physical assets and patient data privacy concerns; (2) efforts to integrate the eHealth system with facility workflow and routines; (3) infrastructural challenges such as power and network to server; (4) leadership engagement, staff attitudes and identification of system champions; (5) user training and IT support; and (6) the design of the eHealth system and technological problems encountered.

An enabler of adoption was enhanced security of facility premises to protect the computer hardware from theft. Solar equipment were the most vulnerable assets due to their high demand on the market, but even these were protected. Security of patient data was a further inhibitor of implementation and adoption of the eHealth in the HIV clinic, where it was withdrawn. Although the system was designed to allow only clinicians access to diagnosis and treatment data, this data became available to all other staff. Although patient data was protected from the public, it was shared amongst the health workers of all cadres, even those who were not directly involved in patient care; since clinicians and nurses could not find enough time to enter patient data they would ask low cadre staff to enter data, and in the case of electronic records passwords were shared for this task. In response to this, access to diagnosis and treatment data was permitted for all staff involved in data entry, similar to the paper-

based system.

There have been changes in practices at the health facilities in response to the introduction of the eHealth system. Requiring health workers to enter data into both the paper record and the electronic record was an inhibitor to adoption. This was overcome by having lower cadre health workers enter data from the patient-held paper record into the electronic system. There have been further changes in the workflow at the facilities.

Facilities with leadership that was supportive of the eHealth project made significant progress in adopting the eHealth system, while facilities with leadership that was either indifferent or opposed to the project made little progress. Levels of adoption were not dependent on age, cadre or gender, but rather on the interest of the staff member. System champions, such as data clerks, have been a very important asset to the design of the eHealth system and its adoption at the facilities. It was clear from the review of data and discussion with staff that there was a very significant need to ensure that data is of good quality. Experienced health workers and IT staff need to coach staff entering data to encourage consistent recording. Continual review of monthly statistics and discussing their meaning among staff is vital to improving the quality of data.

Software for the eHealth system took over six years to develop in an iterative approach, in which the distinctions between analysis, design, implementation and evaluation have blurred. During this time, technical problems emerged as others were resolved, which brought moments of frustration and elation to users and designers. Being proprietary software, it did not have the advantage of a large community of developers to improve the system.

Adoption of eHealth promises a number of substantial benefits, including better care and decreased healthcare costs (Bowman 2013). It is therefore imperative to identify

and leverage enablers of implementation and adoption of eHealth, particularly in developing countries, so that the full benefits of these systems may be realised. To maximize health care quality, developers, implementers and certifiers of eHealth should focus on specific features, rather than simply aiming to deploy an eHealth system regardless of functionality (Poon et al. 2010). Several models have been developed to profile and evaluate successful implementation (Ahmadi et al. 2015) and adoption of IT in healthcare settings (Lau et al. 2013; Idowu et al. 2006; Black et al. 2011; Heeks 2006; Jimoh et al. 2012). Further consideration and use of these models in future planning and research is recommended.

As discussed in this study, challenges to eHealth adoption not only include technical and infrastructure barriers, but also lack of attention paid to social factors, which are important both for shaping the design of new systems but also act as mediators of diffusion as these systems becomes embedded into healthcare practices (Black et al. 2011; Berg 1999). One may have a flawless system, but it is these socio-technical factors that make or break eHealth implementation and adoption in healthcare facilities, embedded in organizational culture, leadership, user attitudes, and methods of training, mentorship and support. Investments in such programmes need to anticipate and plan for both IT and non-IT related factors, recognising the influence of context on the balance between these and the need to tailor resources and adapt timescales accordingly (Ko & Osei-Bryson 2008).

When compared to the Health Centres case study, Madalo Hospital had a more successful adoption due to enhanced commitment by management, presence of a local IT team, and a longer period of implementation. To some extent, this was reflected in the Early Adopter facilities as compared to the other adopter groups. Future implementation projects need to have strong engagement with facility leaders, with system champions and implementers making sure that they regularly report back to the facility in-charges, and the in-charges become one of the super-users or system champions. Further, there is need to have a local IT support mechanism at the

facilities. This can either be at macro level, where the eHealth system proprietor has a country team to support the implementing sites, or at local level, where super-users at the facilities or in the surrounding communities are trained to perform basic troubleshooting and fixes to the hardware and software. Finally, it has been shown from literature and the case study that benefits, particularly financial benefits, are only realised after more than five years of implementation. Most implementation funding is three to five years long, after which the eHealth systems are abandoned, just as they are reaching the peak of their impact. Nevertheless, there are quick wins that can be observed, and can be leveraged to sustain the eHealth system, such as production of HMIS reports and increases in health facility revenue without considering inflation.

Fee-for-service (FFS) facilities are expected to support digital solutions to make their processes more efficient and transparent, hence more likely to be early adopters of eHealth. However, in the present case study, FFS facilities were in both the later adopter and laggard categories. People who can appreciate improvements in efficiency tend to be the staff, and those who can appreciate improved transparency tend to be the managers. Interviews were done with clerical and clinical staff who may have benefitted from poor transparency, and may have not been happy with the eHealth system, as it closed loopholes in money transactions, closing off means of earning extra cash from clients. As such, they capitalised on the reduced efficiency due to staff's slow typing skills and the ensuing patients' complaints that the system slowed down service delivery. There is need for strong leadership aware of these dynamics in FFS facilities to ensure use of the system, similar to Madalo Hospital, in order to not let staff personal concerns determine system adoption.

Implementation of the eHealth system programme lacked a reflexive approach at the outset. Only after it became a crisis did they start to analyse this with the use of technical assistants from the UK. It was mostly at technical level and too late, but they did manage to isolate some of the challenges and make some key recommendations

on how this should be done. As such, having a strong monitoring and evaluation component, if it was done earlier and concurrently as done through this thesis, the outcomes could have been different. It needs more than just IT support, but also someone who steps back and observes it at a distance to help steer the activities. For instance, for a long time the system was used in the same way as paper, which meant that old problems were simply repeated. It was quite late before this was recognised and the ward clerks were brought in to address this. If there had been more insight they would have been recruited earlier. The same is true with the system champions – they ended up being too busy and ended up delegating data entry to lower-level staff such as janitors. If they had set out at the beginning to train and empower these lower-level staff, many of whom turned out to be capable and competent, it would have made a difference. The third thing is something that took time to resolve, and was never really resolved, was to have local IT support for the hardware, as relying on the suppliers or the central IT team to deal with this caused problems. From a software point of view, it would have been better if the suppliers had set up a local office, because sending questions to Tanzania and waiting meant that use of the system was held back, often for quite trivial things.

Finally, one of the key policy recommendations is to have adequately-trained personnel. Ministry of Health should make informatics part of in-service training, having knowledge of informatics and having a large pool of people trained in using computers and information systems. This study has shown the potential of low-skilled staff such as security guards and janitors to learn and use computers competently. In a setting with limited medical personnel such as Malawi, training these lower-cadre staff in computer skills would enable use of the eHealth systems implemented without compromising clinical care. Secondly, for the Ministry, stronger standards for information systems that are coming into the country are recommended, and not just assume that it has been checked by the donor. The damage that such systems – built poorly – could cause, is significant. Government needs a governance mechanism – having stronger oversight on such implementations

would be worthwhile. A lot of work is needed to adapt systems between countries. Even if they are bordering one another, they may be a world apart. Having a simpler version of a project like this is important for all new eHealth projects, so you can evaluate and improve things at an early stage.

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APPENDICES

1. Search Strategies for Four Databases

Database 1: Google Scholar

Search strategy:

"electronic" AND "medical" OR "health record" OR "information system" AND "quality of care" OR "effectiveness of care" OR "efficiency of care" AND "developing country*" OR "low income country*" (3,830)

"electronic" AND "medical" OR "health record" OR "information system" AND "continuity" OR "continuity of care" (212,000)

"electronic" AND "medical" OR "health record" OR "information system" AND "data quality" OR "quality of data" (17,400)

"electronic" AND "medical" OR "health record" OR "information system" AND "data quality" OR "quality of data" OR "decision making" (17,600)

"electronic" AND "medical" OR "health record" OR "information system" AND "data use" OR "use of data" (17,100)

"electronic" AND "medical" OR "health record" OR "information system" AND "decision making" (750,000)

Database 2: Medline

Database: Ovid MEDLINE(R) <1946 to March Week 3 2015>

Search Strategy:

Quality of healthcare

72 exp Information Systems/ or exp Medical Records Systems,

Computerized/ or exp Medical Records/ or electronic medical record*.mp. or exp Ambulatory Care Information Systems/ or exp Electronic Health Records/ (236809)

73 limit 72 to abstracts (172024)

74 exp Africa, Western/ or exp South Africa/ or exp Africa, Eastern/ or Africa.mp. or exp "Africa South of the Sahara"/ or exp Africa, Central/ or Africa/ or exp Africa, Southern/ (186528)

75 exp Primary Health Care/ or exp "Quality of Health Care"/ or quality of care.mp. (5156073)

76 continuity of care.mp. or "Continuity of Patient Care"/ (16977)

77 exp Ambulatory Care Information Systems/ or exp Quality Indicators, Health Care/ or exp Health Care Sector/ or exp Patient-Centered Care/ or exp "Quality of Health Care"/ or exp "Delivery of Health Care"/ or exp Health Care Surveys/ or exp Quality Assurance, Health Care/ or exp Primary Health Care/ or exp "Continuity of Patient Care"/ or exp Peer Review, Health Care/ or exp "Delivery of Health Care, Integrated"/ or exp Ambulatory Care/ or exp Physicians, Primary Care/ or exp Point-of-Care Systems/ or exp Patient Care/ or exp Ambulatory Care Facilities/ (5803901)

78 72 and 74 and 75 and 76 and 77 (10)

Quality of data for decision making

33 exp Electronic Health Records/ or exp Medical Records/ or exp Medical Records Systems, Computerized/ or exp Information Systems/ or electronic medical record*.mp. (236591)

34 exp Financial Management/ or exp Economics, Hospital/ (96330)

35 33 and 34 (6024)

36 Malawi.mp. or exp Malawi/ (4073)

37 limit 36 to abstracts (3294)

38 35 and 37 (1)

39 exp Africa, Central/ or exp "Africa South of the Sahara"/ or Africa/ or exp South Africa/ or exp Africa, Eastern/ or exp Africa, Southern/ (165282)

40 35 and 39 (20)

41 data quality.mp. or exp Research Design/ (346957)

42 33 and 39 and 41 (75)

Finance

1 exp *Practice Management, Medical/ or exp *Information Systems/ or exp *Medical Records Systems, Computerized/ or exp *Medical Records/ or electronic medical record*.mp. or exp *Ambulatory Care Information Systems/ or exp *Electronic Health Records/ (115823)

2 limit 1 to abstracts (68677)

3 exp Africa, Western/ or exp Africa, Central/ or exp "Africa South of the Sahara"/ or exp Africa/ or exp South Africa/ or exp Africa, Eastern/ or exp Africa, Southern/ (188789)

4 finance.mp. or exp Developing Countries/ (66209)

5 revenue.mp. or exp Economics, Hospital/ (24205)

6 exp Economics, Medical/ or exp Economics/ or exp Economics, Hospital/ or economic.mp. (580782)

7 1 and 3 and 4 and 5 and 6 (1)

8 1 and 3 and 4 (89)

9 1 and 3 and 5 (2)

10 1 and 3 and 6 (112)

11 8 or 9 or 10 (187)

18 8 and 9 and 10 (1)

Database 3: Scopus

TITLE-ABS-KEY ("electronic" AND "health record" OR "medical record" OR "patient record" OR "information system" AND "implementation" OR "adoption" AND "systematic review") AND (LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011))

Database 4: Web of Science

TOPIC:(electronic) AND TOPIC: (health record) OR TOPIC: (medical record) OR TOPIC: (patient record) ORTOPIC: (information system) ANDTOPIC: (implementation) OR TOPIC:(adoption) AND TOPIC: (systematic review)
Timespan: 2011-2017. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC.

2. Madalo Hospital In-Depth Interview Reference Table (Labelled 'IDI')

IDI001	BM(MCH)
IDI002	**1. At the outset, what changes did you expect to occur with the implementation of [bespoke eHealth system]?**
IDI003	*a) At the ART clinic, it was difficult to follow up clients using the hard copies.*
IDI004	*It was very difficult to report using the hard copies. We were thinking the computer will be adding up the figures*
IDI005	*b) I expected to learn how to use computers after my studies,*
IDI006	*and to browse for the necessary information about the clients*
IDI007	*c) We were thinking we can trace any patient anywhere, like when I am in the outpatient department I can check which patient is at any other department*
IDI008	*d) I expected that there was a module for communications on the local network through internal emails*
IDI009	*e) We had challenges with collection of fees. It eased the work of the accounts staff. At a click they can check how much consultation has billed and whether they tally with the money collected. Indeed, it's happening. It is restricted to clerks and accounts departments to be able to go into the billing system.*
IDI010	*f) Discharges and admissions. We have seen a significant change. Someone comes with their [bespoke eHealth system] number, the information is there about his treatment and if they have a balance to pay. We couldn't do that before. We had a small till before [bespoke eHealth system] where Mr Kalumo was sitting. It was difficult to count one by one. It's now abolished.*
IDI011	*g) People who couldn't type on computers can type on computers, especially the cadre of patient attendants. They are not professionally trained, but they are able to put data into [bespoke eHealth system]. The training which Chris was conducting helped a lot. They called them end-user trainings. But there is a challenge. We are underutilising their service. [System champion] writes in [bespoke eHealth system] and I admire him for that, but us clinicians only write in health passports, so we are underutilising it. We can't use it offline, then we should access the server through laptops like [system champion] does. You are faster on your own keyboard. People don't use the desktops, they prefer their own laptops. The laptops should connect to the server.*
IDI012	**2. How did you expect those changes to come about?**
IDI013	*a) I didn't expect abrupt changes, it takes time. Now nobody today can collect drugs without registration into [bespoke eHealth system]. This has reduced wastage of drugs. This time, they are asked receipts for registration and drugs. There are several checks because of [bespoke eHealth system]. It is a checking point.*
IDI014	
IDI015	*c) N/A*
IDI016	*d) Internet came and with it came Skype. I remember we can use Skype to communicate to Mr Mzama (The Principal Hospital Administrator)*
IDI017	**3. What changes do you think have happened as a result of [bespoke eHealth system]?**
IDI018	**Probe: How did [bespoke eHealth system] bring about those changes?**

IDI019	**Probe: Why do you think the expected changes did not happen?**
IDI020	**Unintended consequences of EHR**
IDI021	**4. Are there things that you did not plan that happened as a result of [bespoke eHealth system]?**
IDI022	**Probe: Positive? Negative? How did they happen?**
IDI023	*Nothing negative. At first I was saying how accurate would that be. It's difficult to read the things that we write. So that may make it difficult to have good quality data.*
IDI024	**Barriers and facilitators of implementation of EHR**
IDI025	**5. How do you think implementation of [bespoke eHealth system] has gone?**
IDI026	*Very tremendous. Today in the Deputy Medical Director's office, whatever information he wants, he can see. For me, if I want to check information in the medical ward, I check in [bespoke eHealth system]. Just a number gives me the file. They are even using [bespoke eHealth system] now for filing.*
IDI027	**6. What factors have helped with the implementation?**
IDI028	*a) Those people who were coming from Tanzania were sincere with our IT team*
IDI029	*b) We can see that the IT team is committed*
IDI030	*c) Some protocols on how to use the system, restrictions, who or what can do something*
IDI031	*d) The lead person was flexible in allowing some key staff to access particular modules*
IDI032	**7. What things have prevented good implementation of [bespoke eHealth system]?**
IDI033	*a) Not all departments have enough computers*
IDI034	*b) Network problems*
IDI035	*c) ESCOM (national electricity grid) problems which was making or servers to be down*
IDI036	*d) Is the air conditioner okay in the server room?*
IDI037	**8. (For health centres) Are there things about your particular health centre that have made it easier or more difficult for implementation of [bespoke eHealth system]?**
IDI038	**Probe: Human resources? Quality of staff? Attitude of staff? Infrastructure (computers, electricity)? The software? IT support? Support from district office/ diocese?**
IDI039	*a) Some staff, by attitude, they just look at the system and say they can't use it. Many of us are not entering the data. Some have little knowledge of computers.*
IDI040	*Some it's the workload.*
IDI041	*b) Infrastructure. Before there weren't even any desks, but now with the computers there are desks, even though one cubicle has no computer. Even the ultrasound room has no computers. We may have the computers, but we have no space.*
IDI042	*c) The software is very slow.*
IDI043	**9. How have you adapted the project ([bespoke eHealth system] modules, change management, infrastructure) to suit your needs?**

IDI044	*a) A Scottish lady wanted to develop a website using [bespoke eHealth system] data. However, there was no data as the modules were not activated.*
IDI045	*b) VIA data module not activated.*
IDI046	**10. Have you changed the way the facility works to make the project work? How?**
IDI047	*a) Billing system*
IDI048	*b) Discharge style. Nobody can go home without going through [bespoke eHealth system]*
IDI049	*c) Refining of diagnoses*
IDI050	*d) Follow-up in the medical clinic, appointment date. [System champion] can check appointment date for epileptic and diabetic patients*
IDI051	**11. Which components of the project have worked and which have not worked? Why?**
IDI052	*a) We are at a distance as clinicians. If it was to create a database, it has worked. For reporting, extracting and analysing data for decision making at department level, it has not worked. I have never seen [bespoke eHealth system] data analysed in the morning report.*
IDI053	*b) Billing has gone good. Tracking credits from patients can be done better.*
IDI054	*c) They are now able to separate inpatient and outpatient fees, which was not possible with the manual system*
IDI055	**Impact of EHR on quality of data for decision making (For ward and facility in-charges)**
IDI056	**12. What data was available to your ward/ facility before [bespoke eHealth system]?**
IDI057	*a) Inpatient registers for admissions and discharges, death and live discharges*
IDI058	*b) Also had two HMIS desk with two officers in OPD entering data into the HMIS register. I don't know how they were marrying with inpatient registers.*
IDI059	**13. How reliable was that data?**
IDI060	*Reliability depends on the people filling the data in. Were all indicators filled? That is happening even today.*
IDI061	**14. How have things changed in terms of data quality with the introduction of [bespoke eHealth system]?**
IDI062	*Very difficult. I hear much from David. For finance it's okay. But for diagnosis and drugs, it's not okay. Clinicians see 80% of the patients, more than the specialists. Data quality is not up-to-date, maybe the past five months where the antenatal module was used. Outreach clinics are offline. There are six places. That's why the HMIS register has 50% more clients.*
IDI063	**Conclusion**
IDI064	**15. Present draft logic model and ask for feedback**
IDI065	*Heather Cubie asked lab to fill in all HPV results into [bespoke eHealth system]. There was an incident where a clinician was on Facebook while a child was dying in her mother's arms. Since then, there is no internet in the paediatric ward.*
IDI066	**16. Do you have any other comment regarding the project?**
IDI067	*If people are serious, this is a good system. If I had my own clinic, I would adopt [bespoke eHealth system].*

IDI068	**CM(Medical)**
IDI069	**Understanding the intervention theory**
IDI070	**1. At the outset, what changes did you expect to occur with the implementation of [bespoke eHealth system]?**
IDI071	*a) They told us it would help with diagnosis and billing. We thought the work for compiling bills will be simplified*
IDI072	*b) Patients were just given a receipt without details of the service being charged for.*
IDI073	**2. How did you expect those changes to come about?**
IDI074	*a) For diagnosis, we see many patients with diagnoses. We could group the most common in the system, so the clerks would not find it difficult enter into the bill and registers. We also thought billing would be simpler.*
IDI075	*b) With computers, there would be a breakdown of the services being charged.*
IDI076	*c) With [bespoke eHealth system], they wouldn't miss anything. For drugs there are generic names and trade names so it was difficult for the clerks. All drugs now use generic names*
IDI077	**3. What changes do you think have happened as a result of [bespoke eHealth system]?**
IDI078	**Probe: How did [bespoke eHealth system] bring about those changes?**
IDI079	**Probe: Why do you think the expected changes did not happen?**
IDI080	*a) All drugs now use generic names*
IDI081	*b) Billing is quicker if it's working well*
IDI082	*c) Guardians are also able to understand how the bill is derived at, since it has all the details broken down.*
IDI083	**Unintended consequences of EHR**
IDI084	**4. Are there things that you did not plan that happened as a result of [bespoke eHealth system]?**
IDI085	**Probe: Positive? Negative? How did they happen?**
IDI086	*· Positive: When we are stranded with a rare condition, we can Google it and read up on it, which is very useful*
IDI087	*· Diagnosis: Some of the diagnoses in the system are not common in Malawi, while others that we see here are not in the system. This makes it difficult for the clerks to enter.*
IDI088	*· Some drugs are also not available in the system. Some have been added, but there are still some drugs that are prescribed but cannot be charged in the system.*
IDI089	*· Earlier in the implementation, staff were using the computers for Facebook and games instead of attending to patients. We had to discuss this and told them to be responsible and only allowed Facebook and games at night to stay awake. Now they are banned during the day. Also watching movies. Now it is okay.*
IDI090	**w**
IDI091	**5. How do you think implementation of [bespoke eHealth system] has gone?**
IDI092	*It has started well. It's the first time, so there were challenges, but generally it has started well.*
IDI093	**6. What factors have helped with the implementation?**

IDI094	· *Orientation of staff before implementation. There were several meetings. It was also practical for those who would be using it directly, like the clerks.*
IDI095	· *Reporting of issues and there was good technical support*
IDI096	**7. What things have prevented good implementation of [bespoke eHealth system]?**
IDI097	· *Loss of internet or network*
IDI098	· *The IT team stays in town and it is difficult to get support off working hours*
IDI099	· *There was no refresher training for new staff and old staff*
IDI100	**8. (For health centres) Are there things about your particular health centre that have made it easier or more difficult for implementation of [bespoke eHealth system]?**
IDI101	**Probe: Human resources? Quality of staff? Attitude of staff? Infrastructure (computers, electricity)? The software? IT support? Support from district office/ diocese?**
IDI102	· *Good communication when we had problems for IT support. For example, billing had some drugs missing. Missing diagnoses has not been resolved yet.*
IDI103	· *Departmental meetings to remind each other about the proper use of the computers.*
IDI104	**9. How have you adapted the project ([bespoke eHealth system] modules, change management, infrastructure) to suit your needs?**
IDI105	· *Drugs list has included more drugs.*
IDI106	· *They changed the charges for OPD minor theatre to be different from the main theatre.*
IDI107	**10. Have you changed the way the facility works to make the project work? How?**
IDI108	· *The coming in of ward clerks.*
IDI109	· *It is helping to trace patients who are being readmitted who came maybe last year. It's easy to trace their files, especially those who have lost their health passports.*
IDI110	**11. Which components of the project have worked and which have not worked? Why?**
IDI111	· *Good: Usage has gone well by the clerks*
IDI112	· *Bad: Diagnosis not complete*
IDI113	**Impact of EHR on quality of data for decision making (For ward and facility in-charges)**
IDI114	**12. What data was available to your ward/ facility before [bespoke eHealth system]?**
IDI115	*Number of admissions per month, diagnoses, somehow treatment*
IDI116	**13. How reliable was that data?**
IDI117	*Not reliable. If someone is missed, then they can't be traced*
IDI118	**14. How have things changed in terms of data quality with the introduction of [bespoke eHealth system]?**
IDI119	*We are able to register many patients and grouping the most common conditions such as malaria, pneumonia, TB, hypertension, diabetes*
IDI120	**Conclusion**

IDI121	**15. Present draft logic model and ask for feedback**
IDI122	· *IT knowledge not yet there*
IDI123	· *Continuity of care: We can trace patient files. That used to take us a long time*
IDI124	· *Patient referral: To other hospitals, such as Kamuzu Central Hospital, the system indicates reason for the referral and gives us that data*
IDI125	· *Patient referral: From other departments or sending to other departments can be done in [bespoke eHealth system] by transferring file*
IDI126	· *No patient follow-up. Follow-up in medical clinic patients who was in ward*
IDI127	· *Change in quality of care: When using the paper registers, when they are missed they are lost. Now every patient is entered in the system*
IDI128	**16. Do you have any other comment regarding the project?**
IDI129	*There should be a refresher training every six months or a year to cater for new staff.*
IDI130	DM(Medical)
IDI131	**Understanding the intervention theory**
IDI132	**1. At the outset, what changes did you expect to occur with the implementation of [bespoke eHealth system]?**
IDI133	*a) Getting statistics*
IDI134	*b) Getting patient records*
IDI135	**2. How did you expect those changes to come about?**
IDI136	*With manual records you have to count patient by patient. It was bad for meningitis and much worse for malaria. Reports I wanted to do were discharge, detailed and summary, including deaths and absconders, by sex, and also calculate bed occupancy rates.*
IDI137	**3. What changes do you think have happened as a result of [bespoke eHealth system]?**
IDI138	**Probe: How did [bespoke eHealth system] bring about those changes?**
IDI139	**Probe: Why do you think the expected changes did not happen?**
IDI140	*a) The system provides bed occupancy rates. This helps me to know which wards are busy which part of the year. Bed occupancy rate for maternity ward is 150 to 160 percent, and for children's ward it's 40 percent. As such, management may change the lower paediatric ward to maternity ward after observing another malaria season.*
IDI141	*b) Mortality rate from the system shows quality of care, for example it is not supposed to go beyond 5% for maternity*
IDI142	*c) Discharge diagnosis report shows which are the top 5 diseases for planning for medical supplies*
IDI143	**Unintended consequences of EHR**
IDI144	**4. Are there things that you did not plan that happened as a result of [bespoke eHealth system]?**
IDI145	**Probe: Positive? Negative? How did they happen?**
IDI146	*a) Many sleepless nights! I didn't know it would be so difficult to get the system regularly functioning. Issues include staffing, power, planning for example servicing plans*

IDI147	*b) I thought we could do billing straight from [bespoke eHealth system] for insurances and service level agreements. Outpatient billing is not registering them. System is designed for cash patients only.*
IDI148	*c) It's too slow*
IDI149	*d) Vertical programme reports for inpatients available since July 2010*
IDI150	**Barriers and facilitators of implementation of HER**
IDI151	**5. How do you think implementation of [bespoke eHealth system] has gone?**
IDI152	*It's taken way too long*
IDI153	**6. What factors have helped with the implementation?**
IDI154	*Staff who are interested in computers*
IDI155	**7. What things have prevented good implementation of [bespoke eHealth system]?**
IDI156	*IT team problems*
IDI157	**8. (For health centres) Are there things about your particular health centre that have made it easier or more difficult for implementation of [bespoke eHealth system]?**
IDI158	**Probe: Human resources? Quality of staff? Attitude of staff? Infrastructure (computers, electricity)? The software? IT support? Support from district office/ diocese?**
IDI159	*a) Location of the hospital, unstable electrical power, equipment damaged due to high temperatures*
IDI160	*b) Staff not used to handling sensitive equipment*
IDI161	*c) Staff interest in computers*
IDI162	*d) No in-country support for [bespoke eHealth system] was a big problems*
IDI163	**9. How have you adapted the project ([bespoke eHealth system] modules, change management, infrastructure) to suit your needs?**
IDI164	*We designed our own reporting*
IDI165	**10. Have you changed the way the facility works to make the project work? How?**
IDI166	*a) We hired ward clerks*
IDI167	*b) There is better collection of revenue*
IDI168	*c) Inpatient records are much better*
IDI169	*d) We redesigned patient charts*
IDI170	*e) We changed the way we store patient files*
IDI171	**11. Which components of the project have worked and which have not worked? Why?**
IDI172	*a) Registration and billing worked well, with the exception of service level agreement billing report*
IDI173	*b) Diagnosis and treatment for inpatients worked well*
IDI174	*c) Not working well are OPD diagnosis and treatment, ART, RCH and laboratory, so there is no linkage across the system*
IDI175	**Impact of EHR on quality of data for decision making (For ward and facility in-charges)**
IDI176	**12. What data was available to your ward/ facility before [bespoke eHealth**

	system]?
IDI177	**13. How reliable was that data?**
IDI178	*Unreliable*
IDI179	**14. How have things changed in terms of data quality with the introduction of [bespoke eHealth system]?**
IDI180	**Conclusion**
IDI181	**15. Present draft logic model and ask for feedback**
IDI182	*a) It has not reduced duplication*
IDI183	*b) Reporting and revenue have improved*
IDI184	*c) Quality of care is not dramatic. It has changed my practice when a patient has lost their health passport, critical for diabetics, epileptic and hypertensive patients*
IDI185	*d) It's easier to retrieve patient charts from long ago beyond the patient's health passport record from previous inpatient visits as they are stored using their [bespoke eHealth system] registration numbers*
IDI186	*e) Too few staff using the system to measure staff satisfaction*
IDI187	*f) Patient satisfaction if for getting a bill and receipts for every transaction*
IDI188	*g) Definite increase in efficiency in inpatient records and billing*
IDI189	*h) It provides a strong argument for the indoor residual spraying for malaria*
IDI190	**16. Do you have any other comment regarding the project?**
IDI191	*a) It is not possible to have electronic medical record capability because of the patient load*
IDI192	*b) It can keep prescription data and billing that we are not using yet*
IDI193	**24-Nov-14**
IDI194	**Which reports are produced by [bespoke eHealth system] that you use?**
IDI195	*a) Discharge diagnosis summary report, used to detect primary diagnoses*
IDI196	*b) Inpatient department census, available 1st July 2010, but prone to human error, where males are found in the maternity records while they are actually male babies in the Kangaroo Mother Care, which are supposed to go under paediatric records. When we were presented with a shield prize for infection prevention, we used diagnosis data from each ward from [bespoke eHealth system]*
IDI197	*c) Diagnosis listing summary report, available since May 2014, tells major diagnoses for each ward to help buying medications and train staff in the relevant skills. It was not accurate, but was almost accurate since April/May 2014*
IDI198	*d) HMIS 15 is not capturing diagnosis in the outpatient department, not registering service level agreement patients, antenatal module is not linked, the reports are not equal to records at the maternity ward paper reports, there are diagnoses in the HMIS15 report that are not captured by [bespoke eHealth system], and the HMIS15 reports from [bespoke eHealth system] is unusable*
IDI199	*EM(IT)*
IDI200	**Understanding the intervention theory**
IDI201	**1. At the outset, what changes did you expect to occur with the implementation of [bespoke eHealth system]?**
IDI202	*a. Change the financial status of the hospital in terms of revenue. I wrote a paper at school covering changing Madalo Hospital to electronic in terms of finances*

IDI203	*b. I expected accurate data*
IDI204	**2. How did you expect those changes to come about?**
IDI205	**3. What changes do you think have happened as a result of [bespoke eHealth system]?**
IDI206	***Probe*: How did [bespoke eHealth system] bring about those changes?**
IDI207	***Probe*: Why do you think the expected changes did not happen?**
IDI208	*a. It has partly covered, but there is still a lot to be done. For registration, it has covered. Billing on the OPD side has been covered. But there are some problems in inpatient billing, where the system does track very well the patients who have outstanding bills. Someone has to vigilantly chase that, like how Rebecca does. A patient is not captured in OPD that the patient has an outstanding bill. You can add the outstanding bill to the new bill.*
IDI209	*b. We expected nurses to use the computers. But it turned out to be a problem for the nurses to work on the computer and deal with patients. That's where ward clerks came in. now it is getting data from the folder into the computer, with a high possibility of making mistakes.*
IDI210	**Unintended consequences of EHR**
IDI211	**4. Are there things that you did not plan that happened as a result of [bespoke eHealth system]?**
IDI212	***Probe*: Positive? Negative? How did they happen?**
IDI213	*a. We did not plan how we would deal with the attitude of people in the hospital. Some make excuses to not want to use the system because they have benefits from the manual system*
IDI214	*b. At first it was Leo, Chris and I, then Leo moved out, remaining with the two of us. It has been a problem getting the new staff used to the system. Staff turnover is something we did not plan. It was difficult to come up with an efficient IT team*
IDI215	**Barriers and facilitators of implementation of EHR**
IDI216	**5. How do you think implementation of [bespoke eHealth system] has gone?**
IDI217	*It went well in the first stages. There are issues coming up because the system hasn't been tested yet, but the first modules are working well, but the new ones are having problems*
IDI218	**6. What factors have helped with the implementation?**
IDI219	*a) In the first stages there was cooperation with management such that we were provided with everything that we needed*
IDI220	*b) Collaboration with the Tanzanian guys. They would give us hints on how [bespoke eHealth system] works so we can help users very well. That helped our work with the users.*
IDI221	**7. What things have prevented good implementation of [bespoke eHealth system]?**
IDI222	*a) The software is complex. It's big! What we are using here is minimal. For us to change the system, we need someone to work on the programme. That took long as we outsourced those services. Though the coming in of Bernard sort of solved some of the problems, it wasn't to our expectations, as he has to oblige to the requests of his employers and it took time to solve the problems. We need to train someone local to fix errors. When correcting errors, other errors are simultaneously created*

IDI223	*b) We first started the system with normal servers which are not adequate for the growing hospital. This will improve the speed of the system. We have limited servers … we don't have servers, we have desktops.*
IDI224	**8. (For health centres) Are there things about your particular health centre that have made it easier or more difficult for implementation of [bespoke eHealth system]?**
IDI225	***Probe*: Human resources? Quality of staff? Attitude of staff? Infrastructure (computers, electricity)? The software? IT support? Support from district office/ diocese?**
IDI226	*The users. We expected the clinicians and nurses to use the system. Though we made efforts to train them, there is resistance to use it. We don't have a policy as Madalo Hospital that forces the employees to use the system.*
IDI227	**9. How have you adapted the project ([bespoke eHealth system] modules, change management, infrastructure) to suit your needs?**
IDI228	*Reporting part has changed to suit hospital and Ministry of Health requirements.*
IDI229	**10. Have you changed the way the facility works to make the project work? How?**
IDI230	*The mind-set at the hospital has changed to accommodate [bespoke eHealth system] after visits from the Scottish teams at management level, but not at user level. We have an example of someone who would unplug the computer so that the accounts could authorise use of manual receipts because he benefitted from the manual system. This was at the cashiers' office.*
IDI231	**11. Which components of the project have worked and which have not worked? Why?**
IDI232	**Impact of EHR on quality of data for decision making (For ward and facility in-charges)**
IDI233	*a) Registration, cashier, inpatient billing have worked well, though with some minor problems*
IDI234	*b) It has not worked well in RCH module, which is still being incorporated*
IDI235	*c) ART module was working but they are not using it anymore. I haven't followed up.*
IDI236	**12. What data was available to your ward/ facility before [bespoke eHealth system]?**
IDI237	*Now number of patients registered at OPD, diagnosis and treatment*
IDI238	**13. How reliable was that data?**
IDI239	*Now 90% reliable*
IDI240	**14. How have things changed in terms of data quality with the introduction of [bespoke eHealth system]?**
IDI241	**Conclusion**
IDI242	**15. *Present draft logic model and ask for feedback***
IDI243	**16. Do you have any other comment regarding the project?**
IDI244	*We need full support of the administration side to the IT department. We shall depend much on management.*
IDI245	**JC(IT)**
IDI246	**Understanding the intervention theory**

IDI247	**1. At the outset, what changes did you expect to occur with the implementation of [bespoke eHealth system]?**
IDI248	*a) Things will be faster. Clients will move faster. All information such as village will already be in the system*
IDI249	*b) Data retrieval will be easier than going through the registers*
IDI250	*c) Reduce loss of revenue at registration for consultation, as it would track every patient at every stage*
IDI251	*d) Improved storage of data. Now you don't need as much space as for paper records*
IDI252	**2. How did you expect those changes to come about?**
IDI253	**3. What changes do you think have happened as a result of [bespoke eHealth system]?**
IDI254	**Probe: How did [bespoke eHealth system] bring about those changes?**
IDI255	**Probe: Why do you think the expected changes did not happen?**
IDI256	*a) When it started it was very fast. There was only OPD registration, inpatient department, and diagnosis and treatment. Things were very fast then. We even had better computers. The queues were not as long as they are now.*
IDI257	*b) Data retrieval is possible. But there is a difference now with the slow system. One can retrieve patient data. The system crashed in 2012 soon after Ellard came and we lost all the data. Seventy-five percent of the data has now been recovered. The computers are small. There is a problem of viruses.*
IDI258	*c) I can assure you that it's working, as long as we have power. Nobody can bypass the system.*
IDI259	*d) Storage is good. We have a good big offline backup, one terabyte, 500Gb for online system and 1Tb backup server external hard drive.*
IDI260	**Unintended consequences of EHR**
IDI261	**4. Are there things that you did not plan that happened as a result of [bespoke eHealth system]?**
IDI262	**Probe: Positive? Negative? How did they happen?**
IDI263	*a) I saw how fast the system was and it brought joy to my heart. When it became slow it was distressing. We formatted the domain controller to make it faster. The policy to not keep personal files on the server helped, but now it is not being followed, with one person using up to 15Gb. This brings threats of viruses as the computers synchronise with the server.*
IDI264	*b) Data retrieval is possible for some modules, especially the last ones. There is, however, duplication of data when someone loses their health passport, the same patient having multiple health records.*
IDI265	*c) ART requirements have been changing frequently.*
IDI266	*d) Structures of reports have changed frequently.*
IDI267	**Barriers and facilitators of implementation of EHR**
IDI268	**5. How do you think implementation of [bespoke eHealth system] has gone?**
IDI269	*First years it was excellent and fulfilling. At the later years we've had problems as it is not doing what it is supposed to do, especially the reporting module. For RCH module we are stuck.*
IDI270	**6. What factors have helped with the implementation?**

IDI271	*a) Human resource. Negative attitudes of employee trainees, who find computers as a waste of time. But when Ellard used a different approach, they were convinced.*
IDI272	*b) There are other employees who are very dedicated to using the system, for example in the inpatient department. They are very responsive and communicative, giving feedback. The administrative department has been supportive. There are now over 80 terminals. There is need to provide funding for hanging and upgrading the hardware.*
IDI273	**7. What things have prevented good implementation of [bespoke eHealth system]?**
IDI274	*Not having a stable programmer based at Madalo. This delays identification and fixing of problems.*
IDI275	**8. (For health centres) Are there things about your particular health centre that have made it easier or more difficult for implementation of [bespoke eHealth system]?**
IDI276	**Probe: Human resources? Quality of staff? Attitude of staff? Infrastructure (computers, electricity)? The software? IT support? Support from district office/ diocese?**
IDI277	*a) What has made it easier is are the core people who have pushed the system to work.*
IDI278	*b) Resources, especially terminals are available. When we want to network to a new office, we have all the resources that we need.*
IDI279	*c) What has made it easier is [System champion], who is very interested in [bespoke eHealth system] and follows up issues even when he is not the one using it. He is very helpful in notifying us of problems quickly.*
IDI280	*d) What had it more difficult is new staff, change of staff from an active [clinician 1] to the lazy [clinician 2]. Rotation of staff across the wards has had a negative effect.*
IDI281	**9. How have you adapted the project ([bespoke eHealth system] modules, change management, infrastructure) to suit your needs?**
IDI282	*a) After registration, directing the patient to a specific health worker after booking (registration)*
IDI283	*b) ART continuously changing*
IDI284	*c) Case follow-up*
IDI285	**10. Have you changed the way the facility works to make the project work? How?**
IDI286	*Nothing*
IDI287	**11. Which components of the project have worked and which have not worked? Why?**
IDI288	*a) Not worked: reports, RCH and ART*
IDI289	*b) Worked: SLA reports*
IDI290	**Impact of EHR on quality of data for decision making (For ward and facility in-charges)**
IDI291	**12. What data was available to your ward/ facility before [bespoke eHealth system]?**
IDI292	**13. How reliable was that data?**
IDI293	**14. How have things changed in terms of data quality with the introduction of**

	[bespoke eHealth system]?
IDI294	**Conclusion**
IDI295	**15. Present draft logic model and ask for feedback**
IDI296	*a) Reduced duplication: New [bespoke eHealth system] number for those who have lost their health passport, improving quality of data*
IDI297	*b) Reduced duplication: There are already values in the drop-down menu*
IDI298	*c) Quality of data: This is low as data in the system is different from HMIS data*
IDI299	**16. Do you have any other comment regarding the project?**
IDI300	*Madalo IT staff needs to be trained in system modification without getting the source code. Also, the health centre took our attention away from the hospital.*
IDI301	*RM(Paeds)*
IDI302	**Understanding the intervention theory**
IDI303	**1. At the outset, what changes did you expect to occur with the implementation of [bespoke eHealth system]?**
IDI304	*a) It will be easier to access the information*
IDI305	
IDI306	**2. How did you expect those changes to come about?**
IDI307	*a) I could just look it up in the reports. When I want to know when a child was discharges I can …*
IDI308	**3. What changes do you think have happened as a result of [bespoke eHealth system]?**
IDI309	**Probe: How did [bespoke eHealth system] bring about those changes?**
IDI310	**Probe: Why do you think the expected changes did not happen?**
IDI311	*Able to find a patient in inpatient report that shows admissions, discharges and deaths*
IDI312	**Unintended consequences of EHR**
IDI313	**4. Are there things that you did not plan that happened as a result of [bespoke eHealth system]?**
IDI314	**Probe: Positive? Negative? How did they happen?**
IDI315	*a) I didn't know I would be able to check all invoices, cash payments because it is important to be able to correct mistakes in that area*
IDI316	*b) I struggled a lot with the data for registration. There was no way to edit the date so it messed up the statistics. Now it's fixed but we still don't have the edit screen for discharge data. That was my biggest frustration. I could correct the bill, the invoices, but the whole thing about the discharge date.*
IDI317	**Barriers and facilitators of implementation of EHR**
IDI318	**5. How do you think implementation of [bespoke eHealth system] has gone?**
IDI319	*It's been difficult. There is a lot of challenges in finding the right diagnosis. The documents you are supposed to write on the folder the discharge diagnosis, which is what we record. Most times it's obvious, but sometimes there is a diagnosis that's not in the codes we have. It is not really accurate as we take the diagnosis that closely fits what the doctors have written.*
IDI320	**6. What factors have helped with the implementation?**
IDI321	*I don't know.*

IDI322	**7. What things have prevented good implementation of [bespoke eHealth system]?**
IDI323	*a) Hardware problems.*
IDI324	*b) Sometimes the slowness of the computer is frustrating*
IDI325	**8. (For health centres) Are there things about your particular health centre that have made it easier or more difficult for implementation of [bespoke eHealth system]?**
IDI326	**Probe: Human resources? Quality of staff? Attitude of staff? Infrastructure (computers, electricity)? The software? IT support? Support from district office/ diocese?**
IDI327	*a) Health workers discharging the patients before they have been admitted into the computer, especially during weekends*
IDI328	*b) The organisation of the patient flow*
IDI329	*c) Files are held by the patients and may not be found for some days*
IDI330	**9. How have you adapted the project ([bespoke eHealth system] modules, change management, infrastructure) to suit your needs?**
IDI331	*a) Report didn't have the discharge date and Ellard fixed it*
IDI332	*b) We added to the patient details screen to include gender*
IDI333	*c) Added GVH, villages, etc*
IDI334	**10. Have you changed the way the facility works to make the project work? How?**
IDI335	*We had to get computers*
IDI336	**11. Which components of the project have worked and which have not worked? Why?**
IDI337	*Not worked: Internet doesn't work. The computer wasn't working for a long time.*
IDI338	*Worked: Able to make bills and sent people down to ….*
IDI339	*Worked: Without [bespoke eHealth system] people would abscond easier.*
IDI340	*Worked: If they haven't paid you can see the fee in the system to follow up*
IDI341	**Impact of EHR on quality of data for decision making (For ward and facility in-charges)**
IDI342	**12. What data was available to your ward/ facility before [bespoke eHealth system]?**
IDI343	*Just the books. A lot of people used to ask for statistics and we would count the register and we had no reports on the various diagnoses and statistics*
IDI344	**13. How reliable was that data?**
IDI345	*Only as good as the people who write them. We didn't write the diagnosis. It used to take two people, one with the admissions book and one with the discharge books. They were not filling out the books completely, with no information on where they were coming from.*
IDI346	**14. How have things changed in terms of data quality with the introduction of [bespoke eHealth system]?**
IDI347	*One hundred percent better, because we didn't know where the people were coming from and what conditions they had. We would guess malaria by looking at quinine.*

IDI348	**Conclusion**
IDI349	**15. Present draft logic model and ask for feedback**
IDI350	*Improved data quality*
IDI351	**16. Do you have any other comment regarding the project?**
IDI352	*No.*
IDI353	*SK(MCH)*
IDI354	**Understanding the intervention theory**
IDI355	1. At the outset, what changes did you expect to occur with the implementation of [bespoke eHealth system]?
IDI356	*a) Get a precise drop-down menu of the diagnoses to be specific*
IDI357	*b) Will solve my burden, that when I enter the data once, the computer will analyse at the end of the month*
IDI358	*c) Replace the health passport, saving money for patients while providing information for the provider*
IDI359	*d) Assist to follow protocols*
IDI360	2. How did you expect those changes to come about?
IDI361	*a) Nothing*
IDI362	*b) Report module is available*
IDI363	*c) It has not replaced the health passport yet*
IDI364	*d) Nothing*
IDI365	3. What changes do you think have happened as a result of [bespoke eHealth system]?
IDI366	*Probe*: How did [bespoke eHealth system] bring about those changes?
IDI367	*Probe*: Why do you think the expected changes did not happen?
IDI368	*a) There is a drop-down menu for diagnoses, for all VIA diagnoses*
IDI369	*b) There is no report module working, still counting paper registers*
IDI370	*c) It does not allow me to save if critical areas are not entered, so it makes me follow protocols*
IDI371	*d) [bespoke eHealth system] failing to link all information together. Only accounts and pharmacy linking well, but the other modules are not linked*
IDI372	**Unintended consequences of EHR**
IDI373	**4. Are there things that you did not plan that happened as a result of [bespoke eHealth system]?**
IDI374	**Probe: Positive? Negative? How did they happen?**
IDI375	*a) I didn't expect it would consume so much of my time! But it is not the system, it is our orientation to the computers.*
IDI376	*b) I expected all the clinics to use [bespoke eHealth system], but it's only [System champion], registration, pharmacy and accounts who use [bespoke eHealth system], but most nurses and clinicians do not want to use it. When you are bringing new things, for other people you have to negotiate for others you have to dictate. The clerks are surprisingly using [bespoke eHealth system] more than the nurses and clinicians. There is need for a focus group discussion to find out why they are not using it. Why don't I use it? Too many clients to be entered into two registers and the excel sheet. It used to delay my work until we got a clerk. We get up to 15 clients a day and it takes two minutes to enter into computer. I am not forced to enter into [bespoke eHealth system],*

	and there is no report as an incentive. There is no incentive. Reports are a good incentive and we must make it a must to enter into [bespoke eHealth system].
IDI377	**8. (For health centres) Are there things about your particular health centre that have made it easier or more difficult for implementation of [bespoke eHealth system]?**
IDI378	**Probe: Human resources? Quality of staff? Attitude of staff? Infrastructure (computers, electricity)? The software? IT support? Support from district office/ diocese?**
IDI379	*a) Provision of space*
IDI380	*b) Attitude towards computerised system*
IDI381	*c) Software and hardware problems*
IDI382	*d) Support from IT only for [system champion] because of his influence.*
IDI383	**9. How have you adapted the project ([bespoke eHealth system] modules, change management, infrastructure) to suit your needs?**
IDI384	*I worked with Bernard but he went away so we did not finalise the work. We made changes to the reporting form but we did not finish.*
IDI385	**10. Have you changed the way the facility works to make the project work? How?**
IDI386	*No.*
IDI387	**11. Which components of the project have worked and which have not worked? Why?**
IDI388	*a) Training did not work. You train people but you don't put in measures to make sure they use it. There was lack of hands-on practical work. The confidence to use the system after the training is not there. There is need to follow up and address the issues. Train 2 or 3 people and make sure they are confidently using the system the train the next 2 or 3.*
IDI389	*b) Mr Gomani should either enter data from [bespoke eHealth system] into HMIS register, or from HMIS register into [bespoke eHealth system].*
IDI390	*c) Use the same system as SLA slips to force clinicians and nurses to use [bespoke eHealth system].*
IDI391	Impact of EHR on quality of data for decision making **(For ward and facility in-charges)**
IDI392	12. What data was available to your ward/ facility before [bespoke eHealth system]?
IDI393	*Ministry of Health registers*
IDI394	13. How reliable was that data?
IDI395	*Not reliable. They always go out of stock, such that we have to improvise our own ways to capture data*
IDI396	14. How have things changed in terms of data quality with the introduction of [bespoke eHealth system]?
IDI397	*Better quality as there are validation checks in the system and it does not allow to proceed if you have not met them, leading to improved data completeness*
IDI398	Conclusion
IDI399	**15. *Present draft logic model and ask for feedback***
IDI400	*a. It does not improve continuity of care. How will [bespoke eHealth system] show that a patient is coming for a revisit? We wanted*

	the system to generate an automatic list of patients' review dates. The system does not tell you which patients you are supposed to see on that day.
IDI401	*b. For patient referrals, I want the modules to talk to each other*
IDI402	*c. For diagnosis and treatment, that is in order as we are putting in more diagnoses using ICD10. It is able to give you a specific diagnosis and guide you in treatment.*
IDI403	16. Do you have any other comment regarding the project?
IDI404	*a. Make sure that the hospital makes it a rule to use the system. Clinicians will require someone to be supporting them, for instance a patient attendant*
IDI405	*b. Assign someone in the IT department to provide full time support to clinicians*
IDI406	*SK(Paeds)*
IDI407	**Understanding the intervention theory**
IDI408	**1. At the outset, what changes did you expect to occur with the implementation of [bespoke eHealth system]?**
IDI409	*a) Health workers will have knowledge and skills*
IDI410	*b) Data collection will be made simple and have proper data to present to different stakeholders to access funds*
IDI411	*c) Ease the workload done in the manual data collection we used to do*
IDI412	*d) Means of communication between staff members in the hospital. It was difficult to get information by administration and others on how many patients we are seeing*
IDI413	*e) Fee collection to improve from the patients*
IDI414	**2. How did you expect those changes to come about?**
IDI415	*a) Through training and hands-on work*
IDI416	*b) Initially we were using the manual system which was difficult, especially for people looking for old data, such as malaria by gender, but they ended up going back without tangible data.*
IDI417	*c) Pen and paper needed a number of personnel to do that, and we were busy, so it took more time. The expectation was that it will be easy to enter name personal ID of the patient.*
IDI418	*d) With manual system, for one to access maternity data, for example neonatal deaths, someone coming from paediatric wards, they had to go file by file, which took a lot of time. Other staff were not communicated to about what was happening with the rest of the hospital.*
IDI419	*e) Each and every patient is entered into the system when paying for drugs and any procedure. Paper based records would get lost and patients would not pay for all the services. Also, other offices like administration and accounts can view what is happening during the day through [bespoke eHealth system].*
IDI420	**3. What changes do you think have happened as a result of [bespoke eHealth system]?**
IDI421	**Probe: How did [bespoke eHealth system] bring about those changes?**
IDI422	**Probe: Why do you think the expected changes did not happen?**
IDI423	*a) Yes, but not to the fullest. But at least more than before. When we receive new staff from other hospitals, we can see that their knowledge is lower than those*

	trained at Madalo.
IDI424	*b) Yes. An example is the in-charge of data clerks, [data clerk]. When it's a busy day, it's difficult for nurses and clinicians to enter data into the system. But with data clerks, it is easy to get data for different conditions at different times. In nutrition, we were able to justify to Y-Malawi and World Vision International using [bespoke eHealth system] data and we convinced them to build a peanut butter factory. The Norwegian funding could not continue for five years without the data we get from [bespoke eHealth system] with the FK Project. Madalo is a teaching hospital and we have Malawian and international students because we can present our data better and that makes the College of Medicine trust us with the Family Medicine students. As coordinator for international elective students, and most universities want to see how Madalo is doing for neonatal deaths using [bespoke eHealth system], for example Ohio State University, Cork Island, Rush University, Dundee University, Edinburgh University, Tasmania University in Australia, London College, Otago University in Australia, Stellenbosch University, and most comments are based on [bespoke eHealth system] data, for example Zambia, Tanzania, Malawi College of Medicine. Donations for houses from MMWT are based on [bespoke eHealth system] data. Extension to the new labour ward, guardian shelter.*
IDI425	*c) It's easier, but it needs more training and orientation, more in-depth with hands-on training, especially for new staff and focus on those working with the system every day.*
IDI426	*d) Somehow changed. Every Monday, Wednesday, Thursday and Friday we have staff meetings and presentations based on data collected in the departments, for example surgical ward, from [bespoke eHealth system]. One very important thing right now is non-communicable diseases, particularly diabetes and hypertension. We have seen an increase in the number of people coming in, and we can share this data internally and outside, and we have come to know that it's a problem here. We want to focus on non-communicable diseases now with the Norwegians because of the data we are getting from [bespoke eHealth system]. This applies also from malaria, TB and HIV.*
IDI427	*e) Yes, very much. It's easier for the fee collectors to count during the day and be counter-checked by the administrator, accountant and director. Before they couldn't do that using the manual receipts.*
IDI428	**Unintended consequences of EHR**
IDI429	**4. Are there things that you did not plan that happened as a result of [bespoke eHealth system]?**
IDI430	**Probe: Positive? Negative? How did they happen?**
IDI431	*a) Shortage of staffand we see that patient attendants, clinicians and nurses don't use the system, only people like [data clerk]. The hands-on part of it for frontline workers are not being utilised, especially in OPD because they don't have data clerks.*
IDI432	*b) Projects and students have been embedded into [bespoke eHealth system], which we didn't plan. My friend used to tell me there is power in data, but I dint understand him. Now I understand how to use data, which was difficult to do with the manual system. With [bespoke eHealth system] is it easier to communicate with others. With the ebola, we are updated.*

IDI433	**Barriers and facilitators of implementation of EHR**
IDI434	**5. How do you think implementation of [bespoke eHealth system] has gone?**
IDI435	*It has gone well. This has been a starting point and has borne good fruits. We just need to polish up.*
IDI436	**6. What factors have helped with the implementation?**
IDI437	· *Teamwork*
IDI438	· *Transparency*
IDI439	· *Proper financial management because there were a lot of things taking place like management visits to Tanzania*
IDI440	· *Cooperation and coordination between the IT department and the hospital staff on the ground.*
IDI441	**7. What things have prevented good implementation of [bespoke eHealth system]?**
IDI442	· *Staff turnover*
IDI443	· *Shortage of staff*
IDI444	**8. (For health centres) Are there things about your particular health centre that have made it easier or more difficult for implementation of [bespoke eHealth system]?**
IDI445	**Probe: Human resources? Quality of staff? Attitude of staff? Infrastructure (computers, electricity)? The software? IT support? Support from district office/ diocese?**
IDI446	· *An established IT department, which most departments in Malawi don't have*
IDI447	· *Donor support*
IDI448	**9. How have you adapted the project ([bespoke eHealth system] modules, change management, infrastructure) to suit your needs?**
IDI449	*Establishment of computers in each department. Each department has a computer and data collector.*
IDI450	**10. Have you changed the way the facility works to make the project work? How?**
IDI451	· *Redesigned the reception with addition of computer room*
IDI452	· *Establishment of paying office in OPD with [bespoke eHealth system] where data is entered into [bespoke eHealth system]*
IDI453	**11. Which components of the project have worked and which have not worked? Why?**
IDI454	**Impact of EHR on quality of data for decision making (For ward and facility in-charges)**
IDI455	· *Financial collection is working*
IDI456	· *Keeping patient information is working*
IDI457	· *Data collection is working*
IDI458	· *Hands-on operation of staff is not working, especially in OPD, because there is no data clerk.*
IDI459	**12. What data was available to your ward/ facility before [bespoke eHealth system]?**
IDI460	*Obstetrics and gynaecology*
IDI461	**13. How reliable was that data?**
IDI462	*Not reliable*

IDI463	**14. How have things changed in terms of data quality with the introduction of [bespoke eHealth system]?**
IDI464	*At least there is an improvement. There are mistakes, but they are not so high.*
IDI465	**Conclusion**
IDI466	**15. Present draft logic model and ask for feedback**
IDI467	· *There is increased IT knowledge*
IDI468	· *Somehow increased staff satisfaction*
IDI469	· *Computers increased quality of care. We are able to see what drugs have been given in the previous consultation. Also for example for non-communicable diseases.*
IDI470	· *There is continuity of care. Diabetic and hypertensive patients come every Tuesday and one is able to see previous month's treatment, blood pressure reading and sugar levels. Also in paediatric ward, when patients are coming back for review, we can see previous Hb and continue taking iron supplements. We are able to retrieve patient files to help manage marriage problems. Patients could sue the hospital for not keeping their file for 5 years. We were once taken to the Medical Council of Malawi when after tubal ligation the woman became pregnant. It was difficult for us to get the file the file to defend ourselves.*
IDI471	· *For patient referral, all patients from the health centres are indicated in [bespoke eHealth system] in the labour ward, and why they are being referred. It is easy to go back and see which facility is sending more referrals and why, and how we can best improve, for example the nurse at the facility going to workshops*
IDI472	· *No improvement in diagnosis and treatment*
IDI473	· *For patient follow-p, for example diabetic and hypertensive patients can be followed up when they come back after one or two months. Even in surgical ward, they can give you information when they are coming back*
IDI474	· *For duplication, somehow changed but not much. Major use is at registration and in the department, there is no need to re-write the patient's information. When the cashier wants information, they just scan the barcode.*
IDI475	**16. Do you have any other comment regarding the project?**
IDI476	*Thanks for the discussion. [bespoke eHealth system] is a good system and I hope it continues after we improve some of the areas.*

3. Post-Implementation Focus Group Discussion Reference Table (Labelled 'PI')

Reference Number	Paper Based Resources - System Adopters
	1. Paper-Based Resources
	a. Money for buying pens
PI001	**Ponekela Ground Labourer-Male**: *There was also another thing that they helped, that the money for buying pens was able to be used for other things, because the OPD register uses up pens a lot.*
PI002	**Dalitso Nurse-Female**: *From the large number of people, using a pen, it's true, and the resources are also few. Because there would be two or three months without pens.*
PI003	**Dalitso Nurse-Female**: *So if there is also a computer, because even the pens, sometimes you find two months without the pens coming, so maybe at least there would be an improvement there.*
	b. Paper registers running out
PI004	**Ponekela HSA7-Male**: *The computer has helped us with lack of stationery. We had problems with registers. When our colleagues go to get them, you would hear, 'There aren't any, there aren't any'. So now which tree shall we catch?*
PI005	**Ponekela HSA5-Male:** *We had problems where I was, I will not mention the name. But there were problems that sometimes we would indeed draw the register on a cardboard, yes so that a patient is served.*
	c. Damaged or lost paper registers
PI006	**Winistoni ART Clerk-male**: *Looking at the way work was being done before the computers, we would work with files. Then also considering how the registers were, when the register was there and I start using it, before two weeks it has started tearing.*
PI007	**Ponekela HSA3-Male:** *In the register it would happen that the page you wrote on has torn, it is lost.*
PI008	*d. Money for photocopying*
PI009	**Ponekela Ground Labour-Male:** *When these people have run out of forms, they find that they have to take that form to Madalo with money from their pockets.*
	Paper Based Resources – Medium Adopters
	1. Paper-Based Resources
	a. Money for buying pens
PI010	**Sinelia Midwife Nurse 1 - Female**: *Take like writing in registers. It happens that even the pens that we have been given are finished, such that we were then taking money from our pockets to buy additional pens. But with a computer, we will not have to get money from our pockets to buy a pen. You just sit there, you will be entering your information.*
	Buy-In – High Adopters
	1. Buy-in
	a. Facility leadership approach & buy-in

	Positive
	Negative
	b. Facility staff initial perceptions, reactions and expectations
PI011	**Winistoni ART Clerk-Male**: *It was very pleasing because firstly, one: like I had said earlier that I will know the computer (inaudible) but to me it was ah ah! computers are coming to our facility? I will know the computer, and also when I know the computer, these days everywhere you go they ask, 'Do you know computer?' And to add on to that, my exposure to these things will be that I know something. So that made me very glad.*
PI012	**Winistoni HIV Counsellor 1-Male**: *The coming of the idea that computers will be coming, I was very happy as an HTC, because I believed my workload at HTC will be reduced because the register at HTC is full of circles, just going round and round until the whole book is finished. Now when I heard that computers are coming I was like, 'Yes, my workload will be lighter because I will just be putting it into that computer and the report will not be difficult, I'll just be doing it'.*
PI013	**Winistoni ART Clerk-male**: *When I heard that Madalo is bringing computers, I was joyful … I thought iiih! now that the computers have come, we have learnt like they are saying, it means workload will be reduced. One. Two, there will not be, 'Hey you, have you written the report, can you submit it?' using manual, no. I will just be doing teee! 'Have you already compiled it at HTC?' 'Yes, I have compiled it'. That's it. So, I was happy that the computers will offload some things for me that were delaying me to produce a report. And two, the computer, some of us were just hearing that there are computers, I had never seen one before, maybe I used to see them only when passing by but didn't know how it works, and when you switch it on, what does it say. So those things I had heard I saw that it's a reality. So, I was happy that I was able to use the computer, especially opening it, do something in it, switch it off, and see how many people I have seen here at HTC or even at OPD. It was telling me how many people have been seen at OPD, or even at the other departments, because information was being entered everywhere. So, I was happy.*
PI014	**Winistoni Security guard 1-Male:** *What I was expecting was that because it's a computer, it will be only the seniors who will be using them and not a security guard having a chance to use the computer. I was not expecting that (laugher from others). And so to see that a security guard is also using it, then (continuous laugher from others) what I was expecting did not happen. (laughter and comments of agreement from others). So for this I would like to thank Madalo for not being selective of a person's rank. Yes.*
PI015	**Winistoni *ART clerk - Male:*** *The problem at maternity is not lack of a person to be recording into the computer. No. Rather, it is the people there, they do not have the willingness. Because they are elders. You can focus to previous times, you can go back, there was Wiz, right? He was able to use the computer! Why? He was energetic. But with these two old women, it's somehow a problem. So they cannot manage. No. So we can send someone to be recording into the computer, but the terminologies that they use those guys, it would have been difficult to manage. But it needs them themselves. Someone needs to come who is active, and that person will manage. (laughter)*

	*But with these two, they can't manage. There are things like EDD, sepsis. Can one manage? (**MA(F):** Sepsis is not difficult.) The thing is, there is need to show interest for things to move over there. But the interest – (**MA(f):** The interest will be there when the person will know that they will stop using the papers, because it's documentation. Remember we are failing to record some information.)*
PI016	***Jedawako*** **Hospital Attendant 2 - Male**: *For us who the computers found us, I was very happy, happy because many times we would see computers when we go to the DHO, but also to touch the computer it was a difficult thing that eh! Here we are lucky we will be using them ourselves, we will be like those who are in town. We were very happy because of that. Also, we knew that we will be advanced. We will not be using registers anymore, we will be putting data into the computer. We welcomed the news very happily.*
PI017	***Jedawako*** **Ground Labourer - Female:** *I also found them here. I was very happy when we heard that where we are going there are computers. We were just seeing computers in other people's offices and we were scared of them. But when we came here and were told that we will be using computers and we started using them and others taught us, since we were not formally trained, but because of our interest, we found that we were able to try and know some things.*
PI018	***Jedawako*** **Hospital attendant 1 - Male**: *I was very happy because these times are different from the old times and these things are current things and we need to be modern. Others have known them long ago and when I saw that there are computers, they have come at the right time.*
PI019	***Jedawako*** **HSA - Male**: *We were very happy. Things that seemed to be far away have come near us, because what we expected it was not so high that the computers have come to stay, we should know the computer well before they have become settled.*
PI020	***Jedawako*** **HSA-Male**: *In the past promises were made but not fulfilled. This is disappointing and has negative effects. Promises were made to be conducting quarterly meetings but these have not been fulfilled. That is a contributing factor that things are not going well. This has a bearing on work performance because when you are holding meetings and discuss important issues you become encouraged. It is better not to reveal something with slim chances of happening to avoid negatively affecting the concerned group. There were promises for a printer, but it has not been fulfilled.*
PI021	***Dalitso*** **HSA2-Male**: *I was one of the lucky people at first to be trained in computers at Madalo. It was also a priceless thing because with these days technology, the pen these days, its information gets erased quickly, while the computer was a priceless thing that I needed to learn. In fact, there was no one who wasn't happy at that time. All of us. A car was even coming here to take us to Madalo. All of us were happy people. But also at the beginning, every day we were trying our best to enter the names, there was that label printer, such that it was organized. But it was … it was a very pleasing thing indeed. But also even the clients, when they saw the computers they were like, 'We are now already cured!'*

PI022	***Dalitso*** **HSA-Female**: *When I heard that computers are coming, I felt that work will be moving fast and also information will be kept. I will not be having problems (unclear).*
	c. Initial fears by staff
PI023	**Winistoni ART Clerk-Male**: *There was a bit of fear that, this computer, sometimes you know that sometimes people get retrenched. Will they not come and say that 'No, we will need only a few people'. So it became like a little burden, that what will happen? Maybe the people who will be trained in computer will be two or five. So there was like some jealousy, jealousy that how will work be organized because the computer will only need one person, or two. So we were saying, 'Maybe they'll take me, maybe they'll take this one, maybe they'll take that one'. So that brought some jealousy at work. But all in all, it was very welcomed and everyone was saying that, 'I should learn it, I should learn it, I should learn it'. That's why when you will go there you will see that there are many people who are using that computer.*
PI024	**Winistoni Security guard 2-Male:** *Let me provide a different perspective, because I found the computers here. When I just arrived and found them and saw that everyone is busy with them, so my fear was that since it's not easy everywhere I've been that a guard is using a computer, there was some fear that, 'Aah! Should I use a computer? Who am I to use it?' But then I saw that everyone else was using it, so even I slowly started (inaudible). So it's something that I never imagined because they did not segregate who will be using it. So that's all from me.*
PI025	**Winistoni Security guard 2 -Male**: *Some of the things we were not expected is what has been said already, that the coming of the computers, as they say computers reduce workload everywhere. So when the computers really came, my worry was that when the computers come, other people's jobs will be at risk. There will be transfers and they will be sent to other places where there is heavier workload. So I was expecting that – that that is what will happen. But I'm seeing that up to now, years have gone by (laughter from others) all the people that were there, there is no one who was retrenched or transferred. No one. For me, that was my fear, but it did not happen. (more laughter from others).*
PI026	**Ponekela Ground Labour-Male**: *When we heard that computers are coming, worries were there that, 'Ah! This thing, how will it be used and who will use it? Oh, Madalo will bring people who will be working here'. On seeing that they have given us the thing and we will be the ones using it, I saw that 'Aha! That is a good thing! Because we are the owners, they have given us those things'.*
	d. Sense of ownership
	Positive
	Negative

PI027	***Ponekela*** **HSA4-Male**: *They prioritize people who maybe like to frequently stay on those things. For example, this other day I had an interest in it, to learn those things. But it was found that I was not being given appropriate attention, unlike the people who seem to already frequently use these things. They just – They came to change – I don't know what they came to change this other day. They just briefed the people who seem to do those things frequently, such that even my interest was gone that, 'Ah, I think these things have their owners who can do it, let me just leave it'. (**Male:** They were entering drugs?) Yes.*
PI028	***Ponekela*** **HSA5-Male:** *I am very thankful that I think some of us we are able to participate on things that we often are not involved. They just invite only the people who were trained. So I think this may be – At least if some of us are also approached like this frequently, it can also provide maybe some other encouragement to some of us who maybe did not do things like these.*
PI029	***Ponekela*** ***HSA1*****-Male**: *Just to add to what my colleague has spoken. If these words would be carried and told to those who monitor us. Because at that place it was like there was segregation. Tell them, 'When you go there, you should do what we have done by bringing the people together. They are happy about it'. You should really tell them that they were like segregating the people. (unclear) 'When you go and want those ones, don't just go for those ones. You will see that there is some interest'. But because when you come you just say, 'So and so, please come'. So we just say, 'Eh eh! Is it that I have also be called?' Yes. I wanted to add to the words that have been spoken by my colleague here. Say that 'We have learnt something here'.*
PI030	***Jedawako*** **HSA-Male**: *Another problem there, as has been said, is that because of the training and who goes there it shows that you have already identified the people who you will what? **(Female Interjection**: They will be working with) – they will be working with. It happens that the passwords expire and for a person to – It is difficult, so you have to find that same person and they say that they will do it for you and they fix the problem while you are not there and they just tell you to be typing 'welcome', a thing that is so simple but just because someone doesn't know, it becomes a source of ridicule, where one is seen to be ignorant while the other is glorified, while the purpose is for us to value our work. **(Female:** The one ridiculed is like the ground labourer who has to come here at six to start registering people into the computer and finds that the password has changed and they have to wait for that person who was trained who maybe comes at ten, or even a week without showing up – **(Male:** Having to phone them!) – having to phone them. So aaah! It is worrying.*
	e. <u>Inter-organizational partnerships</u>
PI031	***Ponekela*** **HSA3-Male**: *We were not expecting are the idea that Madalo Hospital had to consider bringing computers to this public facility. It may also be a big donation, because maybe it becomes difficult for the missions and government to provide such assistance. So we have seen that at our place here we have been blessed that Madalo has brought us computers.*
	f. <u>Monitory incentives</u>

PI032	***Ponekela*** **HSA4-Male**: *Many times I have been hearing whispers about things from Madalo, because us Malawians it's become like something we are born with, that when we have been invited then there should be a little something that when we are on our way back we can be able to get our bicycles fixed. For example, we HSAs do no stay here, we stay at the field. So you think, 'They have invited me, but my bicycle is broken-down. So there, what does Madalo do? They don't give anything'. So you think, 'Mmmm – Let me not go there'. I wanted to ask that maybe they should consider like a little lunch allowances that can give a person courage that the things are important, let me go there indeed, because if my bicycle gets broken down anywhere, I can manage to get it fixed. At least it can be given to us like motivation to attend Madalo activities. True.*
	Buy-In – Medium Adopters
	1. Buy-in
	a. Facility leadership approach & buy-in
	Positive
PI033	***Sauko*** **Data clerk-Male**: *At first, I can't say just hearing about it, but being told, because those computers, before they were put here, before being installed, at first we went as a team of four, who were the in-charge, the data clerk, a nurse and a senior HSA. When we went there, they told us how the process is supposed to be like. They said those are the stages, starting from discussions at the district, then here at the health centre, and they asked us whether we have welcomed or not, we have not welcomed it. So everyone who went there at that time, we indeed welcomed it because with how the workload is, and the coming of the computers, our expectations were that the workload will be reduced, and the information will be found without difficulty, and caring for patients will be better.*
PI034	***Malilika*** **Home craft worker-Female**: *When our bosses had told us that we should learn how to use computers, so they would even teach us separately so when the computer would come we would have already learnt.*
	Negative
PI035	***Sauko*** **Ground Labourer 2 – Male**: *It happens that our superiors, they see that our work we have done, we have come to help the others, like the data clerk. But they think that we haven't done our work and we are just rushing to the computers, we are overlooking the work that we do. So for us it becomes like a fear for the future that maybe when our bosses come from Dedza and they say, 'Why is the grass on the ground here not being cut?' while the grass was cut but at that time there was too much work and they just called us that, 'The way things are now, you should not do the work outside, you should work here', so you know a workplace is a bit complex, they look at other's mistakes and not look at their work and how it is going. So for us the threat was indeed there, such as – eeh! there we stumble, because for me the computer has gone to my heart because, as I have said before, to Scotland I can reach there (laughter) because my interest in it and wanting to know it well. Because others come with issues like, 'Why are you doing this and that?' So it makes us to – it gives us fear that, 'So now does it mean I – what about –?' and like that, things are not moving. So if the people from Madalo come and*

	give us a question, 'Is it going alright with the computers?' should we say, 'No, it's not going alright with the computers', while we went for training? So here I feel that our superiors should know this thing well and they should accept it that we welcomed this thing with two hands, it's supposed to be going alright here. So with them we indeed have fear, let me not lie.
PI036	***Sauko*** **Data Clerk - Male**: *the in-charge, the MA, when the in-charge comes it's like the MA does not stay here for long. So they do not have the interest about how the program is going. In fact, most times when our friends from Madalo come, they find him, Bauleni, Kushota and so on.*
PI037	***Malilika*** **Laboratory Technician-Male**: *I wanted to ask that for everything that happens, our bosses should be the first people to know. Because I see that those people didn't know anything and what the program will be like. Us who were called to go to Madalo to be asked questions and plan, I think Henry you were there, right (**Male**: Yes) we were asked whether it would be good to receive computers and be using it on the part of HMIS. And we saw that yes, it's good. Then when we came we gave feedback. It seems our bosses have information … don't have any information concerning these computers. So what was overlooked was explaining to them, sitting down with them and explain that we went to Madalo and we heard this and that. Then when it came they would receive it with two hands. Maybe deciding whether it should come or not. So when they came they of course saw that it is important for there to be computers, but then on most things those people seemed to be blank. They were just relying on us, that there is this and that happening. So I wanted to ask that if there is any communication, it would be good for there to be openness with our bosses. Because those people are not Malawians, they are people who are very conversant with things. So by doing that, there will not be any conflicts, we will be moving together. It shouldn't be just coming, 'We want to do something', and then you just leave afterwards. It gives those people questions like, 'What are those people doing?' Now when you go and explain to those people properly that, 'When we are doing this, it also involves this and that', then they will not be wondering, 'How has this come about?' In that way it will make things easy. We have been with them for a long time. That is why we are doing this, we know them. Sometimes they shout at us, sometimes they ask us questions that we have no answers to. So we are just asking you at Madalo that everything that is happening, you should be releasing information to them that, 'We will do this, we will do that, we will do this'. Then it makes those people free and they know what is happening.*

PI038	***Malilika*** **Laboratory Technician-Male**: *Our bosses at this facility are not Malawians, they are foreigners. So everything that is happening concerning the computers, they know about it more than what we think. They know a lot about these things. So I wanted to ask, with the coming of these computers, are the people from Madalo doing research or it's a program to just come and help us at Malilika? I'm asking this because at this facility I was put as the administrator of the computers, such that when people meet problems I am able to help them that do this and do this. But then it would happened that the people from Madalo would come, those guys, they would come and touch here and there, then leave. So that was affecting those white people, as our bosses. They were very annoyed about it, that the people would just show up, maybe without a notice and do their things and leave. And then when they are communicating with them, it was bringing confusions, especially on my part, because it would appear like I am communicating with the people from Madalo to come and do this and that and then they would go, while the bosses do not know anything about it.*
PI039	*b. <u>Facility staff initial perceptions, reactions and expectations</u>*
PI040	***Sinelia Male HA:*** *we were happy that it was our opportunity now to learn about computer.*
PI041	***Sinelia*** **Mid wife Nurse 3- Female:** *The first things was that I was afraid, on my side. I was afraid because, it's a computer, I was just seeing it or just hearing about it, that our colleagues here are handling computers. Then afterwards I accepted. I was happy that, 'iiiii I should also learn about computer'. It was joyful in my heart. So when we learnt. But because of what I said earlier that we are busy, we are sometimes few, so we were – It makes us to not be on the computer often. But the heart is very joyful that, 'iiii the way I am, I should handle a computer?' It was very joyful for me, and it is still indeed joyful for me.*
PI042	***Sinelia*** **Hospital Attendant 2- Male**: *When we heard that computers are coming I was very happy, because ever since I had never used a computer. I was just hearing from our friends that they are using computers. So I saw that it's my opportunity that maybe I can know it. I was just envying my friends clicking it. So I saw that no, my opportunity has found me, I should also click it, and saw that it is happening. Ah it's a very pleasant thing. (**Paul:** So it happened that you learnt how to click?) It has happened indeed. I know [bespoke eHealth system].*
PI043	***Sinelia*** **Ground Labourer-Male**: *(unclear) the computers I was very happy because I didn't know how a computer works*
PI044	***Sinelia*** **Midwife Nurse 1 - Female**: *When I came here and saw computers, I saw it as something very valuable because (unclear) is simple.*
PI045	***Sauko*** **Data clerk Male**: *many of us saw that it was our chance to touch a computer, because we have never learnt it before. It's a thing that to go and learn computer on our own is doubtful, so I saw that with the coming of modern technology, it will also help us to move with the world.*
PI046	***Sauko*** **Senior HSA – Female**: *When I heard, I thought it was very good news because the information cannot get lost.*

PI047	***Sauko*** **HIV Counsellor – Male**: *My thoughts when I heard that computers are coming, my thoughts were that they would be put everywhere where they are supposed to be at the same time so that they would help at all those places for information to be easily found, but also to help, perhaps the person has come who needs to be served, if they had been here before they should be searched, they should be searched properly and easily and as opposed to have to be searched in the register and in that way the people will be served properly when the computers at all places will need to be installed at the same time.*
PI048	***Sauko*** **Ground labourer 2- Male**: *there wasn't any worry, because I knew that it will improve my life to be more knowledgeable about many things more than I knew previously.*
PI049	***Sauko*** **Hospital Attendant- Female**: *I had expected something positive, what I have already said that I had never know what a computer is like.*
PI050	***Sauko*** **Ground labor 2- Male**: *Let me answer like this: there wasn't any worry, because I knew that it will improve my life to be more knowledgeable about many things more than I knew previously.*
PI051	***Malilika*** **Laboratory technician-Male**: *Yea, when we heard that computers are coming, right? We thought things will be better*
PI052	***Malilika*** **Patient Attendant 1 -Female**: *When I just heard then I was eeee this is the first time I will learn computer. I was very happy that iiii I did not know what a computer was at all, and my ignorance will end. When I just heard I was extremely happy that the computer that was elusive, I will now know it.*
PI053	***Malilika*** **Home craft worker-Female**: *It was the same happiness, that I will know the computer, because there were many of us who did not know computers. We were just seeing them in the offices, wondering how they are used. So when we heard that they are coming we were very happy.*
PI054	***Malilika*** **Cashier-Male**: *It was very pleasing when I heard rumours and coming to confirm that there is [bespoke eHealth system] coming, this software that we will be using. We were very pleased because it is the first time, we had never used a computer at this facility. My only experience was their laptop. But the first development of a first chance at Malilika to use a desktop.*
PI055	***Malilika*** **Patient Attendant 2 -Female**: *It's true that when the computers came we were very happy that no, things will change, because we would just hear from our friends how they are doing, just seeing them and thinking that those things are for the big bosses, simple people cannot use them.*
PI056	***Malilika*** **Nurse midwife 2 -Female**: *When I heard computers are coming I was very happy because reporting will be easy, because the computer will be adding for you and you will not be struggling going page by page like we struggle now. It's just that we are not yet set, but the computer will (inaudible).*
PI057	***Malilika*** **Pharmacy-Female**: *When we heard about the computers we were very happy that this is a good thing and we will learn, and it has helped us that we have some knowledge and in the future we can say that we are experts because (inaudible) it has helped us that we have learnt about computers.*

PI058	***Malilika*** **Dental-Male**: *these things were coming and we were all happy that these things were coming, we didn't know them. Like my friends are saying, maybe those with more experience in computers here we can say is the lab technician. Maybe that's why the large group is saying we failed to catch up early. But our hope was that with the computers, maybe at the beginning we would have classes to know ABC, what is a computer. At least it would have been that maybe when coming up with these systems they would have reached us when we are able to quickly grasp these things.*
	c. Initial fears by staff
PI059	***Sinelia*** **Hospital Attendant 1- Male**: *At first when we heard that, 'Aah, they say they will bring computers', we truly had a lot of joy. But then worries were there, especially because it's something that you don't know. But then I just said, 'Ah aaah is this not something that you need to be taught at the beginning?' Because with these modern things, you enter somewhere where you don't know, causing problems. But when they came I saw that the worries that I had, ah now I can say that it is gone, such that I can use it properly without any problem. So aah! I am very happy that it went well.*
PI060	***Sauko*** **SHSA- Female**: *There were concerns. Is the training they have received only for them, such that the rest of us are in deep waters?*
PI061	***Sauko*** **Data clerk -Male**: *The other concern is what they have said, that this thing, some of us our whole lives have never touched it before, will it not burn us? How are we going to handle that thing?*
	d. Sense of ownership
	Positive
PI062	***Sauko*** **Data Clerk-Male**: *These computers, we work on them because they have been given to us and are expensive, they should not get wasted, let me use them, so I use them.*
	Negative
	e. Inter-organizational partnerships
PI063	***Sauko*** **Hospital Attendant-Male**: *What I did not expect is that Madalo would help us with computers at a public facility like this one. So I just saw that it has happened by God's grace to choose a facility like this one. There are other facilities there like Kaphuka, another very nice facility better than ours here, but they were kind-hearted to us to give us computers here (laughter). So I saw it for myself that it was not something that I expected would happen to us. Yes, sure.*
PI064	***Sauko*** **Ground Labourer 1 - Male**: *Another concern is, maybe I can say, how to care for those computers. Because this is a health centre as you know, and at the government they say this, this and that, meaning that even if we asked them for that thing it would not come.*
PI065	***Malilika*** **Laboratory Technician-Male**: *we just want to thank you for thinking about Malilika to be part of this computer project. Because if Madalo did not think that we should give them to Malilika, we would still be in colonial times, we would still be the way we were all along but at least here we are moving with the world, the way it is.*
	f. Monitory incentives

PI066	***Sauko*** **Data Clerk - Male**: *The problem is the government has gotten us used to bad habits. When they make us sit like this, what we expect is we will receive a lunch allowance, maybe that two thousand something. Now today, our friends have come – We have gotten used to them as friends, they have come, we have remembered familiar faces, they have come. Then when leaving the lady says, 'Alright, see you, see you', maybe Fanta (laughter) When that happens, they don't come again. So for those people to have interest, it gets complicated. So it means when those people come here, if there is indeed a little something, after we have signed, it should happen. It happened that – I will say this – It just happened, I wasn't here at that time, but people were on me, 'You! We just signed a sheet, we didn't see anything'. I don't know if that time our colleagues were signing where there was money, or they were just signing that 'We have found you, it's like this', but I had quite some troubles there. So – but I think this one was there at that time. So what seems to regress things is that.*
	g. Input
	Computer Allocation
	Buy-In – Failures
	1. Buy-in
	a. Facility leadership approach & buy-in
	Positive
	Negative
PI067	***Filipi*** **Clinician-Male:** *At the very beginning, the way I saw it, I saw that the process was not followed well. Because, it's like our own in-charge, who is a nun, is often mobile. That now is away, will be here for two days, out, two days. So, for her, in terms of briefing about the advantages of that thing, generally she does not, as in-charge, she did not know. And up to now, she does not know. So there needed to be, at the beginning, to approach the in-charge and teach her. She should know herself that this thing is important for this and this. And she should accept that thing that, 'Ok, this thing should come to my facility'.*
PI068	***Filipi*** **Patient Attendant – Male:** *But also if you approach her it will be different from the staff. It can carry weight, like you can carry weight, showing that the things would be helpful. Because for us to go explain the things as we have understood it, it can be different. There can be a big difference.*
PI069	***Filipi*** **Patient Attendant 1-Female:** *as has been said by the clinician that the nun needs to be approached face-to-face because she is a person who likes development and she is happy when she sees the place developing. So I think maybe that program, if she had understood it well as has been said, it wouldn't have been difficult. But because there was one small problem that she didn't really understand it. 'We want to take you on a trip to Madalo'. Then travel through Madalo. And she can observe many things in Madalo, things that you wouldn't even know and would marvel when she is telling us here. Because when she travels she – and then she would say, 'You should go to Madalo. As soon as there is a referral case, you should go to Madalo. When you see something, the thing you see you should come here and explain it to me'. That's what she does to us. Then you know yourself that eh! (light laughter). So still, we'll see, since our boss is right here (laughter).*

PI070	***Filipi*** **Clinician-male:** *There is an approach where you meet face-to-face and making a phone call. Two things. These things are different. If you made a phone call, then my in-charge, let me not lie to you, is a person who is busy pondering about projects. And making a phone call, she sees that as nonsense. She just answers with a calm heart. Maybe she just answered you to pass the time. But you were supposed to come straight and meet her face-to-face, tell her first the advantages of the system. She should know. Because if you just tell her, 'We'll remove it', she'll tell you, 'Remove it' (laughter). 'Remove it', that's it. But firstly you should teach her, 'Ah we have come, we want to explain to you this and that, and there are these challenges. So how can we help each other, you as the in-charge?' So her she will take it there that, 'Oh those people have come to me as the senior person'. They maybe – Maybe there to me you wouldn't have reached that far. Because she received an email, and she said to me, 'I have received an email. They say they will take back those things from you (laughter). So they say I should respond, tell me what I should answer'. She announced it in here, showing that she doesn't know those things. 'Those of you who went (laughter), (unlear)'. You see? But we want her as … her things should go well. The facility should go well. She should know. Because me as a person, I wanted it a lot, because I know the goodness of those things. But her, she saw that ah! it's useless. (**Fyness:** Yes, of course the days we were coming we were not finding her. But still, what was making you fail to tell her?) (laughter) For us (laughter) – that's why I said you should meet her face-to-face (laughter). She's a very nice person, and if you had approached her … if for these things you had approached her, you would have seen – She would have just made a commanded herself. She's a person that if – aaah if – When you go with juvenile things, like us – Let's not lie, if you just go with juvenile issues, she will just say, 'That doesn't concern me. Go! You are delaying me, I have things to do'.*
PI071	***Filipi*** **Patient Attendant 2-Female:** *Just for me to add on. I feel that the first approach didn't come well. Like me, I know her how I have been with her. Other places that she has been, that system is still there, it is still going. People have learnt the computers, the computers are still there, so its approach was good. (**Male:** That's at Mtendere?) That's at Mtendere. Yes, so that shows that the approach was not good. Her, she loves development, such that at Mtendere everyone is able to use a computer.*
PI072	***Bisitoni*** **Ground Labourer 2-Male:** *We had learnt and we started getting used to it and when he started stopping that work, it made us go backwards with what we were using for writing on the computer. So for us we were just doing that since we are servants, so when he said, 'Today we shall use the computers', we would listen and use them, when he said, 'We will not use the computers today', what then can we do? (**Paul:** Would you know the real reason why he was saying some days you should not to use them?) There the real reason I cannot know. (**Paul:** Perhaps they were delaying things, or …?) There, there is no real answer. Delaying the work, no I don't think so. They were his own reasons. Sometimes when we want to use them, when we come early in the morning and do our work, we would get the keys, open and start registering the patients, and sometimes he would just say, 'No, today no computers'.*
PI073	***Bisitoni*** **Ground Labourer 1:** *I expected the disconnection of the system because it was us who had a problem, the in charge could command us not to use the system while we were in the process of using the system.*
	b. <u>Facility staff initial perceptions, reactions and expectations</u>

PI074	***Filipi*** **Clinician-Male**: *People's thoughts were joyful that things here will be very sweet, and that things will move*
PI075	***Filipi*** **Senior HSA –** *It was a very good thing, in which we can say we were quite happy, because it's something that was far off, which perhaps it wasn't in our dreams, but it was found that all of a sudden someone has been thoughtful to us at this facility, which was an advantage for those who didn't know how a computer works and so on.*
PI076	***Filipi*** **HIV Counsellor – Male:** *I can say that on the part that it seems it didn't go well, as was said by the clinician that (unclear) at the beginning people didn't know it well, but also didn't know the advantages and disadvantages of the system, how it works. So it would have been good if it was explained about their (unclear).*
PI077	***Bisitoni*** **Ground Labourer 1 - Male**: *At the beginning we welcomed the news with great joy, because we saw that there will be a change.* ***(Paul:*** *What kind of change?****)*** *At first it was like development at this place firstly, but also changes in the way of working because using the computers indicated that things were faster than the earlier ways, as I've already said.*
	c. Initial fears by staff
	d. Sense of ownership
	Positive
	Negative
PI078	***Filipi*** **Clinician-Male:** *There is need for the in-charge to know what this thing is, it is coming here for what reason, how it will be working. Then she would guide us that, 'Ok'. Because it is her who would have told us the advantages of those things. The in-charge. Then when she explains to us the advantage, then she will instruct us people to be using it, and it wouldn't have reached a point of you taking those things. But now, it's like the in-charge does not know the advantage of the computers. That's how I saw it. From the part that I observed. So it is the request from us, as the team that is here, that if it would be possible, if the system will come again, the first thing needed is to take the in-charge, take her to a place where there is the system. She should see. You should show her everywhere, 'It goes like this, it goes like this, it goes like this. And the advantage is like this, is like this, is like this'. Then she should come and sit down, 'Those things that I saw, are they needed at my facility?' Then when she sits, it is herself who will say, 'Ok, if it is needed, then I need to do this, this, this'. Because if you your training was brief, her as the in-charge, if she sees that the system is needed, she would have added more training. Because it is like a benefit for the facility. But it was like the things are for Madalo, they are not for the facility. That's how it looks. Because they said, 'It's for Madalo', everyone was saying it's for Madalo, but not knowing that Madalo has given them to us, it's ours to use, to be keeping information.*

PI079	***Filipi*** **Clinician-male**: *A project indeed has a beginning and an end, it comes with its own things. Let's illustrate the EGPAF project, they support the HIV unit. They bring bicycles, they bring whatever. So should we say that – When they are bringing those things, they say these are yours, you should be using them. So should we say that they bring those things, will they take them away when the project ends, or are they for the facility and they will continue doing that work? Because when the project ends one thinks, 'Ok as I am working on this project, at the end we will have ownership, that this system we are using will continue'. But if we know that for this project at the end the things will be taken back, then it becomes 50-50, either it will continue or stop, because you think, 'Ah! This is somebody else's, it's for Madalo, they will come take them back' (laughter and agreements). That's how it is, oh! it's for Madalo. And the boss says, 'Keep them well –' she is the one who picks the pieces up, she says when she has picked them up, 'Keep them well, they are for Madalo' (laughter). She doesn't have the ownership. 'These things are for Madalo, put them here. Take care of them, I don't want to have to buy Madalo's things'. So you know yourself that, eh! a senior person is saying that (laughter).*
	e. <u>Inter-organizational partnerships</u>
PI080	***Bisitoni*** **Ground labourer 1 - Male**: *Even some people from the villages were wondering asking us that, 'Has Madalo perhaps bought this facility?' But we told them, 'No, they have just helped. They have helped. Because if we use these things well, maybe they will help us with other things'.*
	f. <u>Monitory incentives</u>
	g. <u>Input</u>
	Facility Development – High Adopters
	<u>Facility Development</u>
	a. <u>Improvements to facility security</u>
PI081	**Winistoni** **ART Clerk-Male**: *When the government built these facilities, security was minimal, we were just relying on a person. But the coming of the computers brought increased security. For example, every door where there is a computer, there are burglar bars everywhere. So keeping this very sensitive equipment is not difficult. We just take them, keep them in there and lock. No matter how (inaudible), you know that once you have locked, you will find them in the morning. But also, the coming in of the computers has improved maybe our friends who are on duty at night to be very active. Because they know that the computers are unusual things, and being unusual they know that if anything goes wrong, I will be answerable. So the security has been updated because they are always alert. On top of that, the security at the women's place has also been updated because of the coming in of the computers. Because anything strange that they hear outside, they are alert. So the security of the women has been upgraded because of the computers and also protected, because when they hear anything, then one two guards are outside knowing what is happening, unlike previously where without the computers the guards were just aaaaah, they were relaxed a lot, sleeping, and find that something has happened to the woman and when they find out, it's too late. But with the coming of the computers, it has made security to be very updated.*
PI082	**Ponekela** ***Security Guard*****-Male**: *The things that we were not expecting to happen, for example, are these burglar bars. The government would not have managed to install these burglar bars. They have made the security to be more protected. So*

	that thing is pleasing that they considered us by installing the burglar bars that improve security there. True.
PI083	***Dalitso*** **Medical Assistant-Female**: *The coming of computers here at Dalitso has also helped on the part of security, our security like at OPD. Because for the computers to be safe it needed doors that could close properly. So they put for us burglar bars which have reliable locks. Then instead of just keeping the computers safe, we are also keeping safe our equipment that we use day to day belonging to the government. Previously we would close but find that a mad person has opened and damaged some things. But now when we close, we have really closed. The other items are safe. Those burglar bars and locks that came because of the computers, that's a good thing.*
	b. <u>Bringing electricity to facility</u>
PI084	**Ponekela** **Ground Labour-Male**: *When a patient came at night, they were taking their small torch or anything that they could use during the time they were being served with the patient. So what happened by Madalo, the time they brought the computers, they also put for us one bulb inside that was able to be used only at the time we were with a patient at night. Such that the computers brought other things. So it's the bulb that has been helping us. In fact, when others saw that little bulb, they felt embarrassed that, 'Just one little bulb? Let's add some more'. (**Paul:** Who added more?) Concern. (**Paul:** Concern Universal or Worldwide?) Universal.*
PI085	***Dalitso*** **Medical Assistant-Female**: *At the time that there is no electricity, we are lucky that we still have power, with the coming of the computers, so that we can be using them. But on the other side we can also be using them, like when someone comes with a presentation, we can use the same power. Like maybe we have some fridges that need to be on all the time, power should be there. So that is a blessing on our side, even though, like that OPD building, it's like it is selective in its power supply that it doesn't go to other parts, it's only where the computers are. Yea. So still maybe this can be our opportunity that the fridge where we keep our vaccines so that the cold chain is not disturbed. If there the electricity can – If ESCOM goes off, there should be found sockets for the whole building. For us that is indeed our fortune that we have found of back-up, because we don't have any back-up apart from the one you gave us from Madalo. We don't have solar. So, yea.*
PI086	***Dalitso*** ***Medical Assistant-Male:*** *Since our colleagues at maternity work even at night, so even us we work at night, but if there is a blackout then no work done here. And it's not that the backup only helps in terms of lights only, no. It also preserves some other things for us indeed, as has been said that our fridges are at least active preserving our drugs. Indeed. But unfortunately the drugs are at the maternity ward, so if there is no backup, it just expires.*
	c. <u>Modernization of facility</u>
PI087	**Winistoni** **Medical Assistant-Female**: *The good things we were expecting are what we have said that when people come they say, 'This same Lilongwe DHO?' and we say, 'Yes, Lilongwe DHO'. And when there was internet, when people come they would say, 'Oh let me do this and that, let me check this, let me check that!' (**Male**: Yes).*
PI088	**Ponekela** **HSA5-Male:** *When I came here I was curious that eh! eh! this facility has computers! How did it make progress? It has been favoured. I was very curious. Where I was, there weren't any. Then to see they are being used here eh!*

	very superior.
	d. Other uses of the computers
PI089	**Winistoni Medical assistant-female**: *These people are being assisted. They come with their flash drives and are able to see their information in the flash drive. Yes, I mean just having it but you don't have a computer, where will you put it? (Others agreeing). Yes. That's good indeed. With their little things, they are putting it there, listen to some music, you see? So if the person was sleeping then they have stopped sleeping.*
PI090	**Bisitoni Ground labourer 1 - Male**: *Development at this facility, firstly the computers themselves, even when the people from the villages saw a change that, 'I think at this facility there will be unknown things indeed'.*
	Training & Supervision – High Adopters
	1. Training and Supervision
	a. Training participants & lack of training
PI091	***Winistoni*** **HIV Counsellor 1-Male**: *If there were several people, since we have departments here, there in ART there is a computer, HTC there is a computer, at OPD there is a computer, and then at maternity there is a computer, having a representative there, or two in each, to master the computer, it can go quite well.*
PI092	***Winistoni*** **ART Clerk-Male**: *At first the people who were trained to use the computer were very few. But because everyone is eager to learn the computer, that is why now many people are using the computer. As I've already said that at first there was a clerk, Soulos, right? But everyone who showed interest to learn how to use a computer – As Madalo you came in as a programme for the whole facility, right? And all of us were trained and there is no one who did not learn.*
PI093	**Ponekela HSA1-Male**: *When I heard that computers are coming, my expectations were that all of us working here will be trained on how to use those computers … Those expectations were not met because the HSAs who were trained are maybe two if not – They should be three. While we are eleven HSAs here, but the ones who were trained are three and our colleagues who were here, the ground labourer, are the ones who were trained. But the other HSAs are – When we are talking with each other, chatting, there are things like, 'We were not also trained'. The workload would then be less (unclear).*
PI094	**Ponekela HSA4-Male**: *It went well a bit. Why am I saying a bit? Those who went for training are a few people. To say the truth, I feel that this work burdened only those who were trained. Other people who did not learn were saying, 'Aaah!' Sometimes when they are a bit stuck they were leaving it and calling those who were trained and be there. So I can say rightly that this work, on my part, is challenging because learning that thing seemed to have been hard for me. I feel that we were supposed to have learnt properly so that the things can be used properly.*
PI095	**Ponekela HSA6-Male**: *I want to add that what they have requested, they have only requested training. Because when we talk about refresher, then it will be done only for those three people, while here the ones who do not know it are many. So if we take it as refresher, then you will arrange for two days, or one, for the people who already know it. While training will need several days, because you are starting afresh for people who do not know it.*

PI096	**Ponekela HSA1-Male**: *even though it went well so so, but on the parts that my colleagues are saying that if they could reach there, if the trainings were to take place, because there can maybe be abandoning the work to each other, that the work is not involving all of us. But this work is involving all of us, the HSAs, the ground labourers, or maybe the security guards, or maybe the MA, all of us as a health centre, it's supposed to involve us because we accepted this work at the beginning. It can be good work. But now the shortfalls that will be there, they should remember us quickly and come to assist us. As our colleagues are doing the training, if they can be coming quickly so that the work continues. Because you can agree with me that this facility is doing better on the computers. We hear about other facilities where they have been taken away from them, and so on. But we wanted you to support us that this work could continue, so that the benefits that you saw that Ponekela should have them, if they can be continued. All of us should be trained (unclear) that could be good, and the benefits of the computers can continue as we have explained.*
PI097	**Ponekela HSA4-Male**: *They prioritize people who maybe like to frequently stay on those things. For example, this other day I had an interest in it, to learn those things. But it was found that I was not being given appropriate attention, unlike the people who seem to already frequently use these things. They just – They came to change – I don't know what they came to change this other day. They just briefed the people who seem to do those things frequently, such that even my interest was gone that, 'Ah, I think these things have their owners who can do it, let me just leave it'. (**Male:** They were entering drugs?) Yes.*
PI098	**Jedawako Hospital Attendant 2 - Male**: *It happens that the clinician or nurse are away, so it is a junior who enters the data. In most cases it is a junior who enters the data. So it happens that they don't know anything about the computers. It happens the clerk is not there for a week, gone to a training. So it just stays idle. When it comes to training, you invite the senior staff (laughter and comments of agreement).*
PI099	**Jedawako HAS-Male**: *it happens that when the patient comes they meet with a junior at registration and when they meet the clinician, the clinician just writes in the patient's book and then they come back to the junior to write the diagnosis that the clinician writes in the book. The one who enters that data is the junior. The clinician just writes and that's all. So the computers are in the hands of the juniors. **(Female:** While for the training, it is the seniors who are taken.*
PI100	**Jedawako Ground Labourer - Female**: *Yet the trainings are given to the seniors, like the clerk, but the clerk doesn't do that work – **[Interjection:** The clerk does nothing!] We just see one day they tell us, 'I went to Madalo two days ago, I have chewed it'. **(Female:** It is really painful).*
PI101	**Jedawako HSA-Male**: *Most times – Of course it is not a problem of Madalo but here in Malawi that the one who gets the training is – (**Interjection:** The seniors) – the senior person, who will not use that on the ground. This is a Malawi problem. So this is something that needs to change. We are not saying that training a senior is wrong, no, but the process is what we see that the channel is wrong. Like at this facility for example, had it been everyone was trained in these things then we would have made advances in this area. But because it was only a few who were trained, maybe three, but when we observe those three, all of them are not settled here for a long time, but the ones you find here are those who were not trained in these things. That is what is contributing a lot to the situation where for the computers there are jitters.*

PI102	**Jedawako Hospital attendant 1 - Female**: *Even at maternity, we heard that Mercy went for training but that job can be done by a hospital attendant because they are the ones who are like their assistants, while her she is very busy.*
PI103	**Jedawako HSA - Male**: *We are not saying that it is bad to use the senior members of staff. We should remove those thoughts. Always, wherever there is a leader everything is directed to him. But there is need for the junior staff members to be trained as well for proper flow of information and successful succession planning. When the senior staff is being trained, the junior staff should also be trained so that when the senior staff is not around, the junior staff can do the work.*
PI104	**Dalitso HSA2-Male**: *I expected that many people would know computers here, but aah! Not really. Many don't know. (Some laughter)*
PI105	**Dalitso HSA3-Male**: *Most of the workers don't really know the computer. So it was necessary to have adequate training so that the work can be done quickly, the queue should not be there and people should leave quickly.*
PI106	**Dalitso HSA4-Male**: *What is really needed is training should be extended to many people so that others know it, we should be taking over from each other there. Because the people we see are the same ones. So what if they are away, gone to town for salaries? That means work stops, we take short cuts. Registers, back to the registers. So we are confusing things.*
PI107	**Dalitso Ground Labourer-Male**: *if the opportunity is still there, there is need for the number of people using the computers to increase, for the reason that the work will not be hard or that there should not be a lot of complaints. Because the complaints become much when the one who knows it is not there that day so the computer will not be used. But if we were more, it would be good because someone else will be able to do that work without problems.*
PI108	**Dalitso Nurse-Female**: *I think that, if we look carefully, some of our colleagues were not trained. The ones who were trained are few. There came a program that they would come and would finish the rest of the people. So it seems others were not trained, especially, let me say, our colleagues the HSAs. They have opportunities that maybe they can come and help with the computers. If several were trained, I feel that the work would not be difficult. Because it would be they are passing by, they help. They are the ones we appreciate a lot, like when we have problems at the maternity ward, family planning and so on, they assist us. So if they would be trained on this part, because they are many, and they also have some free time, that would help us.*
PI109	**Dalitso Medical Assistant-Male**: *As my friend has said, that other people have not been trained. And when we look at the computers the people who are found there are the same ones. But our HSA colleagues sometimes are found to have maybe fieldwork that they are supposed to do, so it seems that we again have a shortage. So if you look at the other departments, despite security-wise, but the things are there. Like at HTC the computer is there, I have seen it. But because the people who have learnt how to use and how to manage those stuff are few and they are found maybe they have gone to the field, so it's kind of not functioning a lot. But as for OPD, as my colleagues have said, that at least we are better off that we use it. There are a couple of us who are able to manage.*
	b. <u>Training content & scope</u>

PI110	***Winistoni*** **Medical Assistant-Female**: *The training was like some of the people had to be aware of what is happening, but if there are others who need special to be trained that you should be dealing with what here – the computers. When anything went wrong we had to call the computer, 'Hey, here things have gone like this and that', so that when they come they will know that today we are going to print, we are going to enter diagnosis, we will change roles like we do with the other work. Yes, so for those ones they needed a training that will go in details, how the computer works. Like that, it would have been beneficial to us.*
PI111	***Winistoni*** **HIV Counsellor 1-Male**: *Like what the clinician has said that when something went wrong we used to call, 'Come, we have jammed somewhere!' and there they tell us, 'We are still looking for transport!' (laughs) and then they come maybe when the sun is already down. While if there were a few people who, no, we'll deal with it properly and when it has become too difficult for them, that's when they can communicate.*
PI112	***Winistoni*** **ART Clerk-Male**: *You just said, 'We will come and teach you on report writing'. Verbally. You did not come to tell us how things are supposed to be, it just ended there. So somehow, we were a bit disappointed. So our expectation just ended up hanging, we didn't know what to expect.*
PI113	***Winistoni*** **HIV Counsellor 2-Male**: *You can see that the smallest troubleshooting, we have to report to Madalo, 'Can you come and fix this! What should we do?' The smallest thing, 'Can you tell us how to do this?' You did not tell us we should do this and this and this. So we have the impression that the computers are giving us problems. But in fact the computer here is fine. If you release your knowledge so that we know about the computer, then we will do the work properly. There will not be any more confusion, or to – ummm – Our interaction with the patients to be problematic? No! Everything will go well. But the issue here is that, the information that you have, when training us, was hidden from us. Because the training was very short.*
PI114	***Winistoni*** **Hospital Attendant 1-Male**: *It's just unfortunate that we haven't been given the complete skills (hums of agreement from others). If you had given us the complete skills, then we would not be writing in the register, using the computer only.*
PI115	**Ponekela** **Ground Labourer-Male**: *We told them that, 'What is needed here, you have given us the equipment, it's ours, you should take us somewhere to be taught the maintenance of this equipment so that we should not be calling you'. So our friends are not coming again, did not return to tell us, 'Guys', maybe two or three, 'The maintenance of a computer is like this'. No. Yes, it's how we did at Madalo, we went there for one day, some few hours in the evening. They would also come and tell us here and there. But it's not that maybe we have really known. It's just that because, since it's something we use day after day, we were like some of us can understand the computer. But not as is required. So the request we already made was that we should know everything, since we have been given the thing. Should we keep calling them, 'Ah come, come!'? That is what troubles us.*

PI116	**Ponekela HSA2-Male:** *When something goes awry, for those who come to train us about the computers, they know that when we are using these things, the first thing that starts failing is this and that. At least if there would be the idea that was said by the ground labourer that there should also be an opportunity to make known to others that a computer quickly starts failing in these, and when it happens you need to do this, touch here, touch here, touch here. You will see that not long thereafter the computer is doing its work. It's very different for maybe a person who has been trained can handle and fix it, from waiting for only the person who knows that thing well. It will also take time, and as a result you have stopped working. But if it was like that, that they were also trained that when something goes wrong, they will fix it, and at the same time you are continuing working.*
PI117	**Jedawako Hospital attendant 1 - Male**: *There are also other things that there are problems with the computers that are very minor such that if someone was trained we would not be calling people from Madalo that, 'Come, come, come!' as they are very minor. For example, they could be loose cables that are causing the problem and they come and tell us that this is the problem. So if two or three people were trained that if there is this problem then do this, it would help. If there is such a person here, I doubt it.*
PI118	**Jedawako Ground Labourer - Female**: *Also we were expecting that as they come maybe two or three people will be taken to be trained so they have indepth knowledge and come to explain to others back here that this is how things are. But there is only one, or maybe there isn't anyone.*
PI119	**Jedawako HSA-Male**: *What they are trying to mean is the trainings, like what I said before that our expectations were that we shall be trained in computers. We thought that there would be a special training concerning what?* ***(Interjections:*** *Computers) – computers. But you just came here, this is a mouse, this is (inaudible), for [bespoke eHealth system] this is where you go. Issues about putting in drugs or ports they were telling the seniors, the juniors were not there.*
PI120	**Dalitso Medical Assistant-Female**: *When they are called, they should be responding quickly, come and look at the problem for us and fix the problem for us, and tell us what we should do next time. Because they can just fix it for us and not tell us, so we will just keep calling them. But if they explain to us that when this happens, do this, there will not be problems.*
	c. <u>Training length</u>
PI121	***Winistoni*** **Medical Assistant-Female**: *Our training also, I think it was very short. It's just that maybe we were catching up quickly, but the training was too short for people who had – who were completely blank, we didn't know anything. It was too short. In fact, we still find other things to be what – (**Male**: difficult) – difficult.*
PI122	***Winistoni*** **Hospital Attendant 1-Male**: *Mainly you should increase your trainings so that we are well skilled.*
PI123	**Dalitso HSA1-Male**: *I feel that the computer trainings somewhere they were like superficial. Because for a person who has never touched a computer, you can't teach them for two days. What then will they do there? It becomes quite difficult.*
PI124	**Dalitso HSA4-Male**: *Our evidence is the banks. Banks have queues, from here to there. But because those people have mastered those things, and their training was not for a few days, they have known everything. That's why things are fast, and within an hour, two hours, the people in there are out.*

	d. Training style & logistics
PI125	**Ponekela HSA2-Male**: *The time that they come, they have to approach us in an orderly way. Not just – You can give an example of a teacher. Today they teach malaria. Then they include malaria, diarrhoea, bilharzia, at the same time! You find that the student at the end is bewildered, because they will not know what is the difference between this and this? And when I get here and get here, what will be the difference with that there and there? So when our friends come, they do all those things in a short period of time but also very quickly. So for a person who is unfamiliar with that thing, you find that you are just bewildered. Maybe also even to have an interest that, 'Ah, I should also go learnt about – It will just waste my time. Maybe those people are doing that because they don't want me to know that thing'.*
PI126	**Jedawako HSA - Male**: *Few of us went to be told how to use the computer and it was just a few hours and no one could say that they know the computer well and it wasn't good because they were just told that you can jump and you will find this, without knowing why they are jumping, they were not told that.*
PI127	**Dalitso Nurse-Female**: *We welcomed it well. And it was pleasing when we went to the training, there was at some points some jokes on each other (**Male:** Indeed!) (laughs)*
PI128	**Dalitso HSA3-male**: *If there could be some manuals somewhere to leave here so that when somewhere there is a difficulty, we can be checking two or three of us that, 'What is meant here? What is meant here?' Maybe we'll not even need to be going that far. (**Paul:** Oh, there is no manual?) (**Female:** Yes).*
	e. Peer training
PI129	**Jedawako Ground Labourer - Female:** *When we came here and were told that we will be using computers and we started using them and others taught us, since we were not formally trained, but because of our interest, we found that we were able to try and know some things.*
PI130	**Jedawako HSA-Male**: *there are some problems which are simple to resolve which some members know how to fix them but the few people who were trained do not share the information and when you call them they do not give you instructions on how to go about it. This is the disadvantage of providing training to one group of people.*
PI131	**Jedawako Hospital Attendant 2 - Female**: *some are so busy that they cannot find time to train others on how the system works.*
PI132	**Dalitso Nurse-Female**: *Mr Bongwe will be teaching us, Mr Nkhata, there are people who know it. We'll be asking them to help us, how should we click (laughter). Yes.*
	f. Follow-up training, mentoring & supervision
PI133	**Ponekela HSA4-Male**: *We people are in different categories. There are some who are fast learners, there are others the slow learners. And the issue of computers, it seems that since they came to teach us, they don't come again to teach again.*
PI134	**Ponekela HSA2-Male**: *To the people who were trained, we thought that maybe they will indeed be bringing refreshers so that these people will be being updated. But instead of being done these people and the rest of us who did not undergo the training are also being pressured to know that thing very well. Because I understand a lot that being trained by a person who knows this thing a lot and is fit to train others, and being explained to by your colleague, they are two different things. So if maybe there was an arrangement like how you have come today, if it happens like that, it should be like it is continuing, like has already been explained*

	that you have trained those people, let's go and refresh them to see how the work is progressing.
PI135	**Ponekela Ground Labour-Male**: *We don't want to say bad things, that we disappointed each other with the people who have been managing this program, from Madalo. No. But they were taking some days without visiting us to see where the program is. So we should just request that when you go back, you will tell our supervisors that those guys, maybe you should be getting there frequently.*
PI136	**Ponekela HSA6-Male**: *Good work follows supervising that person. Because a person is able to know that, 'This person I have given this work, how are they performing?' And also the person who is doing the work has a lot of motivation because they know that if there is something going wrong, or it is going awry, then reporting is not difficult. This is different from a person saying that this is the thing, just put it there, and they will be coming only maybe when there is some problem that this and that. That work there does not also have quality. So I was expecting a lot from there, that we should be monitored. That's what is really needed, that indeed we should have work that is of quality, that even when you come you will be praising that, 'Ah! Guys, you are really doing good work'. Yes, there.*
PI137	**Jedawako HSA - Male:** *I can give an example of a villager given a phone, who has never had a phone before in their life, even a cheap phone, it is difficult for that person to use it, then what more things like … it's really like that. Slowly (inaudible) by providing support and explaining to them where there is need for explanation it can improve quickly, maybe not quickly but you can tell there is progress.*
PI138	**Dalitso HSA2-Male**: *I want to ask you if at Madalo, when you have sown seeds you need to be visiting it, not just sow and abandon it. You should be coming frequently, because there are some things that go wrong as I have explained. So when we see that you have come, at least we work harder. But also when you hear that, 'They are coming to visit', the way work is done is different from the other times, you try hard so that when the person visiting comes, they should not be disappointed. Indeed. I wanted to request that.*
PI139	**Dalitso Medical Assistant-Female**: *Perhaps many things will also be challenging because of lack of supervision. There is still need to be visited frequently. Where things are going wrong, it is easy to correct a person that, 'Here it should not be like this, it should not be like this'. Because there is – We are still meeting a lot of challenges like password failing to log in, so for a person to go into the system is failing, or network is gone and you don't know where to press, so it becomes quite difficult for us and you need to come frequently so that those people – We should be able to know that when it's like this, we should touch where.*
PI140	**Dalitso Ground Labourer-Male**: *I was just thinking that, as you are saying that the project is continuing, it's what the others have said that there is still need for small trainings frequently. The reason is that when those people have gotten used to it, it will seem that the issue not difficult. But also a person will have the interest and have the thought of being found there often for the reason that they should learn a lot and also things should be done quickly. Yes,*

	indeed.
PI141	**Dalitso Medical Assistant-Female**: *We are still in a learning process, so they shouldn't just let us go but they should be visiting us frequently, reminding us.*
	g. Timing of trainings & supervisory visits
PI142	**Ponekela HSA-Female**: *Your colleagues who come to train us, maybe if they would have time to observe. But also, messages maybe should be that when they are coming here, the one who is over there should know, and the one who is at another place should know, so that perhaps when they come, all of us should be together. Adequate time, if it can be maybe an hour and a half. Because the way it is done, let's just compare the time we have been here, the time we have been here maybe is longer, they would have already taught us and gone. So it seems to be transitory, really just short-cuts. So then the time that they teach us should really be quite adequate so that we should also be able to understand. (**Male:** Often it is maybe ten minutes – (**Male**: Twenty only, just fifteen. Do this, do this. That's it.) But it is also quick, following it is difficult. (**Male:** So for slow learners like us to get it, considering that since birth we have never touched it before (laughter) it was quite difficult for us. So it's a request. Yes.)) A computer is not something that you can just flip flop.*
PI143	**Ponekela Ground Labour-Labour *Male*:** *What was happening – You really need to take those words. But it's not that those people were coming in the morning, when these people are often found here. No. They like to come in the afternoon hours. So the people have worked and have returned home. So what can be established here is that maybe they should be coming here in the morning. So then when they come here they should be giving us – There should be a day in-between so that on the third day, we should be sending messages to our colleagues so that they can be present. That can be helpful. But if they still come in the afternoon hours, they will be missing these people.*
	Training & Supervision – Medium Adopters
	1. Training and Supervision
	a. Training participants & lack of training
PI144	***Sinelia* Midwife Nurse 1 - Female**: *When I arrived, since I found these things, I was expecting that maybe because we are new people then some people will come to train us. But I saw that that didn't happen. Such that this other time they came and I met them, they indeed took names, and entered them. But because here I can say that there is no expert in it, it was found that the issue muddled up.*
PI145	***Sinelia* HSA-Male**: *Like on the part of HTC and ART, I feel that the main problem is the training that they said they will be trained first before using it there. Because those people there were told, 'Wait, we will tell you that we have installed everything required, you can start using it'.*
PI146	***Sauko* SHSA- Female**: *There were concerns. Is the training they have received only for them, such that the rest of us are in deep waters?*
PI147	***Sauko* Ground-Labourer 1-Male:** *the people who were taught computer, most of them have left this place. They received transfers. The ones who we are left here are a few who are here of the ones who went for computer training.*

PI148	***Sauko*** **Hospital Attendant-Male**: *For me, I would have really loved it if our colleagues who went to learn about computers, we have already heard that other people who were here have left, and now there are a few people remaining. So I would have loved it if this program, everyone should know it at this facility, especially us who work at public health office. The person who, like my colleagues have said that ground labourers, you find that they go and do other work. So at the time that they have been sent somewhere, that means the work will not be done. So for us, we would have loved if maybe almost every department, they should know the job, two or three, two or three, whether it's among us loving each other and teaching each other, or you take part. I think that would be good.*
PI149	***Sauko*** **Community Midwife Assistant-Female**: *We are just waiting to be trained so we can see (unclear).* ***(Paul:*** *Did your colleagues not train you?) No. We came while the system was already here. That's why I was not answering anything, I was just quite.*
PI150	***Sauko*** **Hospital Attendant-Male**: *For me, I would have really loved it if our colleagues who went to learn about computers, we have already heard that other people who were here have left, and now there are a few people remaining. So I would have loved it if this program, everyone should know it at this facility, especially us who work at public health office. The person who, like my colleagues have said that ground labourers, you find that they go and do other work. So at the time that they have been sent somewhere, that means the work will not be done. So for us, we would have loved if maybe almost every department, they should know the job, two or three, two or three, whether it's among us loving each other and teaching each other, or you take part. I think that would be good.*
PI151	**Malilika** **Lab technician - Male**: *But at maternity, because of rotations, that the one who was trained has been rotated and gone to the ward working at the ward for three months. It means the one who has remained is stuck, so it becomes difficult. So mainly at the maternity is rotation. But other places they are waiting for training. Because the [bespoke eHealth system] we were trained at first is not the one we are using. At first they brought software and later they changed it and brought another software. For the second software, people were briefed, but mainly the nurses who prescribe. So the change affected even like at the lab and also other places like what I said that people are waiting for training.*
PI152	**Malilika** **Laboratory Technician-Male**: *what was challenging is that it is not all of us at this facility who have learnt what a computer is and how to use it. So when the computers came, we started with [bespoke eHealth system], while the basics of a computer, they can't type, how the keyboard is, it becomes difficult. So, many have tried their best to slowly learn, there was interest. So here at Malilika, the thing is slow, we are doing it little by little, everyone should know the computer, then the programme, the software, they should know it. So we are doing it.*
PI153	**Malilika** **Dental-Male**: *the heartfelt need is there for them to really have that knowledge, because it's a good thing. So those who had the chance to slowly learn are few.*
	b. <u>Training content & scope</u>

PI154	***Sauko*** **Ground Labourer 1 - Male**: *Since for the owners of the computers, as we have said computers are coming here for the first time, the care of them, that this thing should be safe and so on. Of course they explained to us that, 'It needs to be like this, like this', but maybe because of our lacking, this thing, what can we do for it to be cared for? Somehow it becomes a bit difficult for us. Our worry was there, because when this thing is damaged, when some things are damaged you do this and this, of course they explained it to us, but some of these things have never come up to now. We are still using them, they have become dusty, such that if anything happens then I say, 'Ah, what is happening here?' You just get surprised and say, 'The way this is appearing, it is not well'. Now because the things that they taught us we have not received even one, for example there are barcodes and they say there is something inside, barcode printer,* ***(Paul:*** *Scanner?) yes, scanner, and so on, things that were explained to us, but those things we have forgotten because that thing did not come. Because when someone explains something to you, that thing should come then you know that, 'Oh, here we go through here, go through here, go through here'. It's the same as exams, when you have been taught, you say, 'Ah they taught me this, so if the question comes from here the answer will be this'. So, most things like those, eeh! just went by, I shouldn't lie. My worry was there because those things we just learnt but up to now they haven't come. An example is that I have given a number to a patient, they have then lost the card. While that paper that you call a scanner, when you just paste it, it has been pasted indeed. For it to come off then the card reached some extent, maybe it got soaked or maybe the person lost it. So I see that to be an extra worry.*
PI155	***Sauko*** **Hospital Attendant Male**: *For me the worry that I had, I have seen that it has been realized in terms of what I had said earlier that if something is damaged, then they will just be grounded while waiting for the person who knows it well to come and fix it. So it really happened that dust entered inside it and it was just dormant for several weeks, up to now it is not back. So my worries were realized in that if people went to be trained in everything, this problem would not have occurred. There would have been found someone like an expert and fix it, and now it would have been working.*
PI156	***Sauko*** **Ground Labourer 2-Male**: *you find that because we were not told properly what we should be doing, calling that brother as has been said by Stain Phiri, so that if they also tell us about these problems that, 'If this happens, you need to do this, if this happens it needs to go like this', that also gives other problems. But mainly we are very grateful for our other colleagues who direct us, those of us who went to learn computer, who you sent as people who work there, assisting us. Even though sometimes our airtime is not refunded (laughs), yes, because the government pays, they give us airtime that, 'You should be calling here when something goes wrong', but there we do not receive.*
PI157	***Sauko*** **Ground Labourer 1- Male**: *There I have seen the causative. It could be the server. Maybe the server was disconnecting, because even there the server was disconnecting us. Maybe it's because it has taken a long time, maybe because of not having been trained that when something goes wrong then we do this and do this.* ***(Male:*** *They should send us abroad to learn. To Scotland (laughter and comments).) But if that server was okay, but also training us that, 'When things go wrong here like this, you are then required to do this, maybe do this, you should also do this', then it will function. That would be a good thing.*

PI158	***Sauko*** **Ground Labourer 1-Male**: *something that I seem to have forgotten is the issue about batteries. They did not train us how it is. That here, whether it is going down or going up these batteries, how it goes, that we don't know. Taking into account tomorrow or the day after if things go wrong.*
PI159	***Sauko*** **Ground Labour 2-Male**: *Our colleagues have raised concerns that they need to know everything. There is one problem that even when we went for training we did not learn. For that person to have password they come and set it for us individually. They have not trained us that, 'On your own do this, do this, do this, do this' until the person learns. They did not train us in that. We look like we are stingy, while for the passwords, even if we were to tell our colleagues, we didn't learn at all about passwords. Even our colleagues would have been able to log in, but we have to wait for the people from Madalo. When they come as these guys have said, you hear, 'What is your name?' 'This and that', 'Ah come, this is your password'. If they had told us, everyone's password would have been in. But now we have to wait for people from Madalo to come and train us. So this thing I think can be simple, training someone to know it that we go through here, here, here and find that the person's password is set. For example as we are speaking the passwords that can be found are for only a small number of people, including those who have left. Like our colleagues at maternity, for example, there are others whose password have not been set up, up to today, but when you go to Madalo you will find that their names are there, but at the maternity when you put it into the computer, it doesn't come out. But for us, ours come out because they were set there, and also some were set here. So I think that maybe if they train us that a person should go into the system so that their password should not give problems, it should be in there, we go through here, through here, we do like this, like this, they didn't teach us that. So if there can be such an opportunity, that they train us, so that our colleagues can find that chance. Because the computers can just come, you install them everywhere, but for the password you have to wait for people from Madalo again to come and assist us. Or even for us, when it expires, the password expires (laughs), of course I know how to go about it, take it there, there, there, until it comes and I can log in. But how can we train our colleagues? It's difficult for someone to immediately go into the system and be stable. So my request is for those guys to train us there so that we can assist our colleagues. We should also know those things.*
PI160	***Sauko*** **Hospital Attendant – *Male***: *I still feel that things are not going well. The things that I expected have not happened. Because the people who were sent to be trained were supposed to be two or one of them to know how to fix that thing, such that when it has a small problem, they can instantly work on it and the work continues. But when it has just become dusty we wait until people from Madalo to come and fix it. So the things that I was expecting are not those. I was thinking that the thing that you have given us as a gift, that we should be using at this facility, we should also have the know-how that when there is a small problem, we should be able to fix it ourselves, things that will not need money if the items that are needed have been given to us.*
PI161	**Malilika Laboratory Technician-Male:** *What we were expecting at Malilika was that when they come they will start computer training. So it became difficult that we started with [bespoke eHealth system] and some very basic things that cannot change a person that they know computer. We were taught [bespoke eHealth system] more while the person doesn't know computer. So it confused people and not understand the computer and it took our bosses to sit down and*

	organize computer classes. So it was unexpected that we will learn [bespoke eHealth system] while we don't know computer.
	c. Training length
	d. Training style & logistics
PI161	*e. Peer training*
PI162	***Sauko*** **Ground Labourer 2-Male**: *we are very grateful for our other colleagues who direct us, those of us who went to learn computer, who you sent as people who work there, assisting us.*
PI163	***Sauko*** **Ground labourer 2- Male:** *because of the coming of this program, it has made some of us to know where to press for the computer maybe to switch on through just our colleagues telling us, because I did not go to the training.*
PI164	***Sauko*** ***Male:*** *I am one of the people who did not go for training, I was trained by this gentleman here what you trained him at Madalo.*
PI165	**Malilika** **Cashier-Male**: *there was a burden that now there were few. People would come from maternity to come learn here, from general ward to come learn here, because of few number of these things. So just because this is our chance, grace has found us, if it was possible and there were many then maybe our learning would have been much quicker … But when you are doing it yourself, because you say we learn through corrected mistakes, so through that we would have now been at a good mile that we now have an attempt of how to use.*
PI166	**Malilika** **Laboratory Technician-Male**: *we are all different people, some are nurses, here we don't have clinicians at the facility, so the ones being trained are nurses or the ones we are seeing now. So these guys are always mobile, they can be at the ward full time, they can be anywhere. So when the training is coming we find that to find someone here at OPD, when that one is trained, then the next issue is that you should train your friends who were not there. So to be trained by your peer it's like two blind people, it is different from (laughter from others) the one who knows that work. In fact, there are only a few here who were met and trained properly by people from Madalo. Most of them it's like, 'They say we should do it like this, it's like here we should do it like this'. So that also contributes to failure. But also, for example, there are, let's say pharmacy or at the cashier, it happens that someone, like someone is at the ward, the one who has been trained, so the one who was trained at the cashier's is a certain lady who as we speak is at school, and these guys were just told 'Here you should do this, here you should do this, here you should do this'.*
PI167	**Malilika** **Dental-Male**: *our bosses tried their best, my friends can bear witness. They told us, 'You should learn! Those who have not learnt, we're giving you a time limit'. When that time came they asked us, 'Have you done some learning?' So that on our own, because that thing, if you think that it is important, we should try to really teach ourselves. Maybe this one knows, they would say, 'I will teach you a bit what I know'.*
	f. Follow-up training, mentoring & supervision

PI168	**Malilika Cashier-Male**: *in my thinking, we are lacking the motivation factor. I'm not trying to say money. At first, at least you used to come frequently. When those people were coming, right? they used to train us and other things and we felt good with the coming in of the development, right? and then they just disappeared! So it was like, us, how can we be motivated? Those people came to tell us that we will be using these things but then now they are not coming. I know money is not a motivation factor, but to say "thank you" and being encouraged, you become motivated. So they just stopped. Then, you are coming here with this evaluation. It's like somehow (laughs) you are giving us a drawback. So at least that's a distress to me (inaudible).*
PI169	**Malilika Laboratory Technician-Male**: *for the people from Madalo to visit us, it was difficult, like there was communication breakdown. Sometimes they would say 'We'll come', then silence, they don't come. So that has made the system to be a failure. We didn't know where to go, no direction, we would just say, 'Aaa let's do it little by little'.*
	g. Timing of trainings & supervisory visits
	Training & Supervision – Failures
	1. Training and Supervision
	a. Training participants & lack of training
PI170	**Filipi Clinician-Male:** *When it comes to the facility, she should appoint people who should go for the training.*
PI171	***Bisitoni*** **Ground Labourer 1:** *please if we receive a new doctor/ in charge please come and discuss with him/her about training so that he can also give you the recommended people who are willing to use the system rather than getting the whole team with people who are not willing to use the system, because the ones who were trained do not avail themselves frequently. It is only me and my friend who used the system.*
	b. Training content & scope
PI172	**Filipi Cashier - male:** *What I wanted to say is that, for our failure, maybe you also contributed. Because those people who were coming, I mean the IT staff, they would do – Whatever was a problem for us, they would just do it there. They come here and install it in the system then find that the owners of the system themselves are failing. Then say, 'Ok, we'll come tomorrow'. Then it would take two months, or maybe even one month, before coming. When they come, they would come with a strange thing, then they would manage. So for us that strange thing was difficult, they have just done it secretively, now what do we do here? So I wanted to say that our failure, maybe you also contributed. (laughter)*
	c. Training length
PI173	**Filipi Clinician-Male:** *At the training, it's true, it was still, for a person who has never touched a computer, it was difficult for them to learn many things in one week. There it was difficult. It was two hours, it was little.*
PI174	**Filipi Patient Attendant-Female**: *I did not go for the training. I was just taught by my colleagues here.*
PI175	**Filipi Senior HSA –** *The challenge that remained was that, among our friends who went for training, it was mainly that the training was short and also it was busy because to be commuting people to and fro was tiresome.*

PI176	**Filipi HIV Counsellor – Male:** *On the part of the training, because (unclear) they were short, because it would happen that we leave here at 12 o'clock and arrive there at around half-past-one, starting at half-past-two, then at half-past-three we are coming back again. So I feel that the time for training was a bit short.*
PI177	**Filipi Cashier-Male:** *Maybe the challenges can be, we had a training that wasn't – just inadequate (**Male:** It was a briefing). A briefing (laughter).*
	d. Training style & logistics
PI178	**Filipi Senior HSA –** *The challenge that remained was that, among our friends who went for training, it was mainly that the training was short and also it was busy because to be commuting people to and fro was tiresome.*
PI179	**Filipi HIV Counsellor – Male:** *On the part of the training, because (unclear) they were short, because it would happen that we leave here at 12 o'clock and arrive there at around half-past-one, starting at half-past-two, then at half-past-three we are coming back again. So I feel that the time for training was a bit short.*
	e. Peer training
PI180	**Filipi Senior HSA –***I saw that somewhere it will bring us benefits that, maybe knowledge, more especially those who did not go, maybe about small things, we can help them through our colleagues who went for the training. So for me it was also – We would have found a chance to help with other things, because it would need someone who maybe has done that thing in detail. But there are other things that are at a level that we can just orient one another, because the one who has proper knowledge is able to orient their colleague. But the challenge that remained was that, among our friends who went for training, it was mainly that the training was short and also it was busy because to be commuting people to and fro was tiresome. So the content that was there may have been completed, but not to the capability that those people would be able to orient their colleagues at local level, that, 'These minor things we do like this, like this, like this'.*
PI181	**Filipi Patient Attendant-Female**: *I did not go for the training. I was just taught by my colleagues here.*
PI182	**Filipi Patient Attendant 3-Female:** *Many who were trained there taught us.*
	f. Follow-up training, mentoring & supervision
PI183	**Filipi HIV Counsellor – Male:** *When you have learnt something you need a bit of refresher, and the refresher has not happened, the things have been taken back. So I feel maybe if a refresher course had taken place, it would be like we have been reminded to add to the training we received, then maybe it would have done us good. I feel that it was a barrier, it was leading us to go backwards.*
	h. Timing of trainings & supervisory visits
	Computer Knowledge & Competency – High Adopters
	a. Knowledge gained
PI184	**Winistoni Security Guard 1-Male**: *I should admit that I am thankful for bringing the computers. I was ignorant, without knowing what a computer was, so because of these computers I have known how a computer works. I was just hearing, 'mouse, mouse, mouse', I thought that I now have to be knowledgeable*

	(others laugh) that this is how it goes. So firstly I should say that it has enlightened I on other things like what is a computer.
PI185	**Winistoni HIV Counsellor 1-Male**: *With the coming of the computers, some things have changed, especially my knowledge of the computer, that what is a computer. Without going into details, it seems I have made it.*
PI186	**Winistoni ART Clerk-Male**: *For me, I had no knowledge in computers. With the coming in of computers, it has increased my knowledge. Before, when there was a problem we would call James. But now I know where to fix things, so now I'm like the second James (laughter). So I see that there my knowledge was increased.*
PI187	**Ponekela HSA3-Male:** *we have also seen a lot that we didn't know as Ponekela clinic. How to enter diagnoses, how a computer works, we see that we have learnt quite a lot that we were just envying at other places when seeing our colleagues, but we have seen that it has become easy for us because of the computers.*
PI188	**Dalitso HSA2-Male**: *when most people leave from here, they will have knowledge about computers.*
PI189	**Dalitso HSA2-Male**: *The people for whom you have set up accounts, maybe who have the passwords, are still the same ones. But we are quite a crowd. I am asking that maybe when you have a chance you should open for some of us the accounts so that we can go into the computer. It happens that maybe you have arrived at a good time, but you don't know where to begin.*
	b. Confidence using computers
	Positive
PI190	**Winistoni Medical Assistant-Female**: *As an individual, it's easy now to use the computer when you go somewhere else. Because we know which buttons to press. When they say, 'Open the computer', one can open it. There, our minds have been opened.*
PI191	**Dalitso HSA3-Male**: *Our plea is what I have said already about the trainings, because they are explaining that somewhere there is TA, group, it becomes not difficult if the person is very fast, because all the groups are already in the computer, just start with the first letter then the group has already come out. So it needs to be fast, a person has to be fast.*
PI192	**Dalitso Nurse-Female**: *For me, I thought that it would be – It's faster, I should say. What needs to be done is just – Those people, like we have complained that the training – Perhaps the people should be well-trained, everything will be faster indeed. The queues will be well reduced. Because like there are others who know it a lot. Because we can't say all of us do not know it, others know it a lot.*
	Negative
PI193	**Winistoni Medical Assistant-Female**: *To say that this one has become settled on the computer, we have a challenge in the maternity that we have old mamas who are unable to use the computer. Also, to say that there they have their own vocabulary, so for another person to go, they don't know their vocabulary (**Male**: they don't know it) so it becomes a challenge. But for those who are trained, they can be capable as they have been trained for a long time. Those things that appear there, they can be translated one by one by one by one by one. Now when you take them to maternity to enter maternity data, I think they can make it that simple.*

PI194	**Winistoni Security guard 2-male:** *If these people were well trained in computer, then it wouldn't take time because when you write in the computer then it would be possible because writing manually takes more time. What the biggest problem is, is skill.*
PI195	**Winistoni HIV Counsellor-Male**: *At antenatal, that's where if the owners were here, they would have been in a position to say. However, it did not go well because when we come to them and ask them, 'Among these clients you have seen, have you recorded any of them?' they say, 'Aah, I don't know, this thing, I don't know. You should just be coming to be recording in it'.*
PI196	**Winistoni Hospital attendant 1 - Male**: *At antenatal, the problem is that the person who really knows the computer and can be helping the women there, is not there. That is why there, it seems things have failed. So the main thing: experience. The problem that I have been able to capture is that. Because if there was proper training, that the computers have been known adequately, there would also be good things there. But because all of us are amateurs, (laughter) there is no one who knows it, so that is why it seems to be failing. If we knew it well, (laughter and comments about the word 'amateur') it would not have been possible for things to be difficult. One person would have been going there to assist. But because they do not know it, it becomes difficult. So what needs to be done is to train everyone to know about everywhere. Then the whole problem will end.*
PI197	**Ponekela HSA4-Male**: *We people are in different categories. There are some who are fast learners, there are others the slow learners. And the issue of computers, it seems that since they came to teach us, they don't come again to teach again. That there are some staff who, maybe as my colleague is saying, because we are all new here, maybe three people follow it, meaning that the people who are burdened with the work on the computers are the same one who seemed to have understood those things quicker, unlike other people for whom it is difficult to understand those things. Yes, in another way, I want to mean that at the register we indeed to go to assist, while these need a person to know them well so that you do not damage other things.*
PI198	**Ponekela HSA6-Male**: *I am not a stranger, I am old here but I don't touch the computer, I don't want to disrupt it for them.*
PI199	**Jedawako HSA-Male**: *You talked about staff members, it is true as some members do not even know how to enter password to log in into the computer.*
PI200	**Dalitso HSA1-Male**: *A person uses the computer with two fingers, perhaps even just one, paaa! one, then you search for 'm' on the computer while there is a big queue … Let me say that the use of the computer, these fingers indeed are heavy for some of us. Indeed.*
	Computer Knowledge & Competency – Medium Adopters
	1. Computer Knowledge and Competency
	a. Knowledge gained
PI201	***Sinelia* Hospital Attendant 2- Male**: *I saw that no, my opportunity has found me, I should also click it, and saw that it is happening. Ah it's a very pleasant thing. (**Paul:** So it happened that you learnt how to click?) It has happened indeed. I know [bespoke eHealth system].*

PI202	**Sauko Ground Labourer 2 – Male**: *For me, the coming of the computers has helped me a lot. Being helped in that this facility is a health centre, and Madalo is surrounded by many health centres, from where people go to Madalo. It's our good fortune that when I go to another facility, because I know this, I will be an expert there. So I see that in my life it has helped me a lot, because those things, I was far from them. And with that good fortune, I can take it even abroad or somewhere, and they ask, 'Do you know a certain program, [bespoke eHealth system]?' I will be able to use it because I know this thing, unlike when you don't know these things (laughs, others laugh).*
PI203	**Sauko Data Clerk- Male**: *In terms of worries, it was how we would be using it. But that concern went away because they taught us at the beginning that this is a mouse, this is whatever. We were taught how to use it. So in terms of my concerns about how to use it, that worry went away.*
PI204	**Sauko Hospital Attendant- Female**: *I had expected something positive, what I have already said that I had never know what a computer is like. But as they have said now I know when they say a mouse, when they say log off, when they say this and that. So it has given me some little knowledge. I have become wiser because of the coming of these computers.*
PI205	**Sauko Ground labourer 2- Male:** *let me put it like this. It has done us well because it is not all of us who learnt at schools that have computers. But because of the coming of this program, it has made some of us to know where to press for the computer maybe to switch on through just our colleagues telling us, because I did not go to the training. But it has made us to know something that this type of programme we do it like this, to switch on the computers you go here, when you get here you go here, when you get here you go here. It helped us in that, that this is how we switch on a computer. Because it is not all of us who work here who went to a school that has computers. Right? But those things that you brought have made us know that a computer is like this.*
PI206	**Malilika Nurse midwife 1 - Female**: *Things changed, because we were just seeing that our work was just using syringe and pens, but we saw that we were able to use modern things like computers, just like other people in their offices.*
PI207	**Malilika Pharmacy attendant-Female:** *Things have changed indeed, as the ignorance about computers has gone.*
PI208	**Malilika Pharmacy-Female**: *When we heard about the computers we were very happy that this is a good thing and we will learn, and it has helped us that we have some knowledge and in the future we can say that we are experts because (inaudible) it has helped us that we have learnt about computers.*
	b. Confidence using computers
	Positive
PI209	**Sauko Ground Labourer 1-Male**: *Another thing that this equipment has helped us, it's what I have already said at the beginning, that now the heart's desire to buy a laptop is there now, such that work will be done or to work on a laptop now is without worry. We just see our friends with backpacks that, 'So this is where it goes through'. Yes, so I am very grateful for what Madalo has done for me.*

PI210	**Sauko Ground Labourer 1-Male**: *I am saying this that others are experts at computers, more than what we would know it. But when we take [bespoke eHealth system] and how we have grasped it here at Sauko, I have no worries.*
PI211	**Sauko Ground Labourer 1-Male**: *this thing, if we look at it carefully, it's free. If it was other people, they pour in lots of money to learn computer, lots of money. But others with kindness taking you and teach you something like that, it's not a small thing. Like we have already said that this program has no funding to give someone to be using it. What we look at is that, we – Madalo, with your kindness like the health centres that surround Madalo, how have they been assisted? Because I am saying this that others are experts at computers, more than what we would know it. But when we take [bespoke eHealth system] and how we have grasped it here at Sauko, I have no worries. What I have already said that I will endeavor to reach Scotland (laughs).*
PI212	**Malilika Nurse-Male**: *it is easy to use a computer, and it is something we are proud of.*
	Negative
PI213	**Sauko Security Guard-Female**: *Like on the side of maternity, the computers are there so now the people who went for proper training, there is only one person. So the way it is there, there are quite several parts that one person cannot manage. So some of us they just picked us from here and told us you will be doing this here, doing this here, but we don't really know computer. Right now I can say that all the nurses that are there, they also don't really know computer. So it's really a difficult thing. It can appear like the person does not want to do that work, while if there were two or three people, when one is stuck they can ask their colleague that, 'What did they say we should be doing it like here?' Because even when the computer was removed and needs to be reconnected, then if the person who went to do that, that, 'On the computer we take this here and put this here, this we put here like this', if that person does not come, then that's it, we will not work, we will be waiting for that person to come and connect it for us. Because some of us know this thing when it is already on, that we click here and continue.*
PI214	**Malilika Patient Attendant-Female**: *It is true that we are writing in the computer but we are typing slowly because instead of learning how to use it, we have just started using it straight, so the process is slow.*
PI215	**Malilika Dental attendant - Male**: *We are quite a lot of people who are supposed to use the computer. So we can say there is a change in that we did not know and we are learning slowly. But the problem is that those who are here at OPD, maybe we can have a chance to use this more frequently. While those from say maternity, PA or nurses, others are at the wards, so those who are here at OPD they have a chance to use the computer, but at the ward they just use the manual, the ordinary way.*
	Computer Knowledge & Competency – Failures
	1. Computer Knowledge and Competency
	a. Knowledge gained

PI216	**Filipi *HIV Counsellor*** *- In addition, I was happy that ah! this technology (unclear). Our minds become open indeed.*
PI217	**Filipi *HIV Counsellor*** *- You think that ah! this is a bit of an advantage where you are changing day after day, and knowledge is changing.*
PI218	**Filipi Senior HSA –** *For us at this facility, more especially like myself, when I heard that there will be that programme, it would have been helpful to me because some interest that maybe, maybe you didn't have it in mind, sometimes some things just come, maybe without any preparation, but I saw that somewhere it will bring us benefits that, maybe knowledge, more especially those who did not go, maybe about small things, we can help them through our colleagues who went for the training.*
PI219	**Filipi Patient Attendant 2-Female:** *They benefited some of us in that we didn't know how a computer is handled. But it helped us to know that if you want to enter you do like this, there is 'click', there is this and that. So that helped us.*
PI220	**Filipi Patient Attendant 3-Female:** *Positive things that came, we got some knowledge there when we learnt about the computers, because we were just hearing about computers. So when they came, we said, 'Oh! Now we will know how to handle them, how to press the buttons'.*
PI221	**Filipi Senior HSA –** *On the part of reports, it was easier for people who maybe already had some knowledge of computers. That one was like a refresher in the other way, but the majority they indeed knew. But for some of us we were just looking at it and wondering how you switch it on.*
PI222	**Filipi Patient Attendant-male**: *When I heard that computers are coming, I was very happy because I saw that I will learn many, many things from the computer. And when it came I was one of the people to go for the training. When I went there I saw that ah! At first I thought that to know computer is something very difficult. But after one day, the next day I saw that I am slowly getting used to it.*
	b. Confidence using computers
	Positive
PI223	**Bisitoni Ground labourer 1 - Male**: *(**Paul:** How about change in the way you work? That quicker work?) That happened indeed. (**Paul:** But did you not find that when typing it was taking more time than writing with a pen?) At the beginning, because we had not gotten used to it. But when we got used to it we saw that there was quite quicker than writing with a pen.*
	Negative
PI224	**Filipi HIV Counsellor –Male:** *It's just that, being busy is there, it was happening because, if we consider at the beginning how the training was, if we had memorized the things properly, if the training was full, it would have been going well. It would have been that the thing was used. But if we look carefully, the training was just here and there. And with being busy as she is saying, that's why it happened that it got messed up. But if the training was quite good, ah! then it's similar to how we enter into the register, that OPD register. Yes, because when we tried to do like this here, that mouse has done its own thing (laughter), another has done whatever, then – So I feel that it is difficult for us, because the training was brief, that's why these days – Because it was like snippets.*

PI225	**Filipi Clinician - Male**: *You write in the book. Then you enter into the computer. You should check where 'b' is (laughter). While for those who are used to it, since they know that keyboard, they will just be doing this here while maybe asking there and they have already started.*
PI226	**Filipi Clinician-male:** *It would happen that if the one writing there is not using the computer, then here it will get stuck. The one at that place will also stop, because it would happen that the people at that place would get crowded. The person would be like they are slow – Not they will be like they are slow, they* were *slow. It's the same with the one writing there. If the one outside is not using a computer, while inside you are using a computer, you were slow. Because it's like the person has just recently learnt, so it's bit by bit by bit by bit.*
PI227	**Filipi Cashier-male:** *Let me illustrate that, on that day the system is on. Then that side it would also go well. It was just like maybe you are slow, because it's like what he has said, you go search where 'c' is, you go search where 'z' is.*
	Infrastructural & Tech Problems – High Adopters
	1. <u>Infrastructural and Technological Problems</u>
	a. <u>Network & power</u>
PI228	**Winistoni HIV Counsellor 2-Male**: *When it is off, we can say here electricity is a big challenge because when they are off, then you would spend a very long time without using the computer. The batteries that you gave us are now not useful anymore. So when it's off, then there are many who we have not entered into the computer. This means that we don't have a true picture of the number of people we have entered into the computer during that time, especially because of the challenges with electricity.*
PI229	**Ponekela HSA4-Male**: *I was surprised recently when I found that the batteries are depleted. So we have returned to the old times.*
PI230	**Ponekela HSA4-Male**: *When I saw that there are computers here, I thought that the sustainability of that thing will be good. Aha! I did not expect that there would one day be challenges such that the computers are not being used. But I was surprised recently when I found that the batteries are depleted. So we have returned to the old times.*
PI231	**Jedawako Hospital attendant 1 - Female**: *We were expecting that we will be using the computers maybe frequently but it is not like that because the networks are problematic. So sometimes the information, we are still using the papers which can get torn off, sometimes keep in the registers, sometimes in computer, which is not what we were expecting.*
PI232	**Jedawako HSA-Male:** *The issue is, most times it happens that network is difficult, unlike how it was in the first days. So what has happened is that the time when there is no network it was found that – The time when there is no network, for us to use those computers, it is getting where that work is getting indeed difficult, so following that is where we are going to the registers that we do as all times. While at the time when the network was there it was that people really knew that today I should do this work, even getting to work early so that that work should be done quickly. But now with the network, as has been said, is what has seemed to contribute a lot to the information for other days to seem to not be seen there. Another thing, you*

	find that another time, when there is network but the one that is functioning is one computer. So that is being difficult because the same person should register then you come to do diagnosis.
PI233	Jedawako **Hospital attendant 1 - Female**: *Previously it would happen that when the network was not there the people from Madalo were coming to fix it, but now they do not come anymore. So the network problem is getting worse such that in a month we would use it maybe only three days.*
PI234	Jedawako **Hospital attendant 1 - Female**: *I was expecting that we will be using the computers maybe frequently but it is not like that because the networks are problematic. So sometimes the information, we are still using the papers which can get torn off, sometimes keep in the registers, sometimes in computer, which is not what we will were expecting.*
PI235	Jedawako **Hospital Attendant 2 - Male:** *The issue of unstable network has made my expectations to not be met. I was expecting that once we start using the computers, we will not go back to using the registers, because everything will be in the system. But now we are going back because there is no network, batteries are off, electricity is not there, what will we do? For the IT support to come it takes time. Previously, when we told them they would come quickly, within three days, and fix it quickly, and it is working well. In the first days, network was not unstable. There was a big computer, an extension and another computer at maternity, so it seemed that if there is no network here but because of the other computer it was spreading network to other computers and they were working. But when they removed the registration computer, things started going bad and network problems got worse.*
PI236	Jedawako **Hospital Attendant 2 - Female**: *The batteries work in the morning only and they would be off. Earlier they were not going off, but now they go off. Previously, the electricity would go off but the batteries would continue working. But now when electricity goes off, in less than an hour the batteries are off too.*
PI237	Jedawako **Hospital attendant 1 - Male**: *On the computers there are things that need to be repaired. At registration there were small sparks, even the queues (inaudible) [**Paul:** on the walls?] **(All:** Yes) – (inaudible) So there are many problems, apart from the batteries.*
PI238	Jedawako **Hospital attendant 2 - Male:** *the problem is neither associated with Madalo, as when they come they visit all the Departments, nor shortage of staff, but the main problem is the removal of the server, and only one server is remaining, which is making it difficult for [bespoke eHealth system] to work in all areas. When the network is available, no one uses the register to enter data, but the computer. When there is network problem, only one computer that is installed near malaria ward is not affected but the rest of the computers are affected. It happens that in the consultation room there is no network, on registration there is no network, but in the malaria room everything is working well.*

PI239	Dalitso ***HSA3-Male:*** *Like here, at the maternity ward, because there is one at the maternity ward, it is also there. So when the electricity goes off there, access to power is not there because the back-up power is at OPD only.* ***(Paul:*** *Back-up is where?) At OPD only. (****Paul:*** *OPD? Nowhere else?) No. That means only the computers there are the ones that work, while those on the other side do not work.*
	b. <u>Programme design</u>
PI240	Winistoni **Medical Assistant-Female**: *When it comes to recording in the computer, the part where we search for drugs, I would like to just go there once, you search and the drug has been found, all the drugs that you want should appear at the same time when you have prescribed. But now I search, I find amoxycillin, then you record that, then add, search, paracetamol, then record. When I want piriton, then I go back to search (****Male****: yes, going back to search again), searching and searching (Male agreeing). But I was thinking that the drugs that you have recorded, once you press, all of them should come and you should just select taaa taaa taaa, and then save (Male agreeing throughout). So I feel that, that will reduce our workload.*
PI241	Winistoni **ART Clerk -Male:** *When you want to delete when you have made a mistake, the computer refuses. So a person is a human, when recording something you can make a mistake. So the system should allow one to make corrections. It's also the same at paediatric ART, when I'm working with information for paediatric, I find that some information cannot be found, it's not there. So these areas, if you can improve them. Other things you can enter them, others you can't. When you try to correct a mistake, it jams. So if possible, look at it carefully and see what is happening.* ***(Paul:*** *What type of information in paediatric?) At paediatric, we want to enter information like for example name of the child, name of the child, let's just say the whole address of the child. We take that child as a client as well, so when we are entering the person's or the child's information, we want everything about that child because you can enter something here as ART, but to enter for paediatric. You find that it jams. So I was asking if it's possible, all paediatric information should be there separate. For primary care, it should also be entered separately, like it was happening for ART. So it was happening that the patient number that is coming on this side, let's say ART, the person has been tested negative, they have been given a number there, like the number of people who have been tested on that day. Now to go there to track that person, to remove that number and give them another number as someone who is positive, you find that for that person it is refusing. Now you wonder, because at ART we change those numbers; they will have one [bespoke eHealth system] number as a general number, but for us as a department there at ART we have to give that client a new number, the ART number now. So for me to erase that number and enter the ART number there are confusions. So there is need for the system to have ART for ART, primary care it should be primary care, paediatric should be paediatric. That can be helpful.*

PI242	**Winistoni HIV Counsellor 1-Male:** *These numbers – I don't know – Mine will be like a question. When you are setting the serial numbers, are they specific or when they end somewhere they start from one again? I mean, like starting from January up to December? And when it's January do they start from another number? Because when I am entering, I can be writing for some months and then it says, 'This number does not exist. Start again'. And then when you put that number again you find that it is still refusing. Because we can start from number one, number two, number three to over a thousand. And then when you continue to over two thousand or three thousand, you find that, 'This number does not exist. Go back. Start again'. So I'm wondering whether it has a specific figure that you should go up to here and then you start again one two three four, like that?*
PI243	**Winistoni MA-Female:** *Diagnosis. When you reach the duration part, that they are taking the medication twice a day, three times a day, if you just make the mistake that you put, because it comes (inaudible), when you just put BD or TDS, then actual tablets has already come up (words of agreement from others). So when you see that the number of tablets that have come up are not the number you wanted that, 'Oh! I meant to put BD'. When you go back to BD and you want to change, and you click BD, the actual tablets are not removed, it is not removed (**Male**: It remains the same one). It just remains! If you put 600, it remains 600 (laughs, others laugh). I tried like this, like this. Where do I delete? In the same computer, it refuses. So I just leave it and say, 'We'll see how it turns out'. Yes, so it's really difficult there. When you make a mistake, instead of deleting, it fails. (**Male**: Delete refuses). That's what I said earlier that search, search, search, search ah ah! When you search once you should just click taaa, taaa, taaa save. Yes, that would be helpful to me. (**Male:** It's like you do in other phones, when you want to give your friend some music. It just brings the songs rrrrrr and then it says mark, then this one, this one, this one, send. All of them (**Male**: waaaaa). So that's what she wants, that when she just says I want drugs, I want do diagno – I want to do treatment, then you should just go to the drugs teee! all of them. Then 'Oh! With this illness the drugs that I want are –) (**MA(f):** teeee, teeee, teeee, teee) – this one, this one, this one', then when you just save, then all of them – (**MA(f):** All of them) – will come under that person's name. But search: LA, tktktkt taaaa, (**MA(f)** making the same comments) and then search, and then teeeee, amoxicillin, and then (laughter from others) gentamycin teeee, aaah! (**Security Guard 1 (Male)**: It does also not show half tablets. So we just give full tablet, while it is supposed to be half tablet.) (**Male:** If it's cutting they'll cut there)). **MA(f):** So if I need three then I just make calculations so that it tallies with the number of tablets I have given. But for a person – ummm – It needs a person with knowledge, but to them, it's a challenge. Because for me I just change duration, but to change duration the actual tablets will increase. Yes, because the thing is we count tablets, even for the half I know that actual tablets is this, while for them they cannot do it. So we need to have one system, so that when the tablets are four they should be four. The halves and quarters are the ones that are posing difficulties. Of course, for the injectables, they told us to be just putting one, one. Yes. So on those one, ones, some of the injectables we give for five days. So it is still not working, because when I put five, then the actual*

	vials there will come out five, while you have used one vial for all those days. But then it will be five days. It will be five vials. So when you are writing a report, it can give you false report, like, 'All these vials? How were you administering them?' You see, right?
PI244	**Winistoni HIV Counsellor 1-Male:** *I want to say that, when you register a person to know that this one is negative, this one is positive, it just registers as (inaudible) attendance. I want to know this one is negative, this one is positive. Plus, those who go to ART, the ones who are positive, they should know that these ones are positive, these ones are negative from PMTCT. We want to be knowing how many of these ones are positive, how many are negative, PMTCT positive is how many, all of them, then things will be going well. But currently all of them are written as attendance. Yes, they don't know whether this one is negative, this one is positive.*
PI245	**Winistoni MA-Female:** *Because of confidentiality, those positive should be having their own page. (**HIV Counsellor 1 -Male:** When this one has been found positive then taaaa! They should go on their own page) They should go on their own page.*
PI246	**Ponekela HSA6-Male**: *It can happen that those passwords have become inoperative, they have expired. For you to come and sort it out quickly used to be challenging. So it was difficult for us to sort it out, and work would seem to stop. There would also come another person, or we use one person's password. Yes it seemed that somewhere the workload was a bit difficult.*
PI247	**Dalitso Medical Assistant-Female**: *When we go to diagnosis and treatment, we are now having difficulty, I don't know if there is a small problem with the system, some drugs even if you – Like some codes for the drugs we cannot memorise, it is still difficult. So if you search, they don't show here. You have to go in there again and enter it, and that makes time to be going. So that also maybe needs the system to be reviewed well, that all the drugs that we are using at a like health centre, are they all there? And how many milligrams are there? Yes, so that there shouldn't be*

	a problem of searching. Because when it comes to the codes for diagnoses, now we are at least familiar with many codes so we don't need to search like malaria, searching malaria is number what, we just enter the number, the diagnosis comes perfectly. But now for drugs we still have big challenges, so it is delaying somehow. To go search again, that opportunity now. It happens that it is not in the computer.
PI248	**Dalitso Medical Assistant-Female**: *On the issue that was mentioned that we should not keep people for a long time, I think that, ok, let me just record them somewhere then at another time people will enter them. You find that as the day goes, when it's past, when I try to enter the number I find that I did not book the person. So you have to start from the beginning booking them. So I find that it's also difficult because people from night, maybe it can't keep my information for say two days, but if I have time, like during the weekend, I find that I may be able to enter it, but it is not possible. So I see that there is still a problem because since it's computerized it refuses because the date wasn't booked, so you have to book them again. So there are maybe fifty people remaining who you did not enter, so you have to book all of them and enter them again, that's more time. So I just wanted to explain the issue we were discussing earlier.*
	c. Software
PI249	**Winistoni ART Clerk -Male:** *At ART, if maybe – But also here, you can improve the system, like primary case registration. It happens that when you want to register a person, sometimes the information jams, and you find that it is not entering.*
PI250	**Ponekela Ground Labour-Male**: *it seemed that there was a change in the use in the HTC room and the way we use for treatment, for different reasons, as it gives options in the HTC room and the treatment room. There are several things in there which need to be followed up. But they told everyone in 30 minutes, because they said, 'Oh there are some things that need to be changed, this is not there', as they were reminding each other with the counsellor at that time. So they said, 'When we fix this, we will fit in the computer so it can be used'. Since then they haven't come again.*
PI251	**Dalitso Medical Assistant-Female**: *Previously I can say it had problems, but now there are still problems. (unclear) where am I supposed to go here. So that needs them not to be far from us. We are still in a learning process, so they shouldn't just let us go but they should be visiting us frequently, reminding us.*
	d. Hardware
PI252	**Jedawako Hospital attendant 1 -Male**: *In the past they were okay, but now things are not okay due to network problems. We did not have problems with the computers that were first introduced here, but they were taken to Madalo to be fixed and they came back, saying, 'They are not suitable to be used here. We will bring other computers'. They were about three computers. Yes, they brought those computers, which to them were suitable to be used here, but they are the ones that are giving us these problems.*

PI253	**Jedawako HSA - Male**: *The system that was there at first and the one there now, it seems things have been changed. At first there were computers that (inaudible), you can hear by our statements that at first things were good, but then we saw that things started changing, like with the network. The computers that came at first, things seemed to be very good and we didn't see any problems like now. But it happened that all the computers, there were almost three, right? They took them away, saying they want to go and repair them. Then we just saw that they told us that, 'Those computers are not suitable for here as they have many problems, we'll bring you other ones'. And these are the ones that they brought. (**Paul:** So you are able to differentiate? (**All**: Yes.) **Paul:** Between the ones that had a box and these ones? (**All**: Yes.))*
	e. Infrastructure
PI254	**Dalitso Paul:** *what about Maternity department?* **Nurse-Female:** *Have not started.* ***Paul:*** *You have not started?* **Nurse-Female:** *Yes. Setting is what was the challenge because at first they wanted to put it in the labour ward but we thought that would be a challenge with the patients there. So they thought about putting it at post-natal there in the middle where us staff sit. So it stopped there, deciding which place it should be located.*
	Infrastructural & Tech Problems – Medium Adopters
	1. Infrastructural and Technological Problems
	a. Network & power
PI255	**Sinelia Hospital Attendant 1 - Male**: *You find that sometimes there is no or little power. So you find that the computer, for you to use it, it is not possible. So for those people it is now like what they knew, you have now confused them. So you also have the job of explaining to them that, 'Ah, we will go back to the old system. You will be doing this, you will be doing this, you will be doing this'. So it is like it is disrupting like that.*
PI256	**Sinelia Hospital Attendant 2 - Male**: *You find that we are in the middle of doing that work, maybe we have started (unclear), and we are doing bookings and so on. Then you find that the network keeps going off, even if power is there, but you find that the network is off. So you find that it also disturbs us.*
PI257	**Sinelia Midwife Nurse 1 - Female**: *Here at OPD, it is not every day that information is entered into the computer. There challenges are that network, or when it's not that then there is no power.*
PI258	**Sinelia Hospital Attendant 1 - Male**: *Since those things need power, you find that sometimes the people are already on the queue because they have gotten used to it. As soon as they arrive they know that they will arrive at the computer. You find that sometimes there is no or little power. So you find that the computer, for you to use it, it is not possible. So for those people it is now like what they knew, you have now confused them. So you also have the job of explaining to them that, 'Ah, we will go back to the old system. You will be doing this, you will be doing this, you will be doing this'. So it is like it is disrupting like that.*

PI259	Sauko **Ground Labourer 2-Male:** *The network is operational at maternity ward, but what was missing was – what was that again? The extension cable. (Mixed conversations about extension cables among participants). Because what I was trying to mean is that this other time when things went wrong, when they came, we tried it, like only at the maternity ward, we tried and entered some. We should be honest. From the time we entered at that time, it didn't work again. Yes. But if we said we had never used it, we will be wrong. We tried and it worked, we entered some. So after entering, then when trying to enter the other people, it stopped. So we told the boy, 'Come, there is somewhere where it is not well'.*
PI260	Sauko **Ground Labourer 2-Male**: *the thing that is still problematic is the issue of extension cables. It's things that are simple, but because it will depend on how it is at the head office, it will depend on – because funds are a challenge. The extension cables that came are just one here, one there, such that when we connect one you find that it got damaged, put another one it's broken, maybe the ones working are still those two small ones that seem to be stronger, but the others are like – when you say let me put it here you find that it doesn't work, you put it here it doesn't work. The other things is these network, they tell us to be using these networks, sometimes they are troublesome, taking into account this small thing – this small thing that is near the computer – I have just forgotten it, that thing often also gives problems – (**Male:** Monitor?) No, not monitor. It is behind the monitor. Yes, that small thing. You find that often goes off, sometimes comes on, other times goes off, so you find that because we were not told properly what we should be doing, calling that brother as has been said by Stain Phiri, so that if they also tell us about these problems that, 'If this happens, you need to do this, if this happens it needs to go like this'. That also gives other problems.*
PI261	Sauko **Ground Labourer 1- Male**: *There I have seen the causative. It could be the server. Maybe the server was disconnecting, because even there the server was disconnecting us. Maybe it's because it has taken a long time, maybe because of not having been trained that when something goes wrong then we do this and do this … But if that server was okay, but also training us that, 'When things go wrong here like this, you are then required to do this, maybe do this, you should also do this', then it will function. That would be a good thing.*
PI262	Sauko **Security guard-Female**: *But also another thing at the maternity ward is, the time that they came power went off, and it wasn't working. So the part about the battery that it can work when the electricity is off – (**Male:** It hasn't started working, because when power is off, when you try to connect the sockets –) When the electricity is off there, then the computer doesn't work as well, while here when the electricity is off, the computers can work. Electricity from ESCOM.*
PI263	Sauko **Ground Labourer 1-Male**: *up to now there is no any problem, it's twenty-four hours still working. Or is it seventy-two? When I am working using the batteries, I have no problem with them.*

PI264	**Malilika Patient attendant-Female**: *It happens that some days there is no electricity, we did not use the computer, sometimes there is no network, we did not use it, so the report would be false if we used computer data, so we use our registers because we report in the register. So for now we are still using the registers.*
	b. Programme design
PI265	**Sinelia Midwife Nurse 1 - Female**: *I don't know if I messed up the password. But it was found that the person who could fix that thing or enter the name again is not available. So it is found that we are several people who are not found in that computer and can use it because some things got messed up. (**Paul:** So you are not able to login?) No, we don't login.*
PI266	**Sinelia Hospital Attendant 1 - Male**: *The main problem is like where you login into [bespoke eHealth system]. Because maybe the pass – at the beginning a person is able to login okay, getting at the [bespoke eHealth system] you maybe fail to open it and login. So because of that, you find that, maybe, as they have explained that the one who is using it here at OPD, when you are done with your work here then you have to force yourself to go there to login again and do it as well. So then because you wait for your work to be done, your busyness to be over, when it's done, then you should go there. So it happens that there maybe they have served quickly, they are done with the people and they have left, because they know that, 'So what can we do, the system is problematic'. But if it can be that the problem of [bespoke eHealth system], the passwords and so on, if everyone's password is working okay, maybe the problems would be quite less.*
PI267	**Sinelia Midwife Nurse 1 - Female**: *If we take like the maternity ward, the challenge is that the people who are there, maybe I can just say all of us, it is not possible for us to login. So if the information has happened to have been entered, it is that others have perhaps come from the OPD here and go, 'Ah, let me help you', then they will take that information and enter it. But among us who are working there, there is not even one who can take maybe the register and enter the information.*
PI268	**Sinelia HSA-Male**: *About the passwords, everything was indeed done, we were logging in perfectly. And then also in the middle of it we just heard from our colleagues that, 'Iiih they came again, such that we have reset the passwords', which is indicating that even now we fail to login, because we are waiting for when they come again, they will create new passwords for us again.*
PI269	**Sinelia Hospital Attendant 1 - Male**: *I wanted to just know what happens, like in the system, it happens that a person enters there, then at times you find that you have logged in, entered the password properly, it then tells you that, aah, 'Your password has expired'. (laughs) You find that – So some time most would just do that because there you find that you have been given a password properly, maybe it's because when time passes, maybe a month or two, it tells you that, ah the password has expired. So or how to change it, you don't know how you can do it. So starting from that day the person is then is baffled. So then, since it's something you don't know, you find that you have not been there a lot, you find that instead of fixing it properly as how those who login frequently tell you, you just mess it up. So when you try to do this it fails until you find that or even if the person knows it*

	well, you try but you find that it is not responding. So I wanted maybe if you can just inform us there as to how we can do it when we get there. Because many have been perplexed because, previously it was not doing that, but then the time that they perhaps came to get that (unclear) from inside, so when it came the second time, it frequently does that. Even those of us who login frequently, it often does that. You find that when we use it one time, another time it tells you ah! you need to change the password.
PI270	Sinelia **Pilirani**: *Most times we do that. Every computer, or to say every user, it has – When you set a password at first, you have days, that it will expire on such and such date, for security of the things that you put into that computer. There are things that are in there, you put them in as your personal things. We can say you know them yourselves that this is mine, I use it for this and this, no one must see it. So because of that, every computer or every user, we set that their password should be for ninety days. When the ninety days is ending, when it is near, it is going toward expiring, and it shows that you need to change your password, it will expire in such many days. Some of us have seen it, right? (**Group:** Yes) Yes. That time is a good time that when the computer has shown you that your password is going to expire maybe in three days coming, you need to change that password. Don't wait for that day to arrive, it has expired. That when that day arrives, when your password has just expired, then it reaches a point that you cannot change anything, until a certain person, like an administrator or has been given rights to change your passwords, should change.*
PI271	Sinelia **Hospital Attendant 1 - Male**: *You find that a person has indeed been registered, and I have given them a number. So maybe when it takes time, you find that when they come, enter that number, you find that the name that comes out on the computer is different from the one that is written on the book, while everything was done properly. So I don't know what happens. You find that perhaps a person from Sinelia, village it writes from Chitekwere. And they say, 'This is really my card'. So ah! I don't know what happens, so I wanted to know so that maybe – What really happens? Because even us, we get very confused. Maybe that person really – That's really the person, we see them, they come often, but you find that that happens.*
PI272	Sinelia **Hospital Attendant 2 - Male**: *Often it is different maybe for the name and village, while the number is not really a problem. When we enter the number, then we have saved, a number comes out at the top. Then we write that number on the profile, then return it to them. So another time when they come again, entering the number, when we do enter, then you find that that number, maybe it will bring out all the details according to what that person is explaining. When we ask them, 'What is your name?' 'Ah, so and so'. You wonder that the name that they are saying themselves and the one coming out of that computer, maybe the one they are saying is indeed written on that card, but then on the computer, maybe there is another name*

	coming out. Also the village, we say, 'Which village do you come from?' they say the village, on the computer there is also another name. So then – Also for us what then to do can't be found. So we are forced like us to start again from one. So it still seems like it is confusing us, since on that card it's also like a bit careless to erase that number to write another one.
PI273	Sinelia **Hospital Attendant 1 - Male**: *That issue about searching, myself I have tried it several times. But it is not working. Such that when we come to that number, we see that, even doing it like by village, something else is coming out. What is in the book, something else. What they are complaining from, something else. Coming to search their name, not even coming out. It's not working. They tell you the first name, it's not working, it is refusing. (**Pilirani:** Refusing as in it is not bringing any name or –) Other names are coming, but that person's name is not coming up.*
PI274	Sinelia **Hospital Attendant 2 - Male**: *So when we also come to diagnosis and treatment, you find that perhaps when we enter that number, then to give the person diagnosis, it is writing: 'This number is not booked successfully'. Then now it is like, aah! The person is coming from the registration, has already been booked, now we want to give them diagnosis and treatment, it's refusing. So when searching, you get the number from in there, when the person is explaining that, 'Ah I am so and so', you search that name, enter the number, it is still refusing. So I don't know why that happens.*
PI275	Sinelia **Pilirani**: *I believe it doesn't happen to every patient? (**Group:** Yes) It happens to a patient here and there? (**Male:** Yea). That seems to be a problem for even at Madalo. It is possible that it is happening. We reported so that they can fix it for us so that it can change, because it happens that you have booked the patient, they go to receive care, then it tells you this patient has not been booked. And trying to search indeed works. So it's a problem that we have reported. But I believe that when we are receiving a new version, it will be over.*
PI276	Sinelia ***Hospital Attendant 2 - Male:*** *Because when you get there you get confused how to serve that person. The number is refusing, so how can we serve them? So you just tell them to hold on, then another one, find the one who is on the register, 'My friend the number is refusing. Search carefully, maybe you have made a mistake'. When that one searches again and check on the register you find that it's the same number. But to enter it inside here you find that it is not working. So you become very confused now. So it seems to increase the queue now. So as he has responded, we have understood that perhaps it will be sorted out in future.*
PI277	Sauko **Data clerk Male**: *when we go into the system there shouldn't be any jamming. Like when you have gone on the drugs part, there are some drugs that in the system, they are not there. But also the other challenge that I have seen is that the one who was designing other programs and taking into consideration the reports that are needed by the Ministry of Health, some places they differ. For example, antenatal, do you say antenatal? (**Female:** Yes) antenatal was different. When I take the manual register and how it has*

	been designed in the system, they are different, so it becomes difficult in that if we stop using our registers here, then these other indicators, where will we be getting them?
PI278	**Sauko Ground Labourer 2 -Male**: *some doses in those computers, like the one I was using, it happens that sometimes the doses are not tallying with the way the person is. In those computers, when we are entering, it happens that maybe the dose quantity is not found in there. Meanwhile, they came to set that all doses for from under-one to above, their doses are this and that. So when the clinician writes for us, I am sometimes at a loss as to what dose I should give that person because somehow they may be missing in there. Twenty comes out as maybe ten.*
PI279	**Sauko Ground Labourer 1 -Male:** *let's say aspirin for an adult is 600 mg, right? (**Ground Labourer 2 (Male):** Yes, 600mg) And in there it is 300. So now we try to make it 36. There it looks like it is moving. If the system was here, I would have shown you the problems, but those problems are small because those can be fixed.*
PI280	**Sauko Data Clerk- Male:** *My question is really that, when we open, we open, when we have just opened, when [bespoke eHealth system] has opened, when we do registration, it should show that here we have finished with registration. That same one. Just after getting recorded in there, when we have just opened, we have opened [bespoke eHealth system], when we start registration, it should reach where diagnosis and treatment has already been entered, and not – (**Paul:** Oh! Not closing registration –**)** Yes! (**Paul: – a**nd then opening diagnosis and treatment –**)** Yes! That's what I mean.*
PI281	**Malilika Cashier-Male**: *For me, the things that disappointed me a lot was that when you are using the computer, you have kept your password, you have an account. Then, if it takes a month or two weeks without using it, then you find that the account is failing to log in, saying incorrect password. Then they tell us that it means it has expired, you have to reopen it. It makes me ask, 'What is going on now?'*
PI282	**Malilika Laboratory Technician-Male**: *Even reactivating accounts and all that, they were relying on those sirs to come and see how to proceed. These computers, these small printers that came here have many problems. Sometimes they would work, then nothing, it's gone.*
	c. <u>Software</u>
PI283	**Sinelia Hospital Attendant 2 - Male**: *When we come to [bespoke eHealth system], we have started booking those people, when we finish booking that person, we have saved, then you find that that thing we write on [bespoke eHealth system], the details, are disappearing. While at first they were not disappearing, it was just coming with '(unclear) new number, new patient'. So it is coming again at registration.*
	d. <u>Hardware</u>

PI284	**Malilika Laboratory technician-Male**: *when we travel to district hospitals the computers that are there and ours are different. Our friends have touchscreens, yea, no, like this and that, within seconds they are done with the patient. So when these computers came, most found that to be a burden because many thought they will also be touchscreens like at those districts. And to also see that the [bespoke eHealth system] that came eh! Confusing. And to also see here that many people do not know computers. So there were several burdens. So, many were happy when we heard that with computers things will go well, everyone will be entered into the system. So to see that the computers that came had mouse and other things then eeh! confusion. And to see [bespoke eHealth system] then total confusion. (inaudible) But still, it was a welcome development. And now I can see where we are going things will be ok because we are now used to [bespoke eHealth system], but we still see it should have been touchscreen.*
PI285	**Malilika Laboratory technician-Male**: *it was a welcome development. And now I can see where we are going things will be ok because we are now used to [bespoke eHealth system], but we still see it should have been touchscreen.*
	e. Infrastructure
PI286	**Malilika Pharmacy assistant -Female:** *the center unit is here right? So when it's closed here then it means everywhere they will not work and those who are on night duty will not work. When it's closed here it means it's done.*
PI287	**Malilika Nurse midwife technician 1 - Female**: *Our setup is different from Madalo. Our buildings are scattered like here, there and there. So for the computer at the maternity to switch on, it requires the ART computer to also be on. So if it is at night or weekend, it is locked there, and there is no one who can open, so that means there at the maternity you cannot use it, it will be off. Unless someone goes to open. And someone cannot go to open, because if they forget to close again they will be answerable. That's how it is. Maybe if it was independent at the maternity, it should be switched on independently. When we switch it on, then we will see ourselves what to do and not have to be connected to the ART. Because that is a challenge. And the maternity report is really good, if all the data were entered it would be so easy to just release it.*
	Infrastructural & Tech Problems – Failures
	1. Infrastructural and Technological Problems
	a. Network & power
PI288	**Filipi HIV Counsellor –Male:** *Sometimes it used to happen that the network kept going off. Sometimes it would be three days, four days not working. So that was another challenge.*
	b. Programme design
	c. Software
PI289	**Filipi HIV Counsellor– Male:** *I see that what we have been saying that we kept jamming.*
PI290	**Filipi Clinician-Male:** *At first, the [bespoke eHealth system] that came seemed to be different for maternity and registration. It was found that it would – There were several things that were different. So they told us, 'Ah, wait a*

	bit, don't use it yet'. Then when they brought it, the new one was found that they were failing to open it. To download it well was difficult so they said, 'Wait a bit'. Then phone calls and then all these other things happened.
	d. Hardware
	e. Infrastructure
	IT Support – High Adopters
	1. IT Support
	a. Accessibility of support
	Positive
PI291	**Dalitso HSA2-Male**: *Also, accessibility of numbers, whether it is 09, you should leave it with us here. Because when there is a problem here, sometimes the network goes crazy (laughs), you touch here, you touch there, nothing is helping. So at least maybe, maybe give us one person who we should be phoning, whether borrowing that's no problem. Indeed. We should really be communicating … Previously, we had another person there at Madalo, he gave me his number. When the smallest thing happened on the computer, I was calling. Immediately, he would come. Sometimes when some small information disappears, just calling him, he would come. But recently, let me not lie, we were abandoned a bit.*
	Negative
PI292	**Ponekela Ground Labourer-Male**: *What is difficult, as others have explained, is that there are some things, because the computers have come while we are already grown, it happens that it malfunctions, so then when we ask our friends at Madalo, but for them to find a vehicle to come here, those things don't move. So we go back to the old system, those pens. That work becomes difficult.*
PI293	**Ponekela Ground Labour-Male**: *They told everyone in 30 minutes, because they said, 'Oh there are some things that need to be changed, this is not there', as they were reminding each other with the counsellor at that time. So they said, 'When we fix this, we will fit in the computer so it can be used'. Since then they haven't come again.*
	b. Response speed
	Positive
PI294	**Ponekela Ground Labourer-Male**: *When they realized that we are presenting those problems, they came and told us a new way that we have been using. So still, because there they remembered us quickly, and responded to us rapidly, it wasn't difficult.*
	Negative
PI295	**Winistoni HIV Counsellor 1-Male**: *When something went wrong we used to call, 'Come, we have jammed somewhere!' and there they tell us 'We are still looking for transport!' (laughs) and then they come maybe when the sun is already down. While if there were a few people who, no, we'll deal with it properly and when it has become too difficult for them, that's when they can communicate.*

PI296	**Ponekela HSA6-Male**: *It can happen that those passwords have become inoperative, they have expired. For you to come and sort it out quickly used to be challenging. So it was difficult for us to sort it out, and work would seem to stop. There would also come another person, or we use one person's password. Yes it seemed that somewhere the workload was a bit difficult.*
PI297	**Ponekela HSA1-Male**: *But now the shortfalls that will be there, they should remember us quickly and come to assist us. As our colleagues are doing the training, if they can be coming quickly so that the work continues.*
PI298	**Ponekela HSA4-Male**: *It happened that for them to come and replace the batteries it took quite a long stretch. People were still using those same manual ones, showing that the sustainability was like a bit challenging.*
PI299	**Ponekela HSA1-Male**: *if it happens that there is a problem, when we report, if they could be coming quickly to assist us. Because recently when the batteries were depleted it took a long time. Perhaps even the ones who were doing it were forgetting, forgetting how we do it. So maybe you can reach out to the people who come to supervise this work that if we tell them that there is a certain problem with those things, they may be coming quickly.*
PI300	**Ponekela Ground Labour-Male**: *When we have some problems, we shouldn't take long before they have heard about it, and also before they have fixed it for us. When it's like that, our relationship will be very good.*
PI301	**Jedawako Hospital Attendant 2 - Male:** *For the IT support to come it takes time. Previously, when we told them they would come quickly, within three days, and fix it quickly, and it is working well.*
	c. Effectiveness of service
	Positive
	Negative
PI302	**Jedawako Hospital attendant 1 - Female**: *Previously it would happen that when the network was not there the people from Madalo were coming to fix it, but now they do not come anymore. So the network problem is getting worse such that in a month we would use it maybe only three days.*
PI303	**Dalitso Medical assistant- Female**: *I should just give a reminder that one monitor has been taken from the OPD, it was found with a problem, it has not been returned. So registration is still being a challenge, because the computers are few that are there … (**Paul:** When did it go?) September if not October.*
PI304	**Dalitso Medical Assistant-Female**: *To comment on what the supervisor has said, that this project is very good. But we are abandoning it, the ones leading are getting weary. So the constant changing of people who come here, where some seemed to be available, then recently unavailable, then more recently it started looking like it started going well again. Maybe as the project continues, it should be serious with the people who are supporting us, such when the computer develops a fault and we call them, will they come at an appropriate time or it will be taking time? Because it disrupts us as that day we took out the computers, we started with the system, it has developed a problem, then people, 'Wait we'll do them', time is going, people are leaving, but they didn't come, so that means we have missed those people, they have gone. So for the people who will be managing that, there needs to indeed be seriousness that they should know what they are doing.*

	IT Support – Medium Adopters
	1. IT Support
	a. Accessibility of support
	Positive
PI305	Sauko **Data clerk - Male**: *we are thankful for our colleagues who went to Madalo, led by that lady who has come over there, that most times they come. They never get tired. They ask us, 'What is the problem?' We explain to them. If there is a change that the system has changed, they tell us. There also came a sister who loves us, an English lady, who gave us some (unclear). On that side, it is well.*
PI306	Sauko **Ground Labourer 2 - Male**: *We should not forget about the people who are looking ahead, we have boys like James, Pilirani, the lady here, who when we call them, they come. 'Where is the problem?' Because if you forget people like them then tomorrow or the next day it will look like they do not assist us. We should be honest, they come and assist us where things have gone wrong. If the problem persists we tell them, 'But you should try your best to come'.*
PI307	Sauko **Ground Labourer 2 - Male**: *you find that because we were not told properly what we should be doing, calling that brother as has been said by Stain Phiri, so that if they also tell us about these problems that, 'If this happens, you need to do this, if this happens it needs to go like this', that also gives other problems. But mainly we are very grateful for our other colleagues who direct us, those of us who went to learn computer, who you sent as people who work there, assisting us. Even though sometimes our airtime is not refunded (laughs), yes, because the government pays, they give us airtime that, 'You should be calling here when something goes wrong', but there we do not receive.*
	Negative
PI308	Malilika **Laboratory Technician-Male**: *They would say to us, 'We'll come to train you in this and that', then they don't show up. Then they would come as if maybe they were just passing by and say, 'Let's go through Malilika to see how it is going', and say, 'We came, now we're leaving, we're leaving, we're leaving'. So it happened that we had many people who don't know computer and many have questions. Even reactivating accounts and all that, they were relying on those sirs to come and see how to proceed. These computers, these small printers that came here have many problems. Sometimes they would work, then nothing, it's gone. Then many problems, and we would say, 'Who will we be reporting to?' Then we would take those worries to our bosses that, 'If you have a chance to phone them, then please phone them'.*
	b. Response speed
	Positive
PI309	Sauko **Hospital Attendant - Male**: *For me the worry that I had, I have seen that it has been realized in terms of what I had said earlier that if something is damaged, then they will just be grounded while waiting for the person who knows it well to come and fix it. So it really happened that dust entered inside it and it was just dormant for several weeks, up to now it is not back. So my worries were realized in that if people went to be trained in everything, this problem would not have occurred. There would have been found someone like an expert and fix it, and now it would have been working.*
	d. Effectiveness of service

	IT Support – Failures
	1. IT Support
	a. Accessibility of support
	b. Response speed
	Positive
	Negative
PI310	**Filipi HIV Counsellor –Male:** *Sometimes it used to happen that the network kept going off. Sometimes it would be three days, four days not working. So that was another challenge.* ***(Paul:*** *So you would wait for people from Madalo to come and fix it? And that used to take several days?) Yes.*
PI311	**Filipi Cashier - male:** *Then say, 'Ok, we'll come tomorrow'. Then it would take two months, or maybe even one month, before coming. When they come, they would come with a strange thing, then they would manage. So for us that strange thing was difficult, they have just done it secretively, now what do we do here? So I wanted to say that our failure, maybe you also contributed. (laughter)*
	c. Effectiveness of service
	Positive
	Negative
PI312	**Filipi Clinician-male:** *You came and asked me as Sakala that how many challenges are there, and I have been telling you, 'Challenges occurring are a, b, c, d, so you need to do a, b, c, d'. But I did not see that you did any action.*
	Workload & Shortage of Staff – High Adopters
	1. Workload and Shortage of Staff
	a. Reduced workload
PI313	***Ponekela*** **HSA1-Male**: *With the coming in of computers, the work was less because it was showing that quickly, even though there would be many people. This facility is the only one in TA Chauma, but is where many people come, others even coming from other facilities for other reasons. So you find that there are maybe 300 people in a day. So with the computers it was found that the work was less at registration, we were registering in little time, up to many, many patients in a little time. So that's what I see the computers helped for the workload to be reduced.*
PI314	***Ponekela*** **HSA2-Male:** *To add to what my colleagues have explained, they have also reduced our work. Like when a person, at the time you are struggling with a register, you can get tired quickly when you are writing. While when you are at a computer, it's something that you can use like automatic, as opposed to manual. But they have also reduced, as has been said by my colleagues, the stationery for working. We were struggling with papers, pens, while now all those have been reduced. We are using these computers without struggles.*
PI315	***Ponekela*** ***HSA7-Male:*** *the computer is simplifying things. Many things have gotten much lighter because of the computers.*
	b. Increased workload
PI316	**Winistoni Medical Assistant-Female**: *In terms of job distribution, it seems more work has been added as compared to before, that there is now more work added*

	to what we were doing before.
PI317	**Winistoni HIV Counsellor 2-Male**: *It seems the workload has been increased because other information on the use of the computer was hidden, we were not told. So it is a challenge for us.*
PI318	***Jedawako* HSA-Male:** *You find that another time, when there is network but the one that is functioning is one computer. So that is being difficult because the same person should register then you come to do diagnosis. So it seemed like that work is just left to one person, because it happened that often – others are just using the computer that, 'Aah! We are just seeing it right here', but many are not fully trained in computer use.*
	c. <u>Double data entry</u>
PI319	**Dalitso Data Clerk-Male**: *Let me just speak on behalf of my colleagues like the MA. When they write – When it seems like those things are delaying. By themselves they have to write in the little book, by themselves again they have to transfer that information they have written in the little book, they have to enter again into the computer. So it makes it to be – maybe things to be delaying.*
	d. <u>Staff shortage and coping mechanisms</u>
PI320	**Winistoni Security Guard 1-Male**: *This computer – it could be here, I don't know about other places, but here it seems it disturbed many things. Like I'm telling you that I am a guard, a security guard. It happens that it's daybreak in the morning, instead of going home to rest, I stay here because of assisting on the computer, because there isn't a specific person here who is responsible for computers. There isn't. There was one, but they left. So since they left, there isn't anyone who knows how to do this work. So I force myself that, what else can I do? So I assist the clinician there. So slowly it turned out that I am doing more work but without pay. I can't really see the benefit, because I was thinking by doing this, there would be other allowances because I am doing double the work. So it is there that to me I feel that it is quite a burden. Yes.*
PI321	**Winistoni Hospital Attendant 1-Male**: *It appears it is giving us more work and overload, maybe because we are few, otherwise one person would be coming to write in the computer, the counsellor should also write in the manual, then they should enter them there, then it makes us overwork.*
PI322	**Winistoni Medical Assistant-Female**: *That system that you brought of having two computers, where one would print – one would be booking and one recording diagnosis, I think that system was good. It made there to not be congestion inside there. Because inside the medial assistant prescribes, and some drugs we administer right inside there, and then you have to record in the computer, that becomes difficult.*
PI323	**Winistoni Security guard 2-male:** *The other problem that is there is staff shortage sometimes. You find that the staff who know the computer are only two, and the same person sometimes has to be giving drugs at the window, the same person also has to record into the computer, the same person records into the register. So it can maybe be tiresome. But if these people they were well trained in computer, then it wouldn't take time because when you write in the computer then it would be possible because writing manually takes more time. What the biggest problem is, is skill.*

PI324	Dalitso **Medical Assistant-Male**: *For instance, some arrive early in the morning, and for them to be taken from the queue to enter their names into the register, so seeing that there is a shortage of workers, so we just divide among us. So others will be having their names entered into the computer, others we are writing for them before they have been entered into the computer.*
PI325	Dalitso **HSA3-Male**: *I feel that the starting time for work is what delays a bit. Let's take the computers, we divide ourselves, one here, another here, another here. Let's all start. Ah! I feel it can be very quick. But you find that the same clinician to be there, enter here and also enter there. I think training a bit more people, but also the speed should be a good one, then aaa! The computer, I see it to be a good thing, more than a pen.*
PI326	Dalitso **Nurse-Female**: *For me, I thought that it would be – It's faster, I should say. What needs to be done is just – Those people, like we have complained that the training – Perhaps the people should be well-trained, everything will be faster indeed. The queues will be well reduced. Because like there are others who know it a lot. Because we can't say all of us do not know it, others know it a lot. Maybe what has been said that this and that, it may just need us to sit down here to see who among the HSAs that are willing that, 'Us, today, this week will help with the computers. We'll come early in the morning, or we should start early in the morning, so that we help you'. Like the passwords that they were talking about, if they are provided to them and they would start well, and things would go well. The main thing is that you do your side, and us the coordination here, is what can help us that the queue will be reduced.*
PI327	Dalitso **Medical assistant- Female**: *Registration is still being a challenge, because the computers are few that are there. Even if there are two, we can try our best to be diving them, one should be registering here the other here, so they should not be taking a long time before going to the clinician for writing.* ***(Paul:*** *So one should be registering and the other diagnosis and treatment?) No. There should still be two, or three. Those doing registration should still be two so that they will be booking fast so that they get done with the clinician, all should be registered. Because there is some chaos that some go to see the clinician before getting registered because there is only one person doing the registration.*
	Workload & Shortage of Staff – Medium Adopters
	1. Workload and Shortage of Staff
	a. Reduced workload
	b. Increased workload
PI328	Sauko **Ground Labourer 1 - Male**: *What has changed is that we are forced, because of shortage of people, to work there as the statistical clerk, in that we are forced after we have done our work, when we are done there we are forced to assist the statistical clerk because there is only one.*
PI329	Sauko **Hospital Attendant-Male**: *The first thing I can say is that it has increased the workload as the other guys have already said.*
PI330	Malilika **Pharmacy attendant-Female:** *the main problem is the printer. It happens that we as pharmacy attendants enter all the information, but the problem is at the nurses, who have to enter in the book and in the computer, which takes time. So to avoid delay there are too many people we just leave putting in the computer and just do the manual entry. So that is the main problem: the printer.*
	c. Double data entry

PI331	**Sinelia Hospital Attendant -Female**: *Considering shortage of staff, it is still sometimes difficult because we cannot just stop writing in the books, so you find that they have to write here and also write on the computer. Sometimes it can be quite a difficult thing.*
PI332	**Sauko Data Clerk-Male:** *the change is that the workload seems to have increased. But what is causing that is that the program is not yet settled, because we are writing in the manual register, at the same time enter it into the computer. The reason is that, that program, let me say the place where it was put, was the data clerk just using registers, the other part to be done by our colleagues, the MA's inside. So because they are so busy inside there, they don't use that computer, so we are pressed again to do that here.*
PI333	**Sauko Hospital Attendant-Male**: *there has been a change by saying that the people who went for training have gotten new knowledge about how they do their work well, because if those things are being used only in the computer, it would have been work that is easy. But because we are saying that there is manual, they write with a pen in the register, then they go onto the computer, then it seems to be that the workload is now increased.*
PI334	**Sauko Data Clerk-Male**: *Maybe there, if there was – I don't know how they would do it, let's just give an example of Baobab. The computers that Baobab installed, they – You can come early in the morning and register a patient, they go in and the clinician assists them. Or if not like that, they didn't find you and just went to the clinician, they come and you assist them. Everything is done right here. You can be at the desk, there would be one data clerk, but you are able to manage the whole crowd the way it is here. But here because that work is, you come, six o'clock I have arrived, six or before six sometimes. Registration. I have finished all of them properly. But for one to record diagnosis and treatment, that one patient you have to write in that register, the manual one, the same one you enter into the computer so they can go receive drugs. So here we can see maybe, during this season, four hundred, three hundred, when we go fast even six hundred, I find it to be difficult.*
PI335	**Sauko Ground Labourer 2 – Male:** *We were saying that, to enter here at registration and then also enter into the computer, that is a lot of work, I'm not kidding.*
PI336	**Malilika Nurse midwife 1 - Female**: *there was more work. This is a negative effect, there was more workload. If there was a print-out, workload would have reduced. Because we have to type in the computer at the same time we have to write in the health passport, of which it costs a lot of time. That is why we sometimes use it and sometime we do not use it.*
PI337	**Malilika Nurse-Male**: *What is the problem is that when we write in the computer it should print out the prescription and put it in the booklet and they continue from there. With that it can be beneficial, unlike writing in the computer then in the book, it is very difficult.*
PI338	**Malilika Pharmacy assistant-Female**: *We ended up not having those small papers to put in the patient's books so we have to write the numbers again, making us write three times: in the person's book, in the register and in [bespoke eHealth system].*
	d. <u>Staff shortage and coping mechanisms</u>

PI339	Sinelia **Nurse midwife 3 - Female**: *As has been explained by my colleagues already, that due to shortage, it happens that – the patients – To indeed move orderly day to day seems to be quite difficult. But that information is not lost. I feel that it will help us a lot. (**Paul:** When you say moving orderly day to day seems quite difficult, what do you mean?) I mean that, since I have explained firstly that we have – Maybe we are a few on that day. So for us to find the one who stays there to help us, it is found that maybe they are away. So it's how I have explained to say that sometimes it is difficult like that.*
PI340	Sinelia **Mid wife Nurse 3- Female** *Because of what I said earlier that we are busy, we are sometimes few, so we were – It makes us to not be on the computer often.*
PI341	Sinelia **Midwife Nurse 1 - Female**: *Here at OPD it is not every day that information is entered into the computer. There challenges are that network, or when it's not that then there is no power, but also shortage of staff. You can find that power is there, network is there, but a person to be there to be entering information on that day is not there.*
PI342	Sinelia **Midwife Nurse 2 - Female**: *We can say that the main thing is staffing. Firstly, staff is already few. Secondly, among those few staff you will find that some have not been trained. So the very same people who know have to come from OPD, they should go to the maternity ward, or the very same ones have to come from maternity ward and go to HTC. Which is something that they cannot manage. So during the time that network is there or power is there, those people are busy at OPD while at the maternity ward things are moving but the people to be on the computer are not available.*
PI343	Sinelia **Hospital Attendant 1 - Male**: *The one who is using it here at OPD, when you are done with your work here then you have to force yourself to go there to login again and do it as well. So then because you wait for your work to be done, your busyness to be over, when it's done, then you should go there.*
PI344	Sauko **Data Clerk-Male**: *What I had in mind did not happen, because I expected that with the coming of computers the workload will reduce. But instead, they have added more work. Because these computers, before they came, the fact that the data clerk who is there is just one, wasn't noticed. But now it is happening, because these computers, we work on them because they have been given to us and are expensive, they should not get wasted, let me use them, so I use them … But also when it came it brought some threat among my friends, the ground labourers, because when the work gets overwhelming, the bosses ask them that here … since they think that they are just chatting at the time when there is a large crowd, there is a large crowd and because of the large numbers of people, the computer that was in the clinician's room, because it was not being used, when I told them that they are not managing, I was told that, 'Remove it for now, there should be two computers here. So the ground labourers, both of them, I would get them and put one on one computer and the other on the other computer and then at the register. So it seemed to have brought a threat to their work, instead of making the work less.*
	Workload & Shortage of Staff – Failures
	1. <u>Workload and Shortage of Staff</u>
	a. <u>Reduced workload</u>
	b. <u>Increased workload</u>
	c. <u>Double data entry</u>

PI345	**Filipi Clinician - Male**: *there was a big challenge that, for us recording, it was like a big barrier. It used to happen that, like today I am alone, I'm working alone. Here, when I come early in the morning I find that it is full. I'm supposed to go do ward rounds. So as a person who is not used to using a computer, that I am not fast, so for me to write in the book, that same information I should come write it again in the computer.*
PI346	**Filipi Clinician - Male**: *There was a big challenge that, for us recording, it was like a big barrier. It used to happen that, like today I am alone, I'm working alone. Here, when I come early in the morning I find that it is full. I'm supposed to go do ward rounds. So as a person who is not used to using a computer, that I am not fast, so for me to write in the book, that same information I should come write it again in the computer. So it like it's tiresome that you are doing two things. While if there was a printer, just writing like our colleagues do at Madalo, they just write and write and then it comes out faaaa! you just pin it there paaaa! Then it means you have written that the person is complaining about such and such, and the diagnosis is this and that and you have given them such and such medication. So that means the other information will remain in the computer, the other you get out you just pin paaa! That's it, they are on their way. But then it is tiresome, for when you see the queue, you write. Then that made you to be with the patient for fifteen minutes, which was not good. So to avoid that, people would just say, 'Ih! Let this be here a bit, let me do the manual' (laughs).* ***(Paul:*** *So you would be with a patient for maybe fifteen minutes?) Yes. You write in the book. Then you enter into the computer. You should check where 'b' is (laughter). While for those who are used to it, since they know that keyboard, they will just be doing this here while maybe asking there and they have already started*
PI347	**Filipi Cashier-male:** *When you have finished entering into that computer, you also write in the manual system. Indeed.*
PI348	**Filipi Clinician-male:** *Many were not used to that thing, so we were forced to use two things. That is, register and the computer. So it used to happen that, because a person has come out of the clinician's room who has written for them, they go to the register to be entered what we have written, then they would start entering into the manual register, after entering into the manual one, another one will have to also enter that same information into the computer.*
	d. <u>Staff shortage and coping mechanisms</u>
PI349	**Filipi PA-Female**: *It made that, since weekend others are off duty, so it happens that there is a bit of a shortage. So that made it seem to have problems for that work to be done well.* ***(Paul:*** *Alright. Can you explain how it was difficult? Maybe you can expand that a bit.) Since we are from different departments, maybe here there would be, let's say three people, meaning one is at the malaria diagnosis place, another will be working at the wards, mopping and so on, then it would mean here there is no – At registration, someone is at registration there. That would mean the one entering the data into the computer is not there. So it would be like, this one is also busy, they leave this one to also do this, it was just – It kept them busy.*

PI350	**Filipi Patient Attendant-male**: *When it came here, as has already been said that our staff are few, for a person to manage everything, sometimes you would be just two people who are working, maybe there are three, so other places you were failing to manage. So that's why many things were failing to be done.*
	Demand Creation – High Adopters
	1. Demand Creation
	a. Need for the system at the facility
	b. Need for the system in other departments
PI351	**Winistoni HIV Counsellor 2-Male:** *There is someone who comes – What's his name again? He says, 'Ah, I want to have some other information to enter into the computer, like OTP report, it should be entered', and he even asked us to bring it and he took photos of it. He also took the MCH report, the one that I said we don't have but he said, 'Ah in due course we will have it so I just want to have it already saved'. He also took a photo of it and put it in (**Male:** Gerald). Gerald, right? (**Male:** Yes.) Then there was also this other report. So, it just happened that those things just – Up to now. So, it's just a point to say that when you are thinking about those other things to improve other areas, you should also consider at MCH so that those things and also OTP, we'll be doing all that together. Yes, saying that if the chances will be there that, 'Ah, you will also producing reports, this and that,' we should be able to come up with reports like the other sections.*
PI352	**Winistoni ART clerk Male**: *We do have an under-five clinic where we do registration manually, which is tiresome work. It can be an easy job if it is computerized and we can be able to produce reports easily.*
PI353	**Winistoni MA-Female:** *We need a computer at the dispensary. Because sometimes I write the prescription here but maybe they didn't hear and they just pass through. So I need to know that, 'Now that I have written a prescription, has the person received their drugs?' Instead of the person coming out and wondering, 'Ah, have they not started dispensing? Have they not started dispensing? Have they not started dispensing?' But when I search on the dispensary, I should be able to see that they have started dispensing – (**Male:** The drugs) – the ones that I have prescribed, and the drugs that I have prescribed to those people, are they there or they are finished? (**Male:** Or even when people come from the Ministry, they should find things are alright). Yes. Because when the drugs are finished they will not leave their place and come to say that – They will see that they are finished, and I will know that the drugs are finished and I need to go and take out some more.*
PI354	**Winistoni Hospital attendant 1 - Male**: *What we need is to find another one and put it at the under-5 and not remove it from another place. It should be there at under-5 clinic. If you give us a computer at under-5 clinic, everything will go well.*
PI355	**Ponekela HSA7-Male**: *We wanted that other parts, as my colleagues have asked, that maybe you can reach there and maybe arrange a refresher, maybe reach other departments like at public health.*

PI356	**Ponekela Ground Labourer-Male**: *Yea, when the computers came, there was another place where they needed to be there, like at MRDT, where malaria is tested. There were still problems there because a person would also be using a pen there, the same one they had thrown away. So at the MRDT part, there was no computer, where a pen was being used. If it was that the other part we were using computers, such as at registration, at HTC, and MRDT, all those places the computers are working, then work would have been good. Even though the computer in HTC was installed but not trained well, the guys who stay there – Because it was, 'We have installed it, we need to come and say what needs to be done', for the guys the computer is just like a toy in there, they don't use it, because they were not told. They were not trained.*
PI357	**Ponekela HSA6-Male:** *I feel that maybe, on the part my friend Black has requested, that maybe if other parts were – You would also bring for us, like at our public health office, we also have workload that – Maybe like those women there, for us to enter cards, immunizations, and so on, those things also seem to be a great deal of work, so if you can also consider us. At the under-5 clinic there. Yes.*
PI358	**Ponekela HSA1-Male**: *The computers will be at all necessary places, like the public health office and other places that the computers will be installed. Our thoughts were that as the computers are coming like this, that other workload like our public health work will be reduced, because we will be using the computers, like for entering the profiles of the women, the children, entered into the computer. So my thoughts were that the workload will be reduced, but also we will also be using them for that work. Because there are times when we the HSAs are at the facility on duty, so the one who will be on duty will make sure they are aware and understands about the computers.*
PI359	**Ponekela HSA7-Male**: *We wanted that other parts, as my colleagues have asked, that maybe you can reach there and maybe arrange a refresher, maybe reach other departments like at public health. Yes.*
PI360	**Ponekela HSA7-Male**: *When we heard that computers will come we expected that maybe also like at public health office will be found some, on the part concerning at the under-5. But I was surprised that they were not able to reach at the under-5. So we were just waiting that, 'Ah, maybe because they are still installing where – Where we do immunization, then we should still wait maybe it will come to us'. But we saw that time is going and there is still no computer at the under-5. So at the under-5 this issue is still big (unclear) so if you can at least look there also.*
PI361	**Dalitso Medical Assistant-Female**: *At ART there is one challenge. At ART in the meantime we are not using those computers, our data we have not entered into the system. There is need to enter all the patients so that it will not be difficult for us. However, there is still need for more advice with help coming from Madalo that they should come and help us with the data to be entered well so that we have been able to keep that person well. How do we do that?*
PI362	**Dalitso HSA3-Male**: *I saw that they did not reach other places. I only see them at the OPD there, at the maternity ward there, at HTC. But other places, at the environmental office there, it's not there. So I was thinking that maybe if it can be that they have also reached other areas like those, maybe it can also make the work to – (**Paul:** Where is there none?) At environmental office. (**Paul:** But electricity is there?) (laughter) (**Paul:** Is there one at ART) No, at ART there also isn't.*

PI363	**Dalitso HSA4-Male**: *If you can try your best for the computer to be installed at the environmental office, since that's where there are a lot of people. Maybe others can learn there because that's where there would be more space, unlike the way it is at OPD where always it's being used, which can make at least the speed of using it to have an opportunity to be improved through (unclear).*
PI364	**Dalitso Nurse-Female**: *At the maternity ward also needs to (unclear). Though challenges will be found, but the thing will at least be used. Of course there is shortage, but still our colleagues at OPD also face shortages but they find access to (unclear).*
PI365	*c. Need for computer accessories*
PI366	**Ponekela Ground Labour-Male:** *Maybe if they were informed that we now have a photocopier, but what we will be requesting from here are papers and ink, they would not give us problems over that. They can understand that, 'Ah, let's be assisting them'.*
PI367	**Ponekela Ground Labourer-Male**: *When the computers came, at first we were using barcodes. So it was like using barcodes at first was very easy. So because the barcodes stopped, the work was found to have become a bit difficult.*
PI368	**Jedawako HSA-Male**: *There were promises for a printer, but it has not been fulfilled.*
PI369	**Dalitso HSA2-Male**: *Writing the number on the health profile, we write with a pen. Checking there and writing. When there was – Was it a printer? When you had finished then taa taa taa taa! then you just take it and paste it, that's it, you can go. That's it. Then during this period you get the number and someone is speaking (laughter) Yes, you would just take it and paste it, you are done with that number, you can go. So if that can be sorted out well.*
PI370	**Dalitso HSA3-Male**: *He is talking about writing reports and going to print them out. I was thinking aaah! Just have a printer here and not have to go print out, we should be printing here. (**Paul:** Would the toners be able to be bought? (laughter) It will be seen at that time, right? **(Female:** Yes) (laughter))*
PI371	**Dalitso Medical Assistant-Female**: *It looks like the clinician is having several jobs: we ask the person how they are feeling, we write in their book, we type on the computer. So it's like maybe we are able to guide each other about things more than this, if there was an arrangement of maybe finding a printer so that the work of writing in the book should not happen, we should just be asking the person how they are feeling, write on the computer and then print and stick it in that book. Maybe we can save time. But to write in the patient's book – We ask the patient, we examine them, because we need to examine them physically and check them, time is going there, we write on the computer, still time. So if it were, for writing on the computer, we should just write and instead of writing again on the paper, we should just be sticking what we have written on the computer like the way other facilities do, if that is possible. To save time. Yes, it can go well like that.*
	d. Need for other computer programmes
PI372	**Winistoni Medical Assistant-Female** *I feel there should have been a link with Lilongwe DHO. Yes, there should be communication with the DHO there, since they have computers for the DHO and others. If things went that way, it would work. They would be sending us other information of things happening direct into the computer like the way they do. So since this is hard-to-reach, by the time they reach us with information things have already happened. Why? Maybe phone network has been problematic, but also this, letters will arrive late. Yes, so what*

	we expected was that the way you had started, things will be moving forward.
PI373	**Jedawako Hospital attendant 1 -Male**: *Madalo had restricted internet access. Before the restriction, we were using internet as a way of familiarizing ourselves with the computer. We could access pages like Nyasa Times. So we are not happy with the restriction.*
PI374	**Dalitso HSA2-Male**: *Since learning does not end, it can happen that there is someone who is interested in learning, learning about computers here, they removed for them many systems, like Microsoft Word is not there. So for a person to just start at [bespoke eHealth system] without knowing (laughs) where space is, to just start with there, it becomes a bit difficult. Many things I've seen they have removed, but previously they were there. A person was even able to write their name, since a person starts from writing a name before starting the other things.*
PI375	**Dalitso Medical Assistant-Male:** *When I came here I saw that aaah! It's not the same computer, you only have one processor over there connecting a lot of computers. So, naturally at a place when you hear that there is a computer, then you have access to do other things, maybe you want to write a letter, you can just write it on the computer without the trouble of going to have it typed by someone else, no. You can just type it yourself. For example, I admired at the nutrition office. There is a computer, there are two of them, and each has its own processor, and a person has an interest, maybe you want to browse. Because other people have dongles, they have an interest to use the internet, but they have no access to use the internet because at the facility there is a computer, but they can't access an activity of using the internet. Yea. So my thinking that there is a computer, I was thinking that if I want to search for something, if I want to write something, maybe I will be able to do it. Maybe create presentations – because like people have meetings, even at this facility. You want to write things. Elsewhere they want reports, presentations, we can just create it there, since the monitors have those graphs, you just write them then you just take it to print out. But those things here, I see that aaah! With these computers, it's also a challenge. But it's something that indeed –.*
	Demand Creation – Medium Adopters
	1. <u>Demand Creation</u>
	a. <u>Need for the system at the facility</u>
	b. <u>Need for the system in other departments</u>
PI376	**Sinelia HSA-Male**: *Like has already been said, we expected that when the system has come, it will be used in all departments here, (unclear) but suddenly we saw that we had indeed learnt the computers, but there are other parts like at ART clinic. It happened that the computers – It's there, it came, but it is not working. Since it came it is just idle. We were told there would first be training so that we can be entering data there. But up to now, we have not been taught how to enter ART or HTC cases. Such that currently we don't know the computer. It is just idle. We tried to connect it, but we have a problem, the network does not reach there that a person can login. It is not possible.*

PI377	**Sauko HIV Counsellor – Male**: *My thoughts when I heard that computers are coming, my thoughts were that they would be put everywhere where they are supposed to be at the same time so that they would help at all those places for information to be easily found, but also to help, perhaps the person has come who needs to be served, if they had been here before they should be searched, they should be searched properly and easily and as opposed to have to be searched in the register and in that way the people will be served properly when the computers at all places will need to be installed at the same time.*
PI378	**Sauko Hospital Attendant- Female**: *I was expecting that everywhere they have been installed, like in there, they would be working, at maternity, they would be working. I expected that all the work would be possible on the computer. Maybe at the delivery only is where there will be manual.*
PI379	**Sauko Hospital attendant -Female**: *My request is that you should fix for us where the others have already said where the computers are not working. It is also my desire that, since I have gone for training but I am not showing my talent because at our station the things have not started working, so if they have been fixed, I start working on it, maybe even when my children come and see me there they'll say, 'Hey, our mother has changed her job!' (laughter) 'She has changed, now she sits in front of a computer'. So that will make me to be proud. So I will still ask that the way they have started, they should continue so that in all these offices the computers should start working. It will be something to make me proud. Because now I have also started forgetting because the ones I was supposed to use is the one over there. Or maybe I sit at the dispensary and observe that when the clinician does this and that about prescription and then I give the drugs and observe. But that does not happen because at all these places they do not work.*
PI380	**Sauko Hospital Attendant-Female:** *the computers are working at one place, so like there at the dispensary they have not started working. Like at maternity, they have not started working. So I have not seen any difference, because it is still working at one place.*
PI381	**Sauko Hospital Attendant- Female**: *The things that I was expecting, some are those not happening. Because I was expecting that everywhere they have been installed, like in there, they would be working, at maternity, they would be working. I expected that all the work would be possible on the computer. Maybe at the delivery only is where there will be manual. But now (laughs, others laugh) but now it is not going like that, they are not working. So anyway, because of that, I am still (unclear) it is not alright yet. But my expectations were those, that all the work now will be done through these computers.*
PI382	**Malilika Cashier-Male**: *It is difficult because these things are very few and we scramble that, 'If you are done with [bespoke eHealth system] I'm on the queue'. So it would be, 'Let me use it this time because someone else is coming'. If all the departments there were several, then if we have spare time we would sit down and do some things, because it is not all the time that you can be trained.*
PI383	**Malilika Patient Attendant 2 -Female**: *the other problem that we have is that when they came [bespoke eHealth system] (inaudible) because other departments do not have them, which makes it when you don't know you need to find someone to teach you and when you have a chance maybe there is no electricity, when you have a chance the other person is busy, so it made it that sometimes we are doing those things slowly.*

PI384	**Malilika Cashier-Male**: *there was a burden that now there were few. People would come from maternity to come learn here, from general ward to come learn here, because of few number of these things. So just because this is our chance, grace has found us, if it was possible and there were many then maybe our learning would have been much quicker. But it is difficult because these things are very few and we scramble that, 'If you are done with [bespoke eHealth system] I'm on the queue'. So it would be, 'Let me use it this time because someone else is coming'. If all the departments there were several, then if we have spare time we would sit down and do some things, because it is not all the time that you can be trained. But when you are doing it yourself, because you say we learn through corrected mistakes, so through that we would have now been at a good mile that we now have an attempt of how to use.*
PI385	**Malilika Dental-Male**: *the computers were here only and when it's closed here, being OPD, outpatient, and there aren't any at the wards, the maternity and general ward, so those friends there, when they come on night duty, they should return during day shift, then they would suffer. That means we are still remaining with a large group.*
	c. <u>Need for computer accessories</u>
PI386	**Sinelia Hospital Attendant 2 - Male**: *At first when the computers came we were using that printer that was giving us barcodes. So since the barcodes were finished, up to now the printer is not working. So often when perhaps – Let's say when you do that scan, scanner and printer, let's just say they are not working. So the request is that, if they can bring us those barcodes, because they also help us to be a bit quicker as you just scan.*
PI387	**Sinelia Hospital Attendant 1 - Male**: *barcode and printer has been taken away. So that's also maybe why they are not working. When registers are out, you just get that number and (clapping sound) on the patient's book.*
PI388	**Malilika Laboratory technician-Male**: *when we travel to district hospitals the computers that are there and ours are different. Our friends have touchscreens, yea, no, et cetera, within seconds they are done with the patient. So when these computers came, most found that to be a burden because many thought they will also be touchscreens like at those districts. And to also see that the [bespoke eHealth system] that came eh! Confusing. And to also see here that many people do not know computers. So there were several burdens. So, many were happy when we heard that with computers things will go well, everyone will be entered into the system. So to see that the computers that came had mouse and other things then eeh! confusion. And to see [bespoke eHealth system] then total confusion.*
PI389	**Malilika Nurse mid wife 2 - Female**: *When the patient enters into consulting, we ask them their history, we write in the health passport, at the end we enter that same patient into the computer and we stop talking to the patient and they see that we are delaying, especially with the slow typing. So there with the printer, you would just type in the computer and print and the patient exits and you are done.*
PI390	**Malilika Laboratory technician - Male:** *when we are checking patient listing to see how many patients we have served that month, like for maternity, when we do it on the maternity module, it shows that everything for maternity is there, all the figures are there. So I wanted to ask whether there is another way that can be done, like bringing a large printer so we can just print out the whole paper. Because here we just rely on (inaudible) to compile a report but we can see it with our own eyes that the (inaudible) this paper, then that report is done. So we were*

	just saying if it is possible if a large printer was brought then we can store and when we want to print out that report, it would just come out on that paper.
PI391	**Malilika Nurse-Male**: *What is the problem is that when we write in the computer it should print out the prescription and put it in the booklet and they continue from there. With that it can be beneficial, unlike writing in the computer then in the book, it is very difficult.*
PI392	**Malilika Cashier-Male**: *For finances, for us to enter a statement and produce a statement from the finance we need to have a backup. So it happens that there is only one computer, as has been said by my colleagues, that we entered some time ago and then we stopped, we cannot then rely on it otherwise things will not be correct. So now we still use our registers, but then in future we will be using the report. If our accounts reports can be produced by the computers then we will need more computers for, say, backup and many other things so that if this one is lost we will be able to trace it. So we need backup computers.*
PI393	**Malilika Laboratory Technician-Male:** *if the large printer was available then we can just print out the paper. Let's say the whole month we have entered properly in the computer, every problem we have entered it into the system, then we can just print out that paper, then we have a full report there. Then we would not be filling in the other things, we would just be using those. Because I have seen that it's the same one, for maternity it's the same one, for antenatal it's the same one.*
	d. Need for other computer programmes
394	**Malilika Pharmacy assistant-Female**: *there were not enough of them, like those papers for printing patient's names we only used them the first days then they what? they were finished. (inaudible) We ended up not having those small papers to put in the patient's books so we have to write the numbers again, making us write three times: in the person's book, in the register and in [bespoke eHealth system].*
	Demand Creation – Failures
	1. Demand Creation
	a. Need for the system at the facility
PI395	**Filipi Senior HSA –***Two or three days later you hear that, 'They have taken the machines' and then ah! it has flown away.*
PI396	**Bisitoni Ground labourer 1 - Male:** *I also had a question that was in my heart that those people called us and trained us how to use a computer and you really brought the computers, but the time you came to take them away you did not find out what is happening but you just came and take the computers and we heard from others*
	b. Need for the system in other departments
	c. Need for computer accessories
PI397	**Filipi Clinician - Male**: *If there was a printer, just writing like our colleagues do at Madalo, they just write and write and then it comes out faaaa! you just pin it there paaaa! Then it means you have written that the person is complaining about such and such, and the diagnosis is this and that and you have given them such and such medication. So that means the other information will*

	remain in the computer, the other you get out you just pin paaa! That's it, they are on their way.
PI398	Filipi ***HIV Counsellor*** *- The printers were a motivation somehow. Because perhaps you think some thoughts that ah! things will change. You will move from there.*
PI399	Filipi **Patient Attendant 2-Female:** *it did not really help us because it was taken away quickly. So somehow it was like we were left up in the air that ah ah! there is a dance and then they remove the drum, so you don't continue with the dance, you just stand. Yes. But those things made us very happy.*
PI400	Filipi **Clinician-Male:** *For us, we are somehow surprised that you have taken those things, but if you look at your research, you are conducting your research at all the facilities that have computers. While at this facility you have already taken the computers, they are gone. So I am wondering, with your coming, do you want the computers to come back, or you just want to ask us how it used to go for the sake of reporting?*
PI401	Filipi **Clinician-Male:** *When a program starts, you give it some days, then you evaluate and you sit down, before you pull out. But then what you did was to pull out, then you are evaluating. So what will we be evaluating? Because the thing is not there.*
	d. <u>Need for other computer programmes</u>
PI402	Filipi **Cashier-male:** *We felt that it would do us well with the Excel ledgers. I saw that our things will be lighter when writing, that even reports from Excel. Then I saw that we have learnt as if on the sand, two minutes it's over. We come here on the ground to do work and found that ah! internet is not there, search for Excel, it cannot be seen. That's it. So when you are busy you just leave this – Let it just stay there, let me work with the books. So our hope was that, that I was expecting things will be made right.*
PI403	Filipi **Clinician-Male**: *When I heard that the things that are coming are computers, because for a person … our thoughts were still that, since these things use – I don't know what you call it – Maybe internet will be there, so we'll be – When we want to Google some information, maybe it will be like a motivation that a person should not move from the computer. Because there is something that pulls a person to not move from a computer. If that thing is not found, the end result is that you just see it as something that is useless to me. So for us, at first the thing that will firstly entice us is internet. When we find internet – It does not mean that you will just be on the internet. When a patient comes then that thing – The time that you are on the internet it makes one get used to the thing. If you are getting used to it then the patient's information will not be difficult to enter. So I was happy that ah! if those things are like that, it will be a very good thing. I was just surprised that eh! eh! they didn't come those things I am saying. It was quite a bit of a demotivation indeed that – Everyone felt that ah! The time we use that will be when I want to enter information of a patient. Let's consider this facility. Sometimes it happens sometimes that*

	patients come, maybe fifteen. It truly happens. So let's consider there came fifteen. The whole day that thing will just be idle. Because since a person is used to, these days, social media. And you say, 'Ah aah let me just take my phone'. You are there outside with your phone. But if there was internet you would still be there quietly, pressing buttons while you are learning. At the end you will have learnt that thing quickly.
PI404	**Filipi Cashier-male:** *We felt that it would do us well with the Excel ledgers. I saw that our things will be lighter when writing, that even reports from Excel. Then I saw that we have learnt as if on the sand, two minutes it's over. We come here on the ground to do work and found that ah! internet is not there, search for Excel, it cannot be seen. That's it. So when you are busy you just leave this … let it just stay there, let me work with the books. So our hope was that, that I was expecting things will be made right.*
	Overall Impression – High Adopters
	1. Overall Implementation
	Positive
PI402	**Winistoni Hospital Attendant 3- Male**: *To put it all together, the project has gone well. And I can say it has scored 75 percent, as we have discussed here.*
PI403	**Winistoni Security Guard 2- Male**: *The project is good, and also the things that are disappointing are very few, the good things are – Many of the things are good. I'm happy with it.*
PI404	**Winistoni Medical Assistant-Female**: *It's quite good, we just need to work on some areas, but most areas are quite good. It's 99 percent. (laughter)*
PI405	**Winistoni Hospital attendant 2-Male**: *The project we can say is at 99 percent, it's only one percent remaining (laughter). Adding on to the workload only (laughter). But also the report is not going. So it's like it has given us added work but the report is not being taken from the computer, they are still relying on those same registers. So that part is making the little one percent, not the 99, that little one percent. It's like we are still using the old system. Because we are still using those registers, but we wanted the registers to completely disappear. So it will make the work seem less. True.*
PI406	**Winistoni ART Clerk-Male**: *The project has gone very well. Because when we look at all the different good things at OPD, HTC, ART, at maternity, all there it seems – Eespecially registration at OPD, it seems to be going very well, and tracing at ART seems to be going very well. So for most parts it has helped a lot. So seeing that when something is good, there cannot fail to be bad things, a problem is always there. The problem is that it just needs to finish the work, that we should be able to produce a report about the things that we have recorded. Because when someone puts in something, they expect an outcome of that thing you have entered. So what we want now is the outcome of the things we are entering, we should be able to produce it and see it. But*

	all in all, the project has gone well.
PI407	**Ponekela Ground Labourer-Male**: *On the part of registration, treatment, it is well. But HTC, MRDT, it also needed to be like that.*
	Negative
PI408	**Winistoni HIV Counsellor-Male**: *Like at HTC, it has gone well. At OPD, the way I see it, at least. But at antenatal, that's where if the owners were here, they would have been in a position to say. However, it did not go well because when it comes to them and ask them, 'Among these clients you have seen, have you recorded any of them?' they say, 'Aah, I don't know, this thing, I don't know. You should just be coming to be recording in it'. So, can we say that has gone well there?*
PI409	**Winistoni Hospital attendant 1 - Male**: *When it comes to the under-5 clinic there, that it's not there, and at antenatal the problem is that the person who really knows the computer and can be helping the women there, is not there. That is why there it seems things have failed … What we need is to find another one and put it at the under-5 and not remove it from another place. It should be there at under-5 clinic. If you give us a computer at under-5 clinic, everything will go well.*
PI410	**Ponekela Ground Labourer-Male**: *I saw that it's different that the thing is there but it is just flowers, I don't use it. True.*
PI411	**Jedawako Hospital attendant 1 - Male**: *I think if the issues that have been raised are addressed, like the batteries issue, network issue and other things (inaudible) then the work will be going well. Daily we'll be using these computers.*
PI412	**Jedawako Hospital attendant 2 - Female**: *The system can be rated fourty-five percent, because we have used it before and we know the goodness of the system. It is different from the situation whereby the system is just implemented but never used. The system is okay, but the problem is associated with the people who are supposed to fix it.*
PI413	**Jedawako Hospital attendant 1-Female:** *(laughs) Ours at the maternity ward keeps giving problems, that computer. We use them, but not often. (**Paul:** So most times you do not use it?) Yes. (**Paul:** Alright. So the work, the way you were working previously and currently is the same?) Yes.*
PI414	**Jedawako Hospital Attendant 1 - *Female:*** *now the computer is just like – a toy – Just like – Just to amuse someone (laughs) just so people can say at the clinic there is a computer, while in reality – It's not even a computer, it's just like a toy. We did not expect that a computer like that one would be brought here and not be used.*
PI415	**Dalitso Ground Labour-Male:** *Other places I can say that it didn't go well, since like they have said that other departments don't have a computer. Like nursing, at the environmental office, it isn't there. So it would be difficult to say that it went well or it didn't go well because it is completely not there.*

	Mixed
PI416	**Jedawako *Ground Labourer* - Female:** *We can say it has gone well. Mainly the things that we have explained, the concerns that we have raised, if they can be addressed here and there, like if the trainings can take place, the computers that are needed and the network has changed, I believe things can go well. Work can go well. The data we would not forget, they would be done without evading it.*
PI417	**Jedawako Hospital attendant 1 - Female**: *There I can also say that it's gone well, because at first, this thing about computer, was okay. But now it's worse. In fact, if the earlier things have been restored, then things will continue to improve.*
PI418	**Jedawako HSA - Male:** *If we consider our expectations that we had at first and up to the way things are today, I perceive that we have done well in some parts. But taking into consideration the problems that we have raised, it appears that there is a lot of work to be done, because, it appears from how we have explained, there are too many problems with how this work is being done. If things can be improved as we have explained, that there are such and such problems, I have hope that like you people who know computers and what is a computer.*
PI419	**Jedawako Hospital attendant 2 - Male***: I want to emphasize that the way things were when the system was just implemented, the project could meet our expectations. But now that the network usually becomes unavailable, things are not working, and there is need to fix the problems for the work to be enjoyable. This will also assist in the sense that when you come here to collect data you will find that everything is in place.*
PI420	**Jedawako HSA -Male:** *The system can be rated forty percent, because it has been implemented, and when it is up and running, it is used successfully. It is just because of the problems it is associated with that it is failing to meet our expectations.*
PI421	**Dalitso Medical assistant- Female**: *When we talk about at OPD, then it seems it is going well. But at the maternity ward we were left up in the air by those who came to do the installations at that time. Now on the part of the doors, security, up to now, nothing has been done. So we can't say the programme has gone well because we are fearful that if we put it here, since it's indeed the labour ward, someone comes and takes it, whether they take the monitor or whatever. So there is need for security. The doors should be seen at the maternity ward so that the computers look to be protected, they should be used properly.*
PI422	**Dalitso Medical Assistant-Male**: *As my friend has said, that other people have not been trained. And when we look at the computers, the people who are found there are the same ones. But our HSA colleagues sometimes are found to have maybe fieldwork that they are supposed to do, so it seems that we again have a shortage. So if you look at the other departments, despite security-wise, but the things are there. Like at HTC the computer is there, I have seen it. But because the people who have learnt how to use and how to manage those stuff are few and they are found maybe they have gone to the field, so it's kind of not functioning a lot. But as for OPD, as my colleagues have said, that at least we are better off that we use it. There are a couple of us who are able to manage.*

	Overall Impression – Medium Adopters
	1. Overall Implementation
	Positive
PI423	**Sinelia Hospital Attendant 1 - Male**: *To me I would put it at 70 because when I use it, I am indeed quite quick, so it reduces that queue, if there is a long queue. But if I am to perform that work and there is no power problem, there is no network problem, it happens that I have served those people in a very short time as compared to the manual. So because of that, I can put the system at 70 percent. When I use it, it indeed helps a lot.*
PI	***Negative***
PI424	**Sinelia Hospital Attendant-Female**: *To me I can put it a 40 because most time I do not login into the computer. So on my part, I would put it at 40, because it is only the same person who logs in into the computer. (**Paul:** Why are you not able to login? Does it refuse?) It refuses.*
PI425	**Sinelia Ground Labourer-Male**: *I would put it at 40 percent because some of us don't use it at all. For us to use it they hog it and after some time they say, 'Wait, we want to work here, we should do it quickly'. So I don't use it.*
PI426	**Sinelia Midwife Nurse 1 - Female**: *If they were working properly as they should, I would have given it a higher percentage. But taking into consideration our place here, maybe I can put it at 35, because, like here at OPD it is not every day that information is entered into the computer. The challenges are that network, or when it's not that then there is no power, but also shortage of staff. You can find that power is there, network is there, but a person to be there to be entering information on that day is not there. Two: at HTC. The computer is there, but it is idle, not being used as he said. When we go to the maternity ward, I can say that maybe from November up to today, the number of days cannot reach even ten when information was entered into the computer. So for us to give percentages, ah! myself I have put it at 35.*
	Mixed
PI427	**Sinelia Security Guard-Male**: I*t is 50-50 because like at HTC we are not using it. At OPD we are using it, at malaria we are using it.*
	Overall Impression – Failure
	1. Overall Implementation
	Positive
PI428	**Filipi Clinician-Male**: *At our facility there was nothing that went negatively. To say that something negative happened because of the computers? No.*
PI429	**Filipi Patient Attendant 3-Female:** *There is nothing that went negatively.*
PI430	**Bisitoni Ground Labourer 2-Male**: *For that we can just say the project was good, mainly it's positives. There is need to work hard to improve things. But if this is a chance that made the system to be taken away, we need to train the people more, as we are saying that using it today, tomorrow no, then use it the other day, it would make things difficult. But it was a good project indeed.*

PI431	**Bisitoni Ground Labourer 2-Male:** *This project, in terms of use of the system, it was good. There can be other challenges that we met that today we use it or not. Those are the challenges that can be there. (**Paul:** If were to give it a percent, what would it be? Or out of 10? One, 17, 32, 12?**)** To be harsh to the project, I would give it 50%. The project was quite good.*
PI432	**Bisitoni Ground Labourer 1-Male:** *I enjoyed the system and I rated it 90% because it developed our community and that 10% it is because of our leader who caused us not to be successful.*
PI433	**Bisitoni Ground Labourer 1-Male**: *It was implemented in the OPD at the beginning because we had an (inaudible) in-charge, our clinician at the beginning, there was no nurse there. That is why no one went for that training. But it came to be implemented at the maternity. In fact they took one man to be registering at maternity. But they did not put at maternity that it will be kept at OPD. We can't really say there was something that made the implementation at maternity to fail, because there was someone who was supposed to be using the computer there who was also the nurse there. (**Paul:** Who was trained to be entering there? One of the HSAs?**)** Yes, Bizines Chisenga. (**Paul:** So it was the in-charge who was responsible for OPD and maternity?**)** Yes.*
	Negative
PI434	**Filipi Cashier-Male:** *That program, to say the truth, it didn't go well. The reasons are those that have been said. But that program, intentionally when it was being set up, had good intentions. So I was a person who – It just needs to be re-examined. The weaknesses that were there need to be balanced with what were – with the successes. And then we move forward.*
PI435	**Filipi Clinician-Male:** *At the time you came to get those things, it is a confirmation that things there, as the directors, you have seen that these people are failures, and there are valid reasons why you went to get those things. And these people cannot go to get the things without reasons, because there is no need for you to come to us why, to evaluate. Just go to them straight, 'You went to withdraw, so just give us the reasons why, the challenges that made you to withdraw that thing'. Because they have those things. So you were supposed to go to them straight, but you still find that you have come back to the same people. Because we know them, it's not that they don't have the challenges.*
PI436	**Bisitoni Ground Labourer 2-Male:** *the ones trained are not using the system.*
	Mixed
PI437	**Filipi Clinician-Male:** *The OPD was better than maternity ward. Maternity ward was zero. While at OPD, at least we had a lot of information.*
	Service Speed & Patient Experience – High Adopters
	1. Service Speed and Patient Experience
	a. No difference
PI438	**Ponekela HSA6-Male:** *There is no difference because everything that is in the register is still what has entered into the computer. There is no difference. They are just the same information. It doesn't change.* **(Paul:** *And you use it similarly?) Yes. There is no difference. Yes. Indeed.*

PI439	Dalitso **Medical Assistant-Female**: *The coming of computers didn't – I can't say changed much because those people we still ask them their names, where they are coming from, when they were born, like at the time of registration. It is happening like before that maybe after they get recorded by the clinician, when they are being entered into the register they still have to be asked their name and where they are coming from. So I feel that there has not been a lot of change because we are still able to speak with the people. At the register, we still speak with them. At the computer also, we still speak with them.*
PI440	Dalitso **Ground Labourer-Male**: *There is no any change that is found, because the way they were doing previously when they arrive at OPD, they are supposed to get their name recorded, everything on the card, and on the computer the same things are being recorded. So there is no any change, no any difference between the past and today. Everything goes the same way.*
	b. <u>Patients have positive experience with computers</u>
PI441	Winistoni **HIV Counsellor 1-Male**: *It also helps my work, to write those things is simpler. When asking a person, 'What is your name?' all the other details just come and you just proceed without having to ask this and ask that. It has reduced the amount of time you would have spent asking that person or patient or client. I just do it simply.*
PI442	Winistoni **Hospital attendant 2-Male:** *Now these patients are all different. There are others who are really happy about the computer. They are quite happy that, 'Also me, if my little name has been entered into the computer, the computer has kept my name, that's quite good'. So we can say that these patients, there are others who feel the computer is delaying them, although others just come and stand, you find a person has just come to stand in front of the computer and we tell them, 'Today we are not booking because the network seems to be having problems', and you see them standing in front of the computer, showing that it is indeed a good thing.*
PI443	Winistoni **HIV Counsellor 2-Male**: *When it comes to the interaction with patients and the use of the computers, there is no problem. Things are indeed going the way they are supposed to go.*
PI444	Winistoni **Medical Assistant-Female**: *Yes, we have talked about the people, but now people are used to it that there is a computer, and they even say, 'Today there is a computer!' Some ask 'Hey, are you not going to use the computer today?' and they say, 'Today they are using the computer!' (inaudible), while others say, 'Will you not use the computer again today? I wrote my patient number on my new health passport!' So as we have said there are people with different characters. Others we tell them, 'When the health passport is full, you should bring your patient number. When you have the patient number, there will be no delay here.' So many people are now bringing their patient numbers. When their health passport is full they are bringing it, 'Here is my patient number'. We tell them, 'When you lose your patient number, there will be delays because we will be asking you "Where are you from? What is your age?" But when you bring your patient number, as soon as they enter it, all that will be in there, so there will be no delay here'. So, many are getting used to that.*
PI445	Winistoni ***Hospital Attendant 2-Male:*** *The computer has made it that a person, a patient, should not be sent home late.*

PI446	Ponekela **Ground Labourer-Male**: *It's quite the same, but the difference happens to be one is fast, another is slow. Because … (**Paul:** Which one is fast?) For the computers … People would have little time to finish receiving their service. While at the time before the computers arrived, people were spending a lot of time at this facility. For example, when they came from seeing the clinician, they were still required to come at the OPD register to enter the medication that have come. There was quite a lot of work. There was also a very long time for a person to be served and find that they have gone. When the computers had come, they reduced that time. A person was spending less time, maybe not more than 25 minutes, it was found the person has been served, has gone.*
PI447	Ponekela **HSA6-Male**: *You delay with the register, while there you just go at the revisit, that means you have served the client quicker. They will not delay in the queue again, they will go to the MA. Because it does not take a long time to interact with the client when you are on the queue.*
PI448	Ponekela **Ground Labourer-Male**: *The time that we have been using the computers, people were quite, they were not talking because they had gotten used to that method. But the time that the batteries seemed to have depleted in there, going back to the OPD registers, that's when we started hearing talks, 'No, these are time-consuming. You are delaying us with these things', showing that the method of computers was fast, unlike that of using the registers. Such that the people got to getting used to that thing. They have gotten used to it. There is indeed a big difference. The computers are quicker, while the register quite delays.*
PI449	Ponekela **HSA4-Male**: *The relationship was good with the clients. Because there are some questions that a person finds themselves asking them, but they have forgotten. So when they say they have forgotten and you continue asking them, it seemed like somehow you would even make each other angry, with the registers. While here, if they have forgotten you just go to that computer, it will give you information, you will not ask them again, you will not continue asking them, which makes your interaction with the clients to be quite good.*
PI450	Ponekela **HSA5-Male**: *When they come, let's say the cover of the profile got lost, then you will have to ask them like starting with like maybe village, everything to do with register, the one written by hand. Then you will have to ask them village, age, name. While at the computer, then you just go straight, then just click, then if there is that number that you gave them that first time, then all the information has been traced. Then having to ask so many questions, you will not ask anymore, you just go to where you have to start feeding into the computer.*
PI451	Ponekela ***HSA7-Male:*** *The sick people don't even see it as a problem. They are not taking long. So, what my colleagues already said that – Ummm – The clients have gotten used to that thing. Yes. So they are things that statements like, 'Ah you are taking long!' you can see that are not there because they see that the work is indeed being done much faster and those people are also receiving care a bit faster.*
PI452	Ponekela **HSA6-Male**: *Because when you take a person in the register, that patient, you take time for you to write. Let's say they are new. You record them. While in the computer, you register them, when the same one comes again you just click there. That means you are done with them, they are entering the MA's room. While in the register maybe you have to write some things again.*
PI453	Jedawako **Hospital attendant-Male**: *OPD. It just happens that previously when we work without computers we are slow. But when we use computers, it seems*

	we are very fast, and also we handle the people quickly. Because it is rapid, unlike the manual, the old system.
PI454	**Jedawako Hospital attendant 1 - Female**: *The relationship between the staff and patients I think is good when we are using the computer, because we seem to be asking more questions and they feel welcomed, unlike when using the register, just putting them on the queue, that's it. We just record for them … you check on the cover for the name, you just check the name and so on and not ask them many questions. So I feel that the relationship is very good between the staff and the patients when we are using the computers.*
PI455	**Jedawako Hospital attendant 2 - Female**: *A certain woman was very happy that, 'This time, things are going well that they are putting us in a TV' (laughter). They are very happy that they have been put in a computer.*
PI456	**Jedawako Hospital attendant 1 - Male**: *There is need to be prepared. We see that they have been attended to and this one has just gone through without being booked and we know that they have jumped the queue.*
	c. <u>Patients have negative experience with computers</u>
PI457	**Winistoni Hospital Attendant 1-Male:** *With the coming of computers, my interaction with patients, sometimes it seems like we are confusing them, because we can differentiate with the amount of time. When they come, I tell them to go and do booking, I book them there, and from there they go to the clinician for recording. When they come from there the same patient has to come to the computer for their diagnosis to be recorded, then that same patient needs to be recorded into the OPD register, the same patient we send them to receive their drugs. So it seems that we are confusing them. That's how I see it, that somewhere it seems it is difficult because before computers came, when we recorded them and stamp for them they would go and meet the clinician, from the clinician they come to the OPD register, from the OPD register then immediately they go and receive their drugs and then they are on their way. But now there are two things that seem to have added effort for one patient instead of (inaudible). The way I know it is that it has added for the patient two places: they should be booked, and the same patient has to come back to the computer to record everything that the clinician has written, and the same patient should go to the OPD register, now manual. After manual, they should go receive their drugs and be released to go. So I feel that the work there has quite increased.*
PI458	**Winistoni Security Guard 2-Male**: *Just to add on to that, many patients (inaudible) that they arrive early in the morning, we enter them as booking (inaudible) then we just end up using the pen and it takes a long time and when they come from the clinician we also have to enter their diagnosis, which takes a long time (inaudible) they come early in the morning (inaudible) long process.*
PI459	**Winistoni Hospital attendant 2-Male:** *These patients, when we say our interaction with them when the computers came, it's true that it seems we are delaying the patient, because of what has been said already that they are booked twice, from the clinician then they come to the computer again, and then OPD register and then they receive their drugs. It seems it has taken longer.*
PI460	**Winistoni Security guard 2-male:** *The computers, we can say they delay work. It's true that they delay work, because that work is done manually, the work that is supposed to be done by maybe four people is done by one person. But what has been very challenging at our facility here is experience. Others can be saying maybe (inaudible) may queue or this and that but it is experience.*

PI461	**Dalitso Medical Assistant-Female**: *With the coming of computers and [bespoke eHealth system], my work has changed like on the part of – considering the length of time people wait before being served so they can go home. They are taking quite a significantly more amount of time than when it was when we were not using computers. So I can say, maybe, the change is there because some complain that they are delayed from going home.*
PI462	**Dalitso HSA1-Male**: *The minutes that the patients are staying on the queue, from the time they arrive to the time they exit, has changed a lot. Let's say they come at 8 o'clock, they go at maybe 2 o'clock, a person who came at 8 o'clock. So the patients are complaining a lot that it is delaying.*
PI463	**Dalitso Nurse-Female**: *That challenge that we see that people are on the queue for a long time. So, since you hear when you are passing by, 'There came their Western things that they are entering in there. Those are what is delaying us'. But now, since when something is starting, it takes time for people to get used to it, maybe slowly they will know.*
PI464	**Dalitso HSA3-Male**: *I want to agree with those who said earlier that the coming of computers has brought – like delaying people from receiving services quickly. But maybe the aim of the computers was not that. What I know about computers is that it makes things to be fast. But now because of the people, most of the workers don't really know the computer. So it was necessary to have adequate training so that the work can be done quickly, the queue should not be there and people should leave quickly.*
PI465	**Dalitso Ground Labourer-Male:** *They just see that it seems to be delaying in reflection of what they think that, 'I will come back soon from there'. So when doing that, they see it as delaying. Yes.*
PI466	**Dalitso Medical Assistant-Male**: *I think the other thing why people were saying they feel there are delays is because it happens that some people just jump the queue. You see? For instance some arrive early in the morning, and for them to be taken from the queue to enter their names into the register, so seeing that there is a shortage of workers, so we just divide among us. So others will be having their names entered into the computer, others we are writing for them before they have been entered into the computer. So these ones reach the front, so it seem to be some quarrels. Of course, the quarrels are not with us but among themselves. That's where others feel there are delays. When they come from here they go there and then they encounter two or more questions. You see? So they feel they are delaying.* ***(Paul:*** *So the ones who have not been entered into the computer seem go to the front of the line?) Yes.*
PI467	**Dalitso HSA4-Male**: *I also feel that there are two parts that make it seem that the computer is causing delays. There is some little information that is in the register, the OPD register. That is in the computer, but in the register is not there. For example, if I am not mistaken, my friends will refute me if I am mistaken, in the computer there is somewhere where it asks, 'Who is the group? Or who is the TA' While in the register, we just look at the village then paaaaa! we have written, fast. That's it. While in the computer, 'Who is the group?' They say it. 'Who is your TA?' They say it. While here, if they just say, 'Kamphata', Kamphata, that's it. We continue. So maybe these two chiefs are adding more, like … Yes.* ***(Fyness:*** *Sorry, I did not understand there). Umm … In the OPD register they just wrote 'Address'. Right. While, when the person is writing, for instance I write in the OPD register sometimes, we just see direct on that book that, 'Oh, their village is Kapedzela', we just write sometimes 'Kapedzela'. Right? While in the computer, we write 'Kapedzela',*

	there is another column that needs who is the group, who is the TA. You see that? While here we just write this and that.
	d. Avoid duplication of patient information
PI468	**Jedawako Hospital Attendant 1 - Male**: *There are many questions that we ask when we are using the computer. When the patient comes, perhaps for registration, we ask two or three questions and when they come from the clinician and come to the register to enter diagnosis, it takes maybe ten seconds. We just write and not need their book. So on the register, when we put them on the queue, 'This queue, enter', that means we have interacted. When they come from the clinician's and come to the register, their information on the cover of their book is enough: name, age. We will just record them, we will not speak to each other because they know that next is that window.*
	Service Speed & Patient Experience – Medium Adopters
	1. Service Speed and Patient Experience
	a. No difference
	b. Patients have positive experience with computers
PI469	***Sinelia* Hospital Attendant 1 -Male**: *The computers help in speed, because when the patient arrives, it doesn't take time, perhaps in comparison to those paper registers. Because for those ones, for you to write, it takes time, while at the computer you don't really delay with the patient. I am able to serve many in little time.*
PI470	***Sinelia* Hospital Attendant 2 - Male**: *As has already been said, it's making us fast, because that patient who already came, who was already booked, we are just able to scan, or to just enter for them that registration number into that computer. Then everything just comes. We don't bother asking a lot of things.*
PI471	***Sinelia* Hospital Attendant 1 - Male**: *This manual system delays quite a bit because it happens that at the register you have the work of asking the person a lot of things, name, maybe where they are coming from, their age and so on. While with that [bespoke eHealth system] system, when a person is returning here we don't ask them anything, just take it and just enter that number. So then everything that they were asked, it comes out on [bespoke eHealth system]. So you just have the job of checking how you are supposed to serve them.*
PI472	***Sinelia* Midwife Nurse 3 - Female**: *That patient, if they have already been registered, they have their registration number, it is not difficult when they come for the second time. You are able to serve them quickly. You don't have to also start asking them these and these names or this and this village and so on, because everything – they are already registered.*
PI473	***Sinelia* Hospital Attendant 1 - Male** *When I use it, I am indeed quite quick, so it reduces that queue, if there is a long queue. But if I am to perform that work and there is no power problem, there is no network problem, it happens that I have served those people in a very short time as compared to the manual.*

PI474	**Sauko Ground Labourer 2-Male**: *With the coming of [bespoke eHealth system], it has also helped us a lot in attracting patients. Others were not going to other facilities saying, 'I should go to "Majiga" so that I can be entered into the computer', and the result was that they would say, 'Are we not using the computers today?' I've seen that as a big change here at Sauko Health Centre.*
PI475	**Sauko Data Clerk-Male**: *On the part of patients, with the coming of computers here at Sauko, there is no any problem. Because, at first people were finding it distressing, but others, as my friend here has said that this is the field, when people come and see that, they see it as a very good thing. We explain to them when they arrive around there (inaudible). We tell them that, 'Before you go in to the clinician you will need to go to the computer', and we explain to them the reason. And also, when they come here, our conversation with the patient is good.*
PI476	**Sauko Hospital Attendant-Female**: *with the coming of the computers, those patients, when the patient is being entered into the computer, it also gives them confirmation that, 'Ah, if they are recording me in that, maybe the service that I will receive will be satisfactory at this place'. So it has helped our patients to be having hope that the service that they will receive is genuine, because I am being recorded in a computer, such that everyone, or even when the bosses come, they will see that this person suffered from this condition and received this service so they have a lot of interest that they have been served properly.*
PI477	**Sauko Counsellor-Male**: *The advantage is that the people, as has been said, have been entered into the system, so their information needed to assist them is not difficult. They are able to follow those people, so it gives hope to the people who are being treated as they are able to receive the information from earlier so it shows that the clinician was paying attention, which makes the communication to be good because if the person realizes that they were understanding each other during the previous visit because of the information from prior visit that is kept securely, because searching from the register would take time, it makes the people feel that there is good communication because it makes them realize that everything that they explained was well understood.*
	c. <u>Patients have negative experience with computers</u>
PI478	**Sauko Hospital Attendant-Female**: *because this is quite rural, so some patients, when you say, 'Aaah, let me write in the computer, enter it here', sometimes they feel that you are delaying them, looking at how they are feeling in their body, they think that, 'Aaa! Should they also be delaying with this and that?' Perhaps also on the part of the clinician, it happens that they are being asked questions while the clinician is on the computer. So others feel that maybe they are not being attended to. Even when you are talking to your friend but your friend is focused on the phone, you feel that they don't care. So somewhere it happens that those patients feel that you are delaying them.*
PI479	**Sauko Data clerk Male**: *maybe like for Baobab, yes for Baobab there are some patients who come to meet the clinician, they just walk straight and enter in there. After entering there they then come here and you are at diagnosis and treatment, to record the patient who you did not book, it refuses. So you start from one, that patient you have to register, then you should also book them, while they are waiting, so the people begin to say, 'You are delaying', they start cursing. So it would be good if – a request – it should be like you have stolen. Because I remember when I was at Chikwawa, some people were doing their own thing, they came to ask us when we were using Baobab, (unclear) so they saw how the queue is moving. So if it can be like the design of Baobab. It's a good one because the*

	clinician there is not involved, everything is done and ends here.
PI480	**Malilika Cashier-Male**: *what we have already said that we are not very conversant with the speed of typing and we have to search where is 'm', where is 'o', we press then search where can I find that, the person is just waiting and their name has nine letters and to type nine letters takes time, so they feel that these things make our interaction to become poor.*
PI481	**Malilika Dental-Male**: *as we speak now, some of our friends, the computer here and there, they are not used to it, they can open, but don't know how to proceed.*
PI482	**Malilika Cashier-Male**: *sometimes we find that there is a very long queue and to deal with each individual, even among the patients there is that murmuring that, 'You guys you are not fast enough!' So with that we just stop it and maybe we do the documentation later so that we can catch up with the length of the queue.*
PI483	**Malilika Patient Attendant-Female**: *Sometimes the patient, maybe we ask them where they are from, they feel we are delaying them, like we are just playing and not serious. They want to get their drugs and go. So when we ask them those questions they feel we are delaying them.*
PI484	**Malilika Cashier-Male**: *What we have already said that we are not very conversant with the speed of typing and we have to search where is 'm', where is 'o', we press then search where can I find that, the person is just waiting and their name has nine letters and to type nine letters takes time, so they feel that these things make our interaction to become poor.*
PI485	**Malilika Dentist-Male**: *the other delay, for us to be not interacting with patients well, we are delaying because we are using 2 systems at the same time. At the cashier, I have to charge the patient through the [bespoke eHealth system] system, but also after charging them I also have to write information in the manual receipt book. Doing 2 things at the same time, making the queue longer and longer. What I see is that, maybe because we are doing it slowly, that is why we are not really fast. But it seems that when we are writing, one should write in the manual and the other in the computer speeds up the work. But for one person to do both, we receive complaints from the patient that we are delaying.*
PI486	**Malilika Nurse mid wife 2 - Female**: *When the patient enters into consulting, we ask them their history, we write in the health passport, at the end we enter that same patient into the computer and we stop talking to the patient and they see that we are delaying, especially with the slow typing.*
PI487	**Malilika Nurse mid wife 1 -Female**: *I also feel that here many people have never been to school, so they are difficult to understand. Others don't even know that it is a computer. Others think you are just playing. To do that you have to explain to the patient that, 'Do not worry, I am doing this and that', and at that time of explaining, you are spending more time. This is another thing, explaining then typing.*
	d. Avoid duplication of patient information

PI488	**Malilika Cashier-Male**: *the patients are different in their understanding. The challenge I meet is that, maybe a patient comes at first, we register them and give them their number and put it on their book. When they come for the second time, they will not complain because we will just type in that number if it is a revisit, that all their information is found. It happens that the patient when coming again, they have changed their book, it has been damaged, so we have to ask them the information all over again and again, 'Why are you asking me so many questions? I think this Malilika is becoming annoying. I think I should change to another clinic'. I feel it hurts them.*
	Service Speed & Patient Experience – Failures
	1. Service Speed and Patient Experience
	a. No difference
PI489	**Filipi PA-Female**: *Nothing changed. Particularly, when I said nothing changed, I mean serving patients.*
PI490	**Filipi Clinician-Male:** *It didn't change anything in terms of work, how we work or its effect on patients. It didn't affect in any way.*
	b. Patients have positive experience with computers
PI491	**Bisitoni Ground Labourer 1-Male:** *With the coming of the computers led to some work to be simpler, especially on the part registers. (**Paul:** What do you means on the part of registers?) Because when we were writing free-hand it seemed to be slower than when we were writing using computers.*
PI492	**Bisitoni Ground Labourer 2 - Male**: *it happens that, especially at the register, we were asking them questions when it is the first time. But when they come again, we would just check their name. If it's found, then that's it, just tick.*
PI493	**Bisitoni *Ground Labourer 1 – Male:*** *During the time we were using just the papers, it was bringing like we were favouring other people, as some would jump the queue. But the time we started using the computers we were using the queues from the first person registered, so it shows that there is order, we were not favouring others. It brought love between us the workers and the patients, because they saw that we were working in an orderly way, while when we were writing using hands it seemed like we were favouring others because others would jump the queue to the front.*
PI494	**Bisitoni Ground Labourer 2-Male**: *the system has solved the problem of quarrels among patients especially when one tries to use short cuts.*
PI495	**Bisitoni Ground Labourer 2-Male**: *It has also speeded up the registration process as already highlighted.*
	c. Patients have negative experience with computers
PI496	**Filipi Clinician - Male**: *But then it is tiresome, for when you see the queue, you write. Then that made you to be with the patient for fifteen minutes, which was not good. So to avoid that, people would just say, 'Ih! Let this be here a bit, let me do the manual' (laughs). **(Paul:** So you would be with a patient for maybe fifteen minutes?) Yes. You write in the book. Then you enter into the computer. You should check where 'b' is (laughter).*
	d. Avoid duplication of patient information
	Storage & Retrieval of Information – High Adopters
	1. Storage and Retrieval of Information
	a. Ability of computer to safely store information

PI497	**Winistoni Hospital Attendant 2-Male**: *Our daily work seems to have changed in that, on how we register names, there seems to be some change in that, especially in storing information, there seems to be no problem. For example, we are registering people to see how many we have registered so when we open the computer we are able to see that today, when we have entered one by one and everyone who has been registered into the computer, we know (inaudible).*
PI498	**Winistoni HIV Councillor 2-Male**: *Yes, the information is there and is kept well, especially at HTC, because we have indeed been entering names in the computer, even in the antenatal clinic for PMTCT.*
PI499	**Ponekela HSA5-Male**: *The benefit of the computer is that a lot of information stays in that computer.*
PI500	**Ponekela *Hospital attendant*-Male:** *In the computer, things are secure. While in the register, things are not secure. Perhaps a register can tear. To find the patient, if they have lost their book, you can't find them, while in the computer, you can find them quickly. That's the benefit of the computer.*
PI501	**Jedawako HSA -Male**: *The coming of computers at this facility of Jedawako, I think has helped a lot, especially on the part of keeping our records. How it was, I see that it is helping a lot because like the records we used to have previously, it would happen that some are lost, while the time that we are using computers, when we keep them in computers. It's that. The time when we want to search information that is needed at that time can be found with no problems.*
PI502	**Jedawako HSA - Male**: *Currently, when we are using computers, we are not using the register anymore. We are just using the person's card, enter that into the computer, that's it. We are done with the person ,they can go.*
PI503	**Dalitso Nurse-Female**: *The good thing about these computers is that if information is in there it cannot go missing. There can be maybe follow ups, then it's easier for a person to trace, to find that information.*
PI504	**Dalitso HSA1 Male:** *Storage of information was fulfilled, even though my colleague, the data clerk, was complaining that to go to some place to find some information, he is having difficulties. But the information is really in there. So on storing information, all is well.*
	b. Retrieval of patient information
	i. General patient and service information
PI505	**Winistoni Medical Assistant-Female**: *The information he is talking about is being kept well. The only challenge is that the information is kept but cannot be released (laughs) so that we can print it ourselves for us to release and compile a report, to compile a report. Yes, so the information is there.*
PI506	**Jedawako HSA- Male:** *these computers are helping a lot, especially on the issue to do with knowing our client when they come here, because we are keeping any information to do with that client without problems. And when we want to follow up that person, it is helping quickly because when we go to those computers, all the information that we want, where they live, everything indeed, such that reaching those people is not very difficult unlike using only those books previously.*
PI507	**Jedawako HSA - Male**: *when we take the part about information, to find the information about the client. Using computers is fast, unlike using papers that we were using previously.*
PI508	**Dalitso Clerk-Male**: *Last time I was compiling reports, I wanted to get information in the computer. So, because of lack of being trained so that I know that thing and to get information, it was very difficult for me. It's that the information is there, but for me to get it, iiiih! I had problems, I had a lot of challenges that time. So,*

	the issue is about trainings.
PI509	**Ponekela Ground Labourer-Male:** *When we just go, 'Oh! The one you want is for when?' Even when it's for the past four months, we can ask it and it tells us that, 'Ah, in the four months you had these and the person who you are looking for, you can find them at such and such'. While when we use the registers, we are still supposed to see how many registers have we filled here, we check where they are supposed to be found, which takes us a bit of time. That's why the use – The results are the same, but the time to receive those results is different.*
	ii. Information for lost, damaged or wrong health passport
PI510	**Ponekela HSA5-Male**: *When they come, let's say the cover of the profile got lost, then you will have to ask them like starting with like maybe village, everything to do with register, the one written by hand. Then you will have to ask them village, age, name. While at the computer, then you just go straight, then just click, then if there is that number that you gave them that first time, then all the information has been traced. Then having to ask so many questions, you will not ask anymore, you just go to where you have to start feeding into the computer.*
PI511	**Ponekela HSA3-Male:** *On the illnesses, as my colleagues have said that, for example, when they have lost their book, it is no longer difficult when they come a second time. We just search in the computer. So I have seen that computer is helpful.*
PI512	**Dalitso Medical Assistant-Male**: *When the people come they have a number that they bring with them. So when the health passport has the number there, it's easy to trace their history, unlike – But also the challenge that happens is that sometimes you find that they have left the book, they have come with another book, so it's like you are starting again the same process from scratch. So that's the challenge that I encounter. So I am lost as to how I will get the history. This person did not memorise their number which they have. But if I am lucky enough, I am able to find it through searching the names. Yea.* ***(Paul:*** *So when you search the names you are able to see their history?) Yes, I am able to see their history.*
	iii. Information for lost or damaged paper registers
PI513	**Winistoni ART Clerk-Male**: *In terms of work, the coming in of computers led to, in terms of information, information like (inaudible) it has been explained by the counsellor, HTC counsellor and the HSA, they explained that the information that we were keeping manually, the registers would tear, even at ART. So when they tear, for me to find that information about that person, it becomes difficult for me. Like the cohort reports, they need to have information from the past up to where we are now. So for those progress reports, they need everyone to be detected well. So, with the computer, they have helped us in that when I have done for those people from a certain month (inaudible) from HTC, we are able to know from how we have recorded that there are these many patients.*
PI514	**Jedawako Hospital attendant-Female**: *Because the book can also get misplaced while what is in the computer is in there.*

PI515	**Dalitso HSA1-Male**: *I have ever collected data, I have ever done what my colleague Saulos is doing, about data collection. I've also seen that it's short, it's fast for all information to be found, unlike from the registers. Sometimes they get lost, one is somewhere another is elsewhere, another is torn, information cannot be seen. While with the computers it is easy to find the information.*
	Storage & Retrieval of Information – Medium Adopters
	1. Storage and Retrieval of Information
	a. Ability of computer to safely store information
	Sinelia Ground Labour-Male: *It is keeping information about patients. It is helping us quite well.*
	b. Retrieval of patient information
	i. General patient and service information
PI516	**Sauko Data Clerk-Male**: *on the side of retrieval of a patient, to see if the patient came, what were they suffering from, oh this one came, what were they suffering from, when I go on the computer, if I entered into the computer when they came, it's good because it instantly shows how many times they came, when they came that time what illness did they have, what medication did they receive. It's good.*
PI517	**Malilika Laboratory Technician-Male**: *In terms of patient information, here we still use OPD register as well as the patient's book. Here at Malilika, there are times we have few people, we do it, but when there are a lot of people it is difficult for us. So we are still using the old system and computer, we are using both. So those who have been entered, when we have searched for them we find them and when they came and how they were served. But we are still using the old system when we are not using the computer. We are still using the register and the patient's book for how they were previously served. But in future I'm sure that when we have settled we will often retrieve information that is in the computer.*
	ii. Information for lost, damaged or wrong health passport
PI518	**Sinelia Nurse midwife 3 - Female**: *These computers, I feel that they help us a lot, because everyone has their own number. So when searching, maybe we want to find a patient, perhaps they lost their book, then we search quickly and find that we gave this and that to this patient. They lost their book, so all the information can be found in the computer.*
PI519	**Sauko Data Clerk-Male**: *My worry … What I had in mind did not happen, because I expected that with the coming of computers the workload will reduce. But instead, they have added more work. Because these computers, before they came, the fact that the data clerk who is there is just one, wasn't noticed. But now it is happening, because these computers, we work on them because they have been given to us and are expensive, they should not get wasted, let me use them, so I use them. But to get from there information, like in this month how many patients came, or reporting, we don't get anything from it, we just register, so we get it by looking at how the OPD register has done. So, it's like that.*

PI520	**Sauko Security Guard-Female**: *There is indeed change because maybe previously a person would come this time and buy another card and then would not take care of it. Another visit they buy another one. But now when they write it there and say, 'This is your number, you should take care of it', so they do their best to take care of that number and when they come to the facility they will just show the same place and then they are entered into the system again, then help them with what is needed. So if others have misplaced the book, that, while they took care of it, some people's houses get soaked and the book has gotten soaked, they are able to remember that, 'No, they told me that my number is so and so'. So when they say that number and we search in the computer, we find that that's their number.*
PI521	**Sauko Data Clerk-Male**: *The other patients, because it is difficult for them to keep things, in terms of the cards, when we enter them into the computer, the patient has a number coming from the system. So we take that number and write it carefully in the patient's card. It happens that when the woman goes home, she loses her card or misplaced it. We just ask them, 'Madam, have you been here before?' 'Yes', then we go into the system and check (inaudible). So on the part of the patient, their care at this facility is going well as always.*
PI522	**Malilika Nurse 2-Female**: *all the patient information is found, because sometimes the patient comes with a different book, they lost the book and brought someone else's. If everyone is entered in the computer we will be able to find all the information.*
	iii. Information for lost or damaged paper registers
PI523	**Sinelia Hospital Attendant 2 -Male**: *It has helped us in how we work. For instance, keeping information about our patients, because they are not damaged. Because to take how we used to do with the registers, they were getting spoiled, maybe getting wet. History is not spoiled.*
PI524	**Sauko Senior HSA – Female**: *When I heard, I thought it was very good news because the information cannot get lost. Because sometimes the registers can get lost or get torn, and when it comes to the report it is not enough as if you did not do any work, while the work was done and because the information is lost it looks like you didn't work enough. So if the computers were doing both sides, like the people are saying, the information would be kept well and we would write good reports with what we have really done, because those papers are difficult for us to keep. The registers get torn, they get worn-out by the work that they do, so other pages tear out, get removed and get lost.*
	Storage & Retrieval of Information – Failures
	1. Storage and Retrieval of Information
	a. Ability of computer to safely store information
PI525	***Bisitoni* Ground Labourer 1 - Male**: *When we talk about the reports, it was showing that the computer was keeping all the information you have done, but also, especially when we start at registration, it gave us the opportunity to check the person's name whether they had come before another day. It was indeed shortening our work.*
	b. Retrieval of patient information
	i. General patient and service information
PI526	***Filipi* Clinician - Male**: *There was change, because when that information is needed, you were able to access it easily. Within five minutes you have accessed that, 'I've seen how many patients? And for malaria, how many*

	were there? For pneumonia, how many were there?' within maybe five minutes, which is not possible to go to the register and start prr prr prr prrr. That was not possible.
	ii. Information for lost, damaged or wrong health passport
PI527	***Filipi* HIV Counsellor Counsellor** *- if we consider when we write in there, as has been said by the clinician, then information would be kept. It happens that some of the registers have pages missing, while with the computers it would be found easily. Maybe some of the reports have problems or have jammed (unclear), copies are lost, that ah! to compile reports maybe from one month up to another month, and maybe a certain page is not in the register, when you check in there, all the information is found without problems.*
	iii. Information for lost or damaged paper registers
PI528	***Filipi* HIV Counsellor** *- Because if we consider when we write in there, as has been said by the clinician, then information would be kept. It happens that some of the registers have pages missing, while with the computers it would be found easily. Maybe some of the reports have problems or have jammed (unclear), copies are lost, that ah! to compile reports maybe from one month up to another month, and maybe a certain page is not in the register, when you check in there, all the information is found without problems.*
	Data Quality – High Adopters
	1. Data Quality
	a. Reverting to manual system
PI529	**Ponekela Ground Labourer-Male**: *What is difficult, as others have explained, is that there are some things, because the computers have come while we are already grown, it happens that it malfunctions, so then when we ask our friends at Madalo, but for them to find a vehicle to come here, those things don't move. So we go back to the old system, those pens.*
PI530	**Ponekela HSA4-Male**: *It happened that for them to come and replace the batteries it took quite a long stretch. People were still using those same manual ones, showing that the sustainability was like a bit challenging.*
PI531	**Jedawako Hospital Attendant 1 - Male:** *When [bespoke eHealth system] was working, we were using the computers. But you find that [bespoke eHealth system] is not working. So now what do we do? We go back to the registers, take that, put it in the register, and do everything well. So the person wanting to collect data goes to the computer for the days it was put in the computer and combine with the days for the register.*
	b. Incompleteness and accuracy of electronic data
PI532	**Winistoni HIV Councillor 2-Male**: *When it's off, then there are many who we have not entered into the computer. This means that we don't have a true picture of the number of people we have entered into the computer during that time, especially because of the challenges with electricity.*
PI533	**Winistoni HSA-Male**: *By then people would just exit from there and we guide them to the collection of drugs and where they write in the register, maybe they would just pass it and go straight to the window to receive their drugs and we would call them, 'Come so that we can enter your details in here!' But now they are used to after being registered they go and meet the clinician, they cannot just pass without coming back to the computer. It means information is being captured well and there is good interaction. And even the patients*

	themselves say, 'I have not been entered! You need to enter my prescription into the computer'.
PI534	**Winistoni HIV Counsellor-Male**: *At antenatal, that's where if the owners were here, they would have been in a position to say. However, it did not go well because when it comes to them and ask them, 'Among these clients you have seen, have you recorded any of them?' they say, 'Aah, I don't know, this thing, I don't know. You should just be coming to be recording in it'.*
PI535	**Jedawako Ground Labourer - Female**: *Sometimes when things have been changed we just sit on that information and do not know what things have been changed in the computers. So because we do not know anything we end up not doing anything. We are told too late that yes, those things have been changed, and so during those days no data has been entered. There are things that have been changed recently and we do not know about it and hear, 'Yes, we went for training and they have changed this and that', but we don't know anything about it. We try to do this and that, entering the password but it refuses, things have been changed on the computer so you end up not doing any work.*
PI536	**Jedawako Hospital attendant 1 - Female**: *Previously it would happen that when the network was not there the people from Madalo were coming to fix it, but now they do not come anymore. So the network problem is getting worse such that in a month we would use it maybe only three days.*
PI537	**Jedawako HSA-Male:** *The time when there is no network, for us to use those computers it is getting where that work is getting indeed difficult, so following that is where we are going to the registers that we do as all times. While at the time when the network was there it was that people really knew that today I should do this work, even getting to work early so that that work should be done quickly. But now with the network, as has been said, is what has seemed to contribute a lot to the information for other days to seem to not be seen there.*
PI538	**Jedawako Hospital attendant 1 - Female**: *We were expecting that we will be using the computers maybe frequently but it is not like that because the networks are problematic. So sometimes the information, we are still using the papers which can get torn off, sometimes keep in the registers, sometimes in computer, which is not what we were expecting.*
PI539	**Dalitso Medical Assistant-Female**: *It disrupts us as that day we took out the computers, we started with the system, it has developed a problem, then people, 'Wait we'll do them', time is going, people are leaving, but they didn't come, so that means we have missed those people, they have gone. So for the people who will be managing that, there needs to indeed be seriousness that they should know what they are doing.*
	Data Quality – Medium Adopters
	1. Data Quality
	a. Reverting to manual system

PI540	**Malilika Cashier-Male**: *we are not really accurate given the fastness of the typing. So with that, it is why we meet problems that it gives us delays and we are not very much accurate. But I am sure that with time we will be able to use it. Like in our cashier office, we find that a person has to book a number then we go on to see how they have been prescribed. Medication is what tells us how much should be billed. So sometimes we find that there is a very long queue and to deal with each individual, even the patients there is that murmuring that, 'You guys you are not fast enough!' So with that we just stop it and maybe we do the documentation later so that we can catch up with the length of the queue. So I think the things is we are not accurate. This is just a new development that we have received. So I am sure that maybe with time you can be coming to teach us more and we get used, then it will be alright.*
PI541	**Malilika Pharmacy attendant-Female:** *the main problem is the printer. It happens that we as pharmacy attendants enter all the information, but the problem is at the nurses, who have to enter in the book and in the computer, which takes time. So to avoid delay there are too many people we just leave putting in the computer and just do the manual entry. So that is the main problem: the printer.*
PI542	**Malilika Laboratory Technician-Male**: *In terms of patient information, here we still use OPD register as well as the patient's book. Here at Malilika, there are times we have few people, we do it, but when there are a lot of people it is difficult for us. So we are still using the old system and computer, we are using both. So those who have been entered, when we have searched for them we find them and when they came and how they were served. But we are still using the old system when we are not using the computer. We are still using the register and the patient's book for how they were previously served. But in future I'm sure that when we have settled we will often retrieve information that is in the computer.*
PI543	**Malilika Patient attendant-Female**: *we compile our reports still using our registers because it happens that some days there is no electricity, we did not use the computer, sometimes there is no network, we did not use it, so the report would be false if we used computer data, so we use our registers because we report in the register. So for now we are still using the registers.*
PI544	**Malilika Cashier-Male**: *For finances, for us to enter a statement and produce a statement from the finance we need to have a backup. So it happens that there is only one computer, as has been said by my colleagues, that we entered some time ago and then we stopped, we cannot then rely on it otherwise things will not be correct. So now we still use our registers, but then in future we will be using the report. If our accounts reports can be produced by the computers then we will need more computers for, say, backup and many other things so that if this one is lost we will be able to trace it. So we need backup computers.*
	b. <u>Incompleteness and accuracy of electronic data</u>
PI545	**Sinelia Midwife Nurse 2 - Female**: *Maybe most times for us to use the things in the computer for writing reports is difficult for us because most times, because of shortage of staff, you find that some information for some days are found that we did not put it into the computer. So (unclear) for us to use the computer is difficult for us because we find that some information is not in the computer. But if it happens that the whole month we have used that computer, for us to write a report month-end would be simple because the computer calculates itself.*

PI546	**Sinelia Midwife Nurse 1 - Female**: *Here at OPD it is not every day that information is entered into the computer. The challenges are that network, or when it's not that then there is no power, but also shortage of staff. You can find that power is there, network is there, but a person to be there to be entering information on that day is not there.*
PI547	**Sinelia Midwife Nurse 1 - Female**: *When we go to the maternity ward, I can say that maybe from November up to today, the number of days cannot reach even ten when information was entered into the computer.*
PI548	**Sinelia Hospital Attendant 1 - Male**: *The one who is using it here at OPD, when you are done with your work here then you have to force yourself to go there to login again and do it as well. So then because you wait for your work to be done, your busyness to be over, when it's done, then you should go there. So it happens that there maybe they have served quickly, they are done with the people and they have left, because they know that, 'So what can we do? The system is problematic'.*
PI549	**Sauko Hospital Data Clerk-Male**: *real change has not been observed, because when we want to write a report now, then for that we use the manual register. There in the computer I cannot take a report … the right information, because diagnosis and treatment is not done. If it's done then it's maybe only a few people are entered, which cannot give me accurate information.*
PI550	**Sauko Data Clerk-Male**: *To see if the patient came, what were they suffering from, oh this one came, what were they suffering from, when I go on the computer, if I entered into the computer when they came, it's good because it instantly shows how many times they came, when they came that time what illness did they have, what medication did they receive, it's good. But now because the computers have not started working well, that now it is incomplete. But if they were working completely, then even the reporting system would be easy and very good.*
PI551	**Sauko Ground Labourer 2 -male**: *The systems are like what they said should be changed about the reports. That is not working and the reason is that treatment and diagnosis, right there, is what is making the reports to not come out. So if that thing is not moving, it is difficult for it to work. So there is need for that information – maybe, if it is possible, turn it around a bit and do like what my brother said that it should be, like it has been lessened, so that when the person has come at one time, nothing should be difficult … Another example I can give is that one can go straight there without even coming here, the same patient going direct to the clinician. So when they enter diagnosis and treatment, means we didn't register that patient. When you take their number to record diagnosis and treatment, the computer refuses, it's supposed to tell you, 'Ahh, have you booked them? You haven't booked them. You are supposed to book them first, then (inaudible)'. So I feel that here, if there was a small change in that when you search them, it should just do it at the same time, everything should be there and not having to enter here, touch there, touch here. Ah, so since I am with my boss here, he will continue from there because he has listened well.*
PI552	**Malilika Cashier-Male**: *I think the thing is we are not accurate. This is just a new development that we have received. So I am sure that maybe with time you can be coming to teach us more and we get used to it, then it will be alright.*
PI553	**Malilika Pharmacy attendant-Female:** *the problem is at the nurses, who have to enter in the book and in the computer, which takes time. So to avoid delay there are too many people we just leave putting in the computer and just do the manual*

	entry. So that is the main problem: the printer.
PI554	**Malilika Dental attendant - Male**: *it happens that today you have information in the computer, tomorrow you don't have that information, so it is a problem. Instead of continuing things, a person cannot have enough information. So you go forward, then go back. So another problem I see is that.*
	Data Quality – Failures
	1. Data Quality
	a. Reverting to manual system
PI555	**Filipi Clinician - Male**: *It is tiresome, for when you see the queue, you write. Then that made you to be with the patient for fifteen minutes, which was not good. So to avoid that, people would just say, 'Ih! Let this be here a bit, let me do the manual' (laughs).*
	b. Incompleteness and accuracy of electronic data
PI556	**Filipi Clinician-male:** *Of course the information was different in the OPD register, it was different.*
PI557	**Bisitoni Ground Labourer 2-Male:** *for us we were just doing that since we are servants, so when he said, 'Today we shall use the computers', we would listen and use them, when he said, 'We will not use the computers today', what then can we do? (**Paul:** Would you know the real reason why he was saying some days you should not to use them?) There the real reason I cannot know. (**Paul:** Perhaps they were delaying things, or …?) There, there is no real answer. Delaying the work, no I don't think so. They were his own reasons. Sometimes when we want to use them, when we come early in the morning and do our work, we would get the keys, open and start registering the patients, and sometimes he would just say, 'No, today no computers'.*
PI558	**Bisitoni Ground Labourer 2-Male**: *we need to train the people more, as we are saying that using it today, tomorrow no, then use it the other day, it would make things difficult.*
PI559	**Bisitoni Fyness**: *When we visited we would take the data and analyse it and we would know that those people stopped 3 months ago without using the system.*
	Data Use – Reporting – High Adopters
	1. Data Use: Reporting
	a. Continued use of paper registers
PI560	**Winistoni HIV Counsellor 1-Male**: *Maybe I'll be needing papers because I want to print the report that I want to send. So it just ends there at registration. When it comes to report, then we start again using the papers or the report books that we use to write, tear out and send. While it could have been a simple job, you want to write an HTC report, you just come to the report part and trrrrr paa! it's out, then you are done. It also means time is reduced. But as of now it is time-consuming because we are still using the old system, writing manually.*
PI561	**Winistoni Medical Assistant-Female**: *It will be like we are repeating, but, the things that did not happen are that the final conclusion after recording into the computer, what next? A report is not being produced. So when we record in the computer, what is it doing in there? We are just keeping that information. By the end of the day we are using manual (inaudible).*
	b. Use of computers

	Positive
PI562	**Winistoni ART clerk Male**: *As a clerk for cervical cancer, the computer is very helpful, we are able to enter information in the computer and get report one hundred percent.*
PI563	**Ponekela HSA5-Male**: *At the time when we are perhaps writing reports, it is not difficult to find the numbers of various illnesses or people who came when writing those reports. That computer helps us in like record-keeping. But also we see that, like in a month, which diseases are giving us problems in this area. Those are also followed through the same computers.*
PI564	**Ponekela Hospital Attendant-Male:** *When people come for supervision wanting reports, it is not difficult because they just open the computer and the reports are found easily, as opposed to the past when there were no computers.*
PI565	**Ponekela Ground Labour-Male:** *when the people from the DHO come here, they see that, even when they ask for reports, they are able to obtain them quickly.*
PI566	**Dalitso Data Clerk-Male**: *As a data clerk, I can say the coming of computers has changed a lot especially my work of compiling reports. For instance, it used to happen that – Let me just give an example, OPD register. It would take me maybe a week compiling that information. But now it takes me two, three minutes, I have finished compiling. Work that was taking me a week.*
PI567	**Dalitso Nurse-Female**: *I will confirm what the data clerk has said that the work seems to be lighter. Because it would be – by 5th every month the report is supposed to have arrived at the DHO. But it would go up the 10th, maybe up to the 12th, maybe up to them following up that, 'No, the reports have not arrived yet'. But now these days they are being done in good time such that by the 5th the reports are being compiled and gone to the office. I feel that it's going well on that side*
PI568	**Jedawako HSA - Male**: *It is helping us even when we want to write reports. Finding totals for how we have done that month is easy, unlike when we go use the registers as has been done previously. Currently, when we are using computers, we are not using the register anymore.*
	Negative
PI569	**Winistoni HIV Counsellor 1-Male**: *The emphasis: reporting system should be updated, so that we should enjoy that we are using computers.*
PI570	**Winistoni ART clerk Male**: *What I have noted is that we just enter the information, enter the information, and when we try to get a report we find that it is not possible. So we don't really know what the use of entering those people into the computer is.*
PI571	**Winistoni HTC Counselor 1-Male**: *I saw that when registering into the computer there was coming just a number, a person's name, surname and guardian and it ends there, not giving the results. Now the rest is not there, so I was like, 'Is this how it is going to be?' So it was like a double-kick, that when writing in the register, circle, circle is still continuing, and then coming to write in the computer again I was like, 'Aah! Is this reducing workload? No'. Anyway, I was happy that computers were coming, because it's knowledge for our work. So – Things are well. (laughs).*
PI572	**Winistoni Medical Assistant-Female**: *We also wanted to really know way forward when we enter those names in there. Up to now it has never been seen. We just enter, but we cannot compile a report from that computer. Yes, so it just distresses us that we cannot see its future, where it is going and what we will be doing, what next.*

PI573	**Winistoni ART Clerk-Male**: *The problem is that it just needs to finish the work that we should be able to produce a report about the things that we have recorded. Because when someone puts in something, they expect an outcome of that thing you have entered. So what we want now is the outcome of the things we are entering, we should be able to produce it and see it.*
	c. Use of both computer and paper registers
PI574	**Winistoni HIV Counsellor 2-Male**: *The whole issue has rested on skills. When these things started and you were training us as orientation, switching on the computer, we learnt, to register, we learnt. Now when it comes to the end of the month, to see how we have done the work, that was hidden from us. We were not told. Because we have reports like quarterly and others, there we were not told that you should do it like this. The work is like we are writing in a book, like the manual, we are writing in the computer, the reason that when we have just written here, then how are we going to write the report? It is better to be using both.*
PI575	**Winistoni ART Clerk-Male**: *When compiling reports, I do not use that, but just knowing how, from HTC, how many have been sent, that helps me, and when I know that I then go to the manual system and from what I have been told from HTC and those I have entered manually, are they the same? So I am able to detect how many were tested. Someone who has been tested there has the freedom to just pass and leave, so I end up having a different number from there of, say, women who are positive, and here have a different number. So it helped me to know how many have been found positive from HTC and for me at ART, how many have I registered. So it was helpful in that way.*
PI576	**Jedawako Hospital Attendant 1 - Male:** *When [bespoke eHealth system] was working, we were using the computers. But you find that [bespoke eHealth system] is not working. So now what do we do? We go back to the registers, take that, put it in the register, and do everything well. So the person wanting to collect data goes to the computer for the days it was put in the computer and combine with the days for the register.*
	Data Use – Reporting – Medium Adopters
	1. Data Use: Reporting
	a. Continued use of paper registers
PI577	**Sinelia Hospital Attendant 1 - Male**: *We can say that because the reports that they come and get, perhaps it happens that where they are coming from they don't know about these systems, that we have computers here. So they are still using – Mostly we are still using those papers. But it is able to be searched in there, as we have been trained, it is highlighted on that paper.*
PI578	**Sauko Data Clerk-Male**: *real change has not been observed, because when we want to write a report now, then for that we use the manual register. There in the computer I cannot take a report – the right information, because diagnosis and treatment is not done. If it's done then it's maybe only a few people are entered, which cannot give me accurate information.*
PI579	**Sauko Data Clerk-Male**: *to get from there information, like in this month how many patients came, or reporting, we don't get anything from it, we just register, so we get it by looking at how the OPD register has done. So, it's like that.*

PI580	Sauko **Data clerk Male**: *The other challenge that I have seen is that the one who was designing other programmes and taking into consideration the reports that are needed by the Ministry of Health, some places they differ. For example, antenatal, do you say antenatal? (**Female:** Yes) antenatal was different. When I take the manual register and how it has been designed in the system, they are different, so it becomes difficult in that if we stop using our registers here, then these other indicators, where will we be getting them?*
PI581	Malilika **Patient attendant-Female**: *we compile our reports still using our registers because it happens that some days there is no electricity, we did not use the computer, sometimes there is no network, we did not use it, so the report would be false if we used computer data, so we use our registers because we report in the register. So for now we are still using the registers.*
	b. Use of computers
	Positive
	Negative
PI582	Sinelia **Midwife Nurse 2 - Female**: *Maybe most times for us to use the things in the computer for writing reports is difficult for us because most times, because of shortage of staff you find that some information for some days are found that we did not put it into the computer. So (unclear) for us to use the computer is difficult for us because we find that some information is not in the computer. But if it happens that the whole month we have used that computer, for us to write a report month-end would be simple because the computer calculates itself.*
PI583	Sauko **Data Clerk-Male**: *if it was that everything was completed well, that's good because it shows in the computer. But now for me to see that (inaudible) because ever since it was installed a report has never been produced. When it shows a report, because when we worked hard on diagnosis and treatment, then we find that it works.*
PI584	Sauko **Data Clerk-Male:** *if once you start here then you are done with it and everything is set, the reports are also found in there, it would have been very good. Because what it is most able to do is only registration, while diagnosis and treatment works but as I have said that the ground labourers will do their work then they come help here. But for there to be a big change, would be the report. The program has not finished getting settled. But if it was that we have finished using those registers, when we want a report we'll find it in there, then it would have been simple.*
PI585	Malilika **Nurse midwife 2 -Female**: *When I heard computers are coming I was very happy because reporting will be easy because the computer will be adding for you and you will not be struggling going page by page like we struggle now. It's just that we are not yet set, but the computer will (inaudible). (**Paul:** Computers have not started reporting? (**All**: No, they have not started.))*
	c. Use of both computer and paper registers
PI586	Malilika **Laboratory Technician-Male**: *In terms of patient information, here we still use OPD register as well as the patient's book. Here at Malilika, there are times we have few people, we do it, but when there are a lot of people it is difficult for us. So we are still using the old system and computer, we are using both. So those who have been entered, when we have searched for them we find them and when they came and how they were served. But we are still using the old system when we are not using the computer. We are still using the register and the patient's book for how they were previously served. But in future I'm sure that when we have settled we will often retrieve information that is in the*

	computer.
	Data Use – Reporting – Failures
	1. Data Use: Reporting
	a. Continued use of paper registers
	b. Use of computers
	Positive
PI587	**Filipi Clinician - Male**: *In terms of reporting, it was very simple, such that you would just go there, three minutes it has given you a report that this whole month you saw this number of people, with malaria this number, under-five this number, over-five this number. So the work was little.*
PI588	**Filipi Cashier-Male:** *The successes can be like, the people who write reports, the work was simple. Let's say, someone says compile a report for the last five months, how it has gone. You can just go there then maybe within one hour – thirty minutes you have finished. But to have to go through the books, to gather information for five months, it's tiresome work.*
	Negative
	Data Use – Patient Care – High Adopters
	1. Data Use: Patient Care
	a. Following protocols
	b. Continuity of care & patient follow-up
PI589	**Winistoni HIV Counsellor 1-Male**: *The other advantage is that information is stored, and when it is stored, maybe I want to follow up someone who didn't come but maybe was booked by the clinician to come today, it would be simple to just go to that file and crrrr it brings me that list and I trace that, 'Yes, this is the person', and go, since we know the particulars. Yes, so it becomes simple to find that person and go follow them up if there was need for them to come again. For example, there are some children for whom they write, 'You should come tomorrow, you should come for injection', so if they didn't come, maybe I did not write on the paper, I can just come straight into the computer and find them. Let's just say it's easily booked in terms of the drugs if they keep follow-up. Like at HTC it's simple, whether it's a man or a woman who is found HIV positive, I can easily find them, so they come for ART. Yes.*
PI590	**Winistoni ART clerk Male**: *At ART we receive information that has been given about the patient coming from, for example, HTC. The ones they have found positive there they register. When they find that person positive there we just check in our computers and we find the person. There can be women who are pregnant and they find them positive there. Instantly I have to start searching. Therefore, we are able to trace those clients.*

PI591	**Winistoni** ***Hospital Attendant 2-Male:*** *Right now it is difficult for the patient to lie to the clinician. What used to happen previously is that when the patient has been registered here and has been found with venereal disease, they would get recorded here and when they are outside they would tear that and throw away the book. When they come back, they would buy another book and get recorded again so that those ones should not be seen. But now because of those numbers that are being given, when they give their name and it is not in there, when I search for them and the village they are coming from, I find that it's that same person who came and tore their book and the number is confirming that. So even if that book was torn, the person didn't sneak through, it's the same person and I catch them. While previously when the person has torn it, it's torn and when they come after two days, for one to know that they came at such and such time and was treated with such and such, they would not reveal and I would not know, they would come like it's a new person. So with this system a person will not trick the clinician and will receive appropriate care.*
PI592	**Ponekela** **HSA5-Male:** *the computers have also helped a lot in patients who came another time, and at their second visit, to trace them was not difficult, and to also know that at the time they came, how much time has elapsed to find that they have come again.*
593PI	**Ponekela** **Ground Labourer-Male**: *The computers also helped a person who came, has been served, and has lost their profile. They have come a second time, but they have lost that book. The illness they have come with is the same one they came with during the previous visit. So the computer, when we ask it if this person came, and when did they come, it told us the person came this day, and received this and this medication. We were taking that person again and give them their number, and the clinician knew I stopped here, I need to start again from here. The computers, on that part, helped us a lot.*
PI594	**Dalitso** **Medical Assistant-Female**: *What I am able to manage to find is the illness that the person suffered from in the past, but also what medication they were taking, and the amount. But now about tests, it seems to still be difficult for me because of lack of knowledge that where do I press for that to happen, to get results from the lab. It is difficult for me like the person went for malaria test and checked RDT, it is still difficult for me. So I just see the diagnosis and the drugs that they got and when they came.*
	c. <u>Keeping health workers alert</u>
PI595	**Winistoni** **Medical Assistant-Female**: *The project is quite good, in that with the coming in of the computers, we are found here in the afternoons. A person would be on the computer, open a little draft and taaa! taaaa! taaaa! And when a serious case comes we are told, 'There is a serious illness here!' and the person is still here. So the computers have quite helped us to keep – to keep us alive all the time.*
PI596	**Jedawako** ***Hospital Attendant 2*** **- Female:** *We were not dosing when we were with a patient, right? We were not dosing. There weren't moments where people would be calling the doctor and you would not sleep when you are at maternity. We would wait for the patient until they have delivered. We would be on the computer, play a bit of Zooma. We would not dose, let me not lie, or sleeping. We can just sit here and someone says 'Hey!' while we are dosing.*
PI597	**Jedawako** **Hospital Attendant 1 -** ***Female:*** *Sometimes there is no work to be done and instead of dosing I do this, waiting until the patient has delivered. You will not sleep until they have delivered.*
	d. <u>Identification of correct patient</u>

PI598	**Winistoni Hospital Attendant 1-Male**: *Here it has helped us because previously, let's say Chichewa names can be similar, so it can be one name from one group village head, another from another group village head, so previously we used to write just the village without writing the group village head. But as it is now we write the person's name, we write the village, we write the group head there, so it makes follow up easy.*
PI599	**Winistoni Security Guard 2- Male**: *In terms of booking, the computers helped me in management of cards. Some patients would borrow each other cards. So, when I take that card I just click that number and it brings the information. So when I see all that information I ask their name, and they mention their real name while the card belongs to someone else and I detect it there that, 'This is not your card, this is someone else's card'. In that, the computer helped us a lot.*
PI600	**Winistoni *Security Guard 1 - Male:*** *You find that the card belongs to the husband, and the wife is using the same card, and the child also the same one. So since the husband was the first one to come to the facility, he was given a number there. And then it is taken by the wife, especially the general ones. Yes, so they come and ktktktkt teee! It's the wife who has brought the book. We tell them, 'Now, there is Mr Moyo's name', 'No, we just use the same one', 'No no no, you should have your own'. So they are forced to buy their own, and they are given their own number. So that's what the guy is saying, that tracing the woman is found to be (inaudible).*
PI601	**Ponekela HSA5-Male:** *When a patient has lost their card, maybe they came before, like, new register, that one will have to – They will have to receive again another new number. It happens that they have really been coming, they are already, like, in our system already, then on this computer here you can track the person's information. It makes it to not make a duplicate. No. Because you will see that this is the same patient, they are the one we are continuing with on that system. (**Paul:** Meaning that they have come – They came, and were given a number – Yes. (**Paul:** Then they come for a second time, they have lost their book, then they will again be given a new number, then you cannot connect that they are the same one?) Yes.*
	e. <u>Patient referral</u>
	f. <u>Patient confidentiality</u>
PI602	**Winistoni Art Clerk-Male:** *There is good interaction. For example, a person has come to HTC, we can say maybe confidentiality, and once the information has been taken from HTC, you have taken the information there, they leave everything there, then maybe they will just be (inaudible) and there will not be any other questions here because everything has already been done. Ok, let's say someone has gone to HTC, there they will ask them everything, they will ask their name, their address, the results will be entered, for example they are positive. So when they come to ART I will not be busy asking them again, I'll just take their book and get their HTC number then all their information is displayed and we just read that, ok, it's like this and that. So it helps our relationship, because the confidentiality of those people, sometimes they will not feel comfortable to be asked several places, they feel they are not being assisted. (inaudible) So when they come there we keep that secret because you just find that information, you write and then you treat that. So we see that the relationship is good. Instead of being asked here, being asked there, the person gets (inaudible) that, 'Should I just be doing this over and over?' But now I think it is very good from the side of ART.*

PI603	**Winistoni MA-Female:** *Because of confidentiality, those positive should be having their own page. (**HIV Counsellor 1 -Male:** When this one has been found positive then taaaa! They should go on their own page) They should go on their own page.*
PI604	**Ponekela HSA6-Male:** *On the same part of the benefit of the computer, on the part of the patients' confidentiality. At the register you can write this and that, such and such illness. While in that computer, you will enter all that, those medications, then some stranger coming to trace, cannot know it, unless you were trained, you can take those things comfortably. That's the goodness of the computer.*
PI605	**Ponekela HSA6- Male**: *Where I was, there were problems that sometimes people would monitor someone going for the testing. Then they really wanted to capture the person's information. As someone working there, you didn't know. So it would happen that it's open, it's been left unlocked. People would go into the register and trace the name of that person, and just be saying that that person's results are like this. So my expectation was that where I am going, if I will be using a computer, I will have my secret code number that no one else will see them. Because when the person hears outside that, 'They are saying I have the virus', they will suspect that it's the counsellor who has revealed it, while we don't say anything.*
	Data Use – Patient Care – Medium Adopters
	1. Data Use: Patient Care
	a. Following protocols
PI606	***Malilika* Nurse mid wife 1 -Female**: *we can say it is good because when we are making a prescription, small things that you would have forgotten when writing in the book, it reminds you, some assessments you are reminded on the computer that I did not ask this, I did not do this. It is quite good.*
	b. Continuity of care & patient follow-up
PI607	**Sinelia Midwife Nurse 2 - Female**: *Maybe in brief we can say that it indeed disturbs us because maybe like a client – Let's consider an antenatal clinic client for VIA came. It has been found that you did not enter her into the computer on that first day. For her to come a second day, you find that to go search for that information in that computer, you cannot find it. It happens that you are not able to provide service, finding that how do I help this person.*
PI608	**Sinelia Hospital Attendant-Female**: *It also helps in that, maybe the card was lost. So when they come they will buy a new one. So if the person is already in the system, they are able to see. Like the clinician is able to see, 'What treatment did I give them? And now they have come with the same problem, so what medication can I give them, since maybe these ones did not help them?'*
PI609	**Sinelia Midwife Nurse 2 -Female**: A *patient or a client can come maybe the first time, another time they come again. For you to find their information if you were just writing in the book, it is difficult, it takes time to find that information. But for you to check on the computer it is simple, you do not delay. You find that information easily, and the client is served properly.*
PI610	**Sauko Counsellor-Male**: *The advantage is that the people, as has been said, have been entered into the system, so their information needed to assist them is not difficult. They are able to follow those people, so it gives hope to the people who are being treated as they are able to receive the information from earlier, so it shows that the clinician was paying attention, which makes the communication to be good because if the person realizes that they were understanding each other during the previous visit because of the information from prior visit that is kept*

	securely, because searching from the register would take time, it makes the people feel that there is good communication because it makes them realize that everything that they explained was well understood.
	c. <u>Keeping health workers alert</u>
	d. <u>Identification of correct patient</u>
PI611	**Sauko Hospital Attendant-Male**: *I can see that there is change because what happens is that if a person is entered into the computer that they are sick from something, this and this illness, whether it's the stomach, or they are having problems with their back or headache, let's say they have come three times, and they see the person's diagnosis, that they keep coming with the same problem, they make a change that they send to a referral hospital. So I feel that the people are being assisted properly because even the clinician wonders that, 'Aah, what is happening with this person, time after time they are coming with the same problem'. So they go from there to another facility. I think there is then an improvement and so those people trust us workers here that at Sauko Health Centre people work hard.*
PI612	**Sauko Ground Labourer 2-Male**: *We are also able to tell them the goodness of those computers, that if they go from here to maybe Madalo, because the number that we give them, because I remember what they told us during the training that maybe there will be another server there that when a person came here, they were not assisted properly and maybe they are still getting sick, so when they go to Madalo, that same number that we gave them here, when it goes to Madalo, they will transfer it into the computer that is there, it will be able to show them what they received here. But because the number – the server at Madalo has not yet been installed, that's where there is maybe a small problem. However, those people are welcoming it with two hands, taking into account that Madalo Hospital is the facility that people from Sauko are assisted.*

PI613	Sauko **Ground Labour 1-Male:** *I would have loved if this north would be doing things together, but with different numbers.* ***(Paul:*** *Meaning?) Meaning that, Filipi have their own number –* ***(Data clerk –Male:*** *My friend, let me cut you there. This thing depends on the interest of the people. For us they removed the computers. They were not being used, they just dumped them there, what we have already said. So it is not possible for all to be the same. That is not possible.)* ***Ground Labourer 1-Male:*** *So, what I meant was a person from Filipi can go to Ponekela without knowing that they removed it at Filipi.* ***(Paul:*** *A patient?) Yes, a patient. Without knowing that at Filipi they removed the computers. There they will just take that person and put a new number for them, but residence is from Filipi. It will happen that one day they will receive drugs from there, another day they go to Ponekela. (****Data clerk:*** *He has forgotten. He has forgotten. Every facility has their own number. If a patient has been registered at Filipi, when they come here, to us they are a new client. When they go to Ponekela, they are a new client.* ***(Female:*** *They said in future maybe they will make connections. (****Paul:*** *I think what they meant was that when the patient goes Ponekela or another Health centre they will be able to see their history that they were already treated at Chimphwanya, as was given such drugs so that there should be smooth continuation of treatment.))) **Ground Labourer 1 (Male):*** *Because a person can change – (****Data clerk-Male:*** *That was explained to us at the beginning. They said a facility like Sauko does not have the right to see the diagnosis of a patient from Filipi. However, at Madalo, they are the only ones who can see what they were ill from at Filipi because a patient's illness is confidential.)* ***Ground Labour 1-Male:*** *But what you remember is those people rotate around here –* ***(Data Clerk (Male):*** *But you cannot see what they were sick from but at Madalo when they want – at Madalo, they are the ones who will be able to. But to you and me, it's confidential. Because they said at the beginning that the ones who will access are those at Madalo only to see this one did this and that, but for you to see – to see this one's account, no. Maybe if there was another way.)* ***Ground labourer 1 (Male):*** *I meant that, I was taking it as if they are the same, that maybe that person, like the way we do ART, that when one has come from somewhere else, like from Ponekela, sent to me by the clinician at Ponekela, there the drugs are not available, so I want, 'They told me to come here to just receive these for emergency'. You see? 'Then when these have run out I shall go again to – if the distribution reaches there'.* ***(Paul:*** *For treatment continuation purpose whereby if a patient is visiting another hospital they cannot do the diagnosis again let's say if the patient was diagnosed with Diabetes and sometimes patients pays a visit to their relatives where it happens that their appointed day is due they can just visit the closest Hospital and the doctor will just check in the system.)* ***Ground Labourer 1-Male:*** *For example we receive psychiatric patients from let's say Ponekela, they come here. The clinician here has a big job of asking them what they are suffering from because they do not know the information.* ***(Paul:*** *yes the system was supposed to be like that, as you can recall we had VOIP system in all 9 health centers. The core purpose was to link all the 9 health centres surrounding Madalo Hospital through [bespoke eHealth system]. So that we can have same information, whether the patient visits Madalo or any other Health centres around Madalo. For example, if you have maternity referral patient to Chimphwanya or Madalo Hospital they will access the information in the system using the number from the Health passport.)*
	g. <u>Patient confidentiality</u>
	Data Use – Finance

	1. Data Use: Finances
	a. Fraud prevention
PI614	**Filipi Cashier-Male**: *It was helping me in that, most times the receipts that we were producing people believed saw that they are original, while these hand-written ones some people can – What you have written, they can erase and write the figures that they may. Which was giving some thoughts that things are not going well. But now with that system, when we produce a printed receipt, it is difficult for a person, maybe they want to go to their office, when they have been sent by their office, to deceive them. Because the receipt was printed, changing anything messes it up.*
	b. Financial governance
PI615	**Malilika Cashier-Male**: *a person has to book a number then we go on to see how they have been prescribed. Medication is what tells us how much should be billed.*
PI616	**Filipi Cashier-male:** *Another thing that pleased me as a cashier, is that, that system had a password for the administrator. So the thing that pleased me was that when we have done our daily activity here, the administrator would just check themselves without the trouble of taking a report to them. Yes. That's the thing that pleased me, that you could just take cash to them, but the rest of the business and how it went was revealed by it.*

4. Monthly Patient Fee Revenue for Madalo Hospital, Jan 2006 – Dec 2013

Month	Total revenue	patie	Drugs	Out-patient	Annual CPI	CPI2	Total Revenue 2012 Prices	Total Revenue 2013 Prices Reset in 2012 Total
Jan-06	1,451,777	-	-	-	226		2,588,286	3,294,888
Feb-06	1,061,731	-	-	-			1,892,896	2,409,656
Mar-06	1,407,364	-	-	-			2,509,104	3,194,089
Apr-06	2,394,490	-	-	-			4,268,991	5,434,426
May-06	1,769,133	-	-	-			3,154,080	4,015,144
Jun-06	2,356,546	-	-	-			4,201,343	5,348,310
Jul-06	1,440,549	-	-	-			2,568,268	3,269,405
Aug-06	1,555,654	-	-	-			2,773,481	3,530,642
Sep-06	1,089,987	-	-	-			1,943,272	2,473,785
Oct-06	813,374	-	-	-			1,450,115	1,845,997
Nov-06	3,224,513	-	-	-			5,748,789	7,318,208
Dec-06	1,582,633	-	-	-			2,821,581	3,591,872
Jan-07	2,110,686	-	-	-	244.1		3,485,529	4,437,078
Feb-07	1,119,829	-	-	-			1,849,255	2,354,101
Mar-07	1,523,205	-	-	-			2,515,379	3,202,077
Apr-07	878,758	-	-	-			1,451,157	1,847,322
May-07	1,287,617	-	-	-			2,126,335	2,706,825
Jun-07	1,179,776	-	-	-			1,948,250	2,480,122
Jul-07	2,663,457	-	-	-			4,398,359	5,599,111
Aug-07	1,985,911	-	-	-			3,279,479	4,174,776
Sep-07	4,640,459	-	-	-			7,663,126	9,755,159
Oct-07	1,370,057	-	-	-			2,262,474	2,880,130
Nov-07	4,645,329	-	-	-			7,671,168	9,765,397
Dec-07	2,172,561	-	-	-			3,587,707	4,567,151
Jan-08	3,064,660				265.4		4,654,727	5,925,467
Feb-08	4,176,695						6,343,729	8,075,567
Mar-08	1,446,566						2,197,102	2,796,910
Apr-08	2,350,052						3,569,352	4,543,785
May-08	3,685,929						5,598,335	7,126,680
Jun-08	1,982,923						3,011,742	3,833,947
Jul-08	3,383,913						5,139,621	6,542,737
Aug-08	1,583,113						2,404,495	3,060,922
Sep-08	3,147,278						4,780,210	6,085,207
Oct-08	2,626,691						3,989,522	5,078,662
Nov-08	2,526,538						3,837,406	4,885,017

Dec-08	3,322,538						5,046,402	6,424,070
Jan-09	2,961,970			554,027	287.7		4,150,053	5,283,017
Feb-09	2,991,801			400,000			4,191,849	5,336,224
Mar-09	2,031,172			990,304			2,845,900	3,622,831
Apr-09	2,073,449			577,372			2,905,135	3,698,237
May-09	2,631,809			392,012			3,687,460	4,694,136
Jun-09	8,940,990			637,500			12,527,331	15,947,292
Jul-09	2,143,264			443,505			3,002,953	3,822,760
Aug-09	7,366,977			474,260			10,321,962	13,139,857
Sep-09	3,746,487			733,710			5,249,249	6,682,294
Oct-09	3,465,034			679,237			4,854,902	6,180,290
Nov-09	7,293,127			477,659			10,218,490	13,008,137
Dec-09	3,169,668			412,720			4,441,061	5,653,470
Jan-10	4,530,760			536,849	309		5,910,515	7,524,086
Feb-10	4,928,675	-	-	552,406			6,429,609	8,184,892
Mar-10	4,522,292	-	-	565,430			5,899,469	7,510,024
Apr-10	3,524,050	-	-	961,962			4,597,231	5,852,276

May-10	3,537,278	-	-	973,185			4,614,488	5,874,243
Jun-10	3,460,723	-	-	943,897			4,514,620	5,747,111
Jul-10	3,785,408	928,208	2,046,628	810,572			4,938,181	6,286,305
Aug-10	3,492,549	795,233	1,874,215	823,101			4,556,137	5,799,962
Sep-10	3,350,666	671,155	1,751,617	927,894			4,371,047	5,564,343
Oct-10	3,517,676	649,870	1,574,686	1,293,120			4,588,916	5,841,690
Nov-10	3,616,646	770,610	1,805,510	1,040,526			4,718,025	6,006,046
Dec-10	3,001,395	450,265	1,782,959	768,171			3,915,411	4,984,319
Jan-11	1,917,940	1,175,115	576,805	166,020	332.6		2,324,479	2,959,061
Feb-11	1,489,440	872,825	475,575	141,040			1,805,151	2,297,957
Mar-11	1,543,855	896,635	530,510	116,710			1,871,100	2,381,911
Apr-11	1,579,380	892,010	560,270	127,100			1,914,155	2,436,720
May-11	1,291,655	400,465	735,670	155,520			1,565,442	1,992,808
Jun-11	1,880,205	1,005,615	724,830	149,760			2,278,745	2,900,843
Jul-11	2,104,340	1,282,460	670,440	151,440			2,550,389	3,246,645

Aug-11	2,270,640	1,373,450	825,180	72,010			2,751,939	3,503,219
Sep-11	2,275,260	1,353,170	777,290	144,800			2,757,539	3,510,347
Oct-11	2,001,067	1,167,907	676,440	156,720			2,425,226	3,087,312
Nov-11	1,913,690	1,086,590	694,170	132,930			2,319,328	2,952,504
Dec-11	1,672,626	585,796	670,480	416,350			2,027,166	2,580,583
Jan-12	5,973,391	2,170,438	3,062,733	740,220	403.1	100.0	5,973,391	7,604,127
Feb-12	7,671,960	2,537,018	4,167,672	967,271			7,671,960	9,766,405
Mar-12	8,608,678	2,534,030	5,023,703	1,050,945			8,608,678	10,958,847
Apr-12	8,395,802	2,599,870	4,532,132	1,263,800			8,395,802	10,687,856
May-12	7,457,167	2,170,780	4,477,627	808,760			7,457,167	9,492,974
Jun-12	7,168,880	2,324,720	4,022,170	821,990			7,168,880	9,125,984
Jul-12	7,206,146	2,500,624	3,564,272	1,141,250			7,206,146	9,173,424

Aug-12	6,386,400	2,327,657	3,152,803	905,940			6,386,400	8,129,887
Sep-12	5,142,745	1,855,922	2,690,783	596,040			5,142,745	6,546,714
Oct-12	6,537,357	1,684,912	4,155,165	697,280			6,537,357	8,322,056
Nov-12	6,285,448	2,170,431	3,443,562	671,455			6,285,448	8,001,376
Dec-12	5,820,266	2,127,810	3,048,921	643,535			5,820,266	7,409,199
Jan-13	2,340,787	2,157,527	13,260	170,000	513.15	127.3		2,340,787
Feb-13	3,177,530	2,317,940	687,390	172,200				3,177,530
Mar-13	3,983,147	2,604,760	1,170,987	207,400				3,983,147
Apr-13	4,163,350	2,424,820	1,479,930	258,600				4,163,350
May-13	3,758,555	2,215,720	1,300,535	242,300				3,758,555
Jun-13	3,712,570	2,554,540	942,730	215,300				3,712,570
Jul-13	5,524,165	3,355,965	1,889,960	278,240				5,524,165

Aug-13	5,518,555	3,405,495	1,820,920	292,140				5,518,555
Sep-13	5,825,322	3,625,039	1,921,643	278,640				5,825,322
Oct-13	5,514,745	3,230,470	1,977,215	307,060				5,514,745
Nov-13	5,331,006	3,424,820	1,637,606	268,580				5,331,006
Dec-13	4,760,417	2,880,420	1,614,287	265,710				4,760,417