

Implementation effectiveness of mHealth interventions for communicable diseases surveillance in the context of sub-Saharan Africa: the case of eIDSR in Tanzania

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Declaration

The candidate confirms that the work submitted is his own and that appropriate credit had been given where reference had been made to the work of others.

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Dedication

To my mother Bertha Mwelu Kinampanda Mndeme
Who sacrificed and went through a lot to see me educated

and

To my late father Elisa Tillian Itunda Mndeme
Who would always remind me to focus on studies and what the future holds

and

To my wife Jacqueline Boniface Mndolwa
For the invaluable support, prayers, love, care and friendship

and

To our kids Glorinda Naanjela, Mathew Togolani Jr, and Milan Akundiwe
For their understanding, encouragement, prayers and patience

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Working on this thesis has been both adventurous and the most challenging experience of my life. If it was not for the God I believe in through Jesus Christ, I would not have come this far. In Him, I have lived, have my being, and walked through this journey with hope while encouraged by His word to remain focused.

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Abstract

The adoption of mobile and wireless technologies for health (mHealth) interventions for national disease surveillance functions in sub-Saharan Africa (SSA) countries is increasing, but implementation processes and outcomes are rarely reported or unreported. Reported interventions are not effectively implemented because they are often rushed, donor driven, focus on the technology, and are not scaled up or evaluated.

This thesis investigated the effectiveness of an integrated mHealth intervention that was implemented for disease surveillance in Tanzania, called eIDSR, by examining how it was adopted and being implemented, the quality of the targeted clinical data, and the value it adds to the availability, quality and use of surveillance data. A mixed-methods design was employed to retrospectively explore the first four years of eIDSR implementation, from the organisational change perspective.

Although eIDSR implementation is supported by a relatively positive implementation climate and had been expeditiously implemented in 50% of all health facilities within the first two years, the results indicate that it had not been implemented effectively. The use of eIDSR to submit data was poor, declining with time, and it was not prioritised to notify outbreaks or inform response activities. This was attributed to the uninformed and non-participatory implementation process that was not supported by evidence of good results, the poor information culture, donors' influence, the focus on the technology and its presumed benefits, the lack of leadership capabilities and technical support, and the effect of the per diem culture.

In order to effectively implement eIDSRs, the thesis proposes an organisation-wide implementation framework emphasising a change management process, which includes improving clinical practices, implementation climate, evidence based practices, and information culture; identifying and addressing explicit and implicit organisational forces affecting implementation decisions; and integrating eIDSR design and practices in flexible health system digital infrastructures to optimise the utilisation of scarce implementation resources.

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List of acronyms and abbreviations

| | |
|---------------|---|
| CHMT | Council Health Management Team |
| CHW | Community Health Workers |
| DH | Digital Health |
| DHIs | Digital Health Interventions |
| DHIS2 | District Health Information Software version 2 |
| DSIS | Disease Surveillance Information System |
| DSP | Disease Specific Programme |
| DSS | Disease Surveillance System |
| DVD | Digital Versatile Disk |
| eHealth | Electronic-Health |
| eIDSR | electronic-Integrated Disease Surveillance and Response |
| eSurveillance | mSurveillance integrated with other digital health technologies |
| FHW | Frontline Healthcare Worker |
| GSM | Global System for Mobile Communications |
| GNI | Gross National Income |
| HF | Health Facility |
| HIS | Health Information System |
| HMIS | Health Management Information System |
| HRHIS | Human Resources for Health Information System |
| HWs | Healthcare Workers |
| ICT | Information and Communications Technology |
| ICT-IS | ICT-based Information Systems |
| IHRs | International Health Regulations |
| IS | Information systems |
| IDSR | Integrated Disease Surveillance and Response |
| IHR | International Health Regulations |
| IMCI | Integrated Management of Childhood Illness |
| IPD | Inpatients department |
| ITN | Insecticide Treated Nets |
| LGA | Local Government Authority |
| LMICs | Low- and Middle-Income countries |
| M & E | Monitoring and Evaluation |
| mHealth | Mobile-health/ Mobile Health |
| MoCT | Ministry of Communication and Transport |
| MoH | Ministry of Health |

| | |
|---------------|---|
| MoHSW | Ministry of Health and Social Welfare |
| MoHCDCE | Ministry of Health, Community Development, Gender, Elderly and Children |
| MoWTC | Ministry of Works, Transport and Communications |
| MRDT | Malaria Rapid Diagnostic Test |
| mSurveillance | mHealth solution for disease surveillance functions |
| NIMR | National Institute of Medical Research |
| NMCP | National Malaria Control Programme |
| OCT | Organisational Change Theory |
| OPD | Outpatients department |
| PDA | Personal Digital Assistant |
| PHF | Primary Health Facility |
| PI | Principal Investigator |
| PIS | Participant Information Sheet |
| PORALG | President's Office Regional Administration and Local Government |
| PPP | Public Private Partnership |
| RC | Reporting completeness |
| RCT | Randomised Control Trial |
| RHMT | Regional Health Management Team |
| RRT | Rapid Response Team |
| RT | Reporting timeliness |
| SARI | Severe acute respiratory infection |
| SCD | Standard Case Definition |
| SMS | Short Message Service |
| SSA | Sub-Saharan Africa |
| UDSM | University of Dar es Salaam |
| USB | Universal Serial Bus |
| USSD | Unstructured Supplementary Service Data |
| VHI | Viral Haemorrhagic Fever |
| VHW | Village Healthcare Workers |
| WHO | World Health Organisation |
| WHO/AFRO | World Health Organization Regional Office for Africa |

CHAPTER 1

Introduction and background

1.0. Introduction

This thesis focuses on the evidence base of mobile and wireless technologies for health (mHealth) interventions by examining implementation effectiveness of mHealth interventions for national diseases surveillance functions in the context of sub-Saharan Africa (SSA). In this thesis, implementation effectiveness refers to an aggregate consistency and quality of use of innovative solutions for the intended purpose as a precondition for achieving the anticipated implementation outcomes (Helfrich et al., 2007, p. 41; Jacobs, S.R. et al., 2015b; Klein et al., 2001).

Despite an increasing trend to adopt mHealth-related interventions for diseases surveillance functions in SSA countries, good quality evidence of improved outcomes is missing, mainly attributed to implementation-related complications and unreported implementation effectiveness (Agarwal et al., 2016; Brinkel et al., 2014; Krah and de Kruijf, 2016; Tom-Aba et al., 2018a). Thus, the thesis sought to understand whether and how mHealth-related interventions implemented for national diseases surveillance and response functions in the context of SSA countries are effectively implemented or used as planned, using an intervention in Tanzania as a case study.

This chapter introduces the research topic and lays the foundation for the work presented in the rest of the thesis chapters. Section 1.1 provides a brief description of mHealth interventions and introduces the intervention investigated in this thesis. Section 1.2 describes the research problem and section 1.3 sets out the research aim and specific objectives. The research rationale is presented in section 1.4. The research background and context are presented in section 1.5. Section 1.6 describes the thesis structure.

1.1. mHealth interventions: etymology and definition

The mHealth is one of several concepts emerged from the application of digital solutions in the healthcare domain such as eHealth, digital health, telehealth, and telemedicine (Agarwal et al., 2016b; WHO, 2011; 2015; 2016a; 2016b; 2018a; 2019a; 2019b). These concepts have different interpretations contingent on their purpose, applied healthcare domain, and deployed devices or technology (Davis et al., 2016; Oh et al., 2005; van Dyk, 2014; WHO, 2018a; 2019a; 2019b). The definition of mHealth concept is derived from eHealth and digital health concepts.

The eHealth concept is defined as “the use of information and communication technologies (ICT) in support of health and health-related fields” (WHO, 2019b, pp. ix). The mHealth is a sub-domain of eHealth focusing on mobility and wireless connectivity

of applied eHealth technologies, defined as “a medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs) and other wireless devices” (WHO, 2011. pp. 6). In recent publications, the term “digital health” (DH) is being preferred to eHealth as it encompasses a broader range of innovative technologies for health such as the use of advanced computing science in big data analytics, genomics, Internet of Things, and artificial intelligence (WHO, 2019a; 2019b). It is defined as “the use of digital, mobile, and wireless technologies to support the achievement of health outcomes” (WHO, 2016a, pp. 126); hence making both eHealth and mHealth sub-domains of digital health.

mHealth interventions

When digital health technologies are put into a context and being applied for a defined health purpose, to address specific health-system challenges, they are referred to as “interventions” (Kaplan, 2006; WHO, 2016a). Notably, the routine usage of digital technologies such as mobile phones communication in the health environment is common (Hampshire et al., 2017), but such usage qualifies as an “intervention” only when there is a sense of intentional usage for a specific purpose (Kaplan, 2006). Therefore, the term mHealth or digital health interventions in this thesis are limited to the intentional usage of technological solutions to achieve a specific health-related purpose.

mHealth interventions for diseases surveillance

In this thesis mHealth interventions for diseases surveillance functions are implemented to facilitate and support public health surveillance functions of prevention, prediction, detection, and response to priority communicable diseases (MoH-Tanzania, 2011; WHO/AFRO, 2015). They are referred to as mSurveillance interventions in this thesis. These interventions are expected to improve functions such as timely identification, reporting, investigation and response to outbreaks; notifications delivering; data quality; real-time monitoring of diseases; systems interoperability, standardisation or portability; data storage, analysis, access or dissemination (WHO/AFRO, 2015). As categorised in chapter 2, mSurveillance interventions can be implemented using any or combinations of mHealth communication technologies or approaches. Likewise, they can be implemented by being integrated with other DH technologies or solutions such as web-based system, emails or geographical information system (GIS), hence referred to as electronic surveillance (eSurveillance) interventions in this thesis.

This thesis referred to an mSurveillance intervention introduced in 2013 by the Ministry of Health (MoH)¹ in Tanzania, to improve the information system component of the national diseases surveillance system (DSS) (Oresto et al., 2014; PMI, 2014; USAID,

¹ Ministry of Health, Community Development, Gender, Elderly and Children

2018). The intervention was named electronic-IDSR (eIDSR) to reflect the underlying WHO-initiated Integrated Diseases Surveillance and Response (IDSR) strategy, which is a framework for strengthening disease surveillance and response functions in SSA countries (MoH-Tanzania, 2011; WHO/AFRO, 2001). The eIDSR was intended to facilitate the capturing and reporting of diseases surveillance data from all health facilities (HFs) countrywide using a mobile phone-based mHealth solution and make them available and accessible at the health management level through a web-based national health database system. The eIDSR intervention and its technological solutions are described in detail later in chapter 4.

1.2. Problem definition and research questions

The eIDSR intervention is the first mHealth initiative in Tanzania to be implemented at the national scale for routine diseases surveillance and response functions. Within the short time of its inception, the intervention had shown some characteristics, suggestively, contrasting what is commonly reported in mHealth studies from developing countries context [discussed in the literature chapter]. Particularly, by the time of designing this research, the eIDSR intervention had been implemented beyond piloting stage; was being expeditiously scaled-up to cover the whole country; and was technically integrated into the mainstream HIS database. These distinct implementation features raise questions as to whether they signify eIDSR was being effectively implemented. Therefore, this thesis sought to answer three main questions; (1) what characterised the adoption and implementation of eIDSR interventions? (2) Is eIDSR being effectively implemented? (3) What factors attribute to the state of its implementation effectiveness?

Since eIDSR is being implemented to improve the information component of the DSS, this thesis considered three immediate information system outputs as potential indicators signifying its implementation effectiveness (McLean and DeLone, 2002; Aquil et al, 2010, Peter et al, 2014, Heeks, 2006). These are (i) effective usage of the eIDSR application for capturing and reporting disease surveillance data; (ii) improved availability and quality of surveillance data; (iii) improved data analysis practices and use to inform diseases surveillance functions.

Before and throughout the development of this thesis, no study has been conducted to investigate the question of implementation effectiveness of the eIDSR in Tanzania or related eSurveillance interventions in SSA. Thus, eIDSR provided an unexplored intervention for research and generating rich knowledge to inform theories and practices related to implementation effectiveness of eSurveillance interventions in the context of SSA. The thesis explored the implementation effectiveness by examining the eIDSR

adoption process, its content, data source, and the employed implementation approach and how its features attribute to the quality and use of the information output..

1.3. Aim and objectives

The thesis aimed to explore the implementation effectiveness of the eIDSR intervention to establish whether and how it stands a chance of being successful. This aim was fulfilled by retrospectively studying eIDSR implementation in the first 4 years through the following specific objectives:

Specific objectives

- (1) To examine the adoption, design, and implementation of the eIDSR intervention (chapter 4 and 5).
- (2) To investigate the clinical value and accuracy of records from which disease surveillance data are captured (chapter 6).
- (3) To establish the value-added by the eIDSR intervention to the quality and use of disease surveillance data (chapter 7 and 8).
- (4) To recommend approaches for effective implementation of mHealth interventions for strengthening DSS in the context of SSA (chapter 9).

1.4. Why studying mHealth interventions for disease surveillance in SSA?

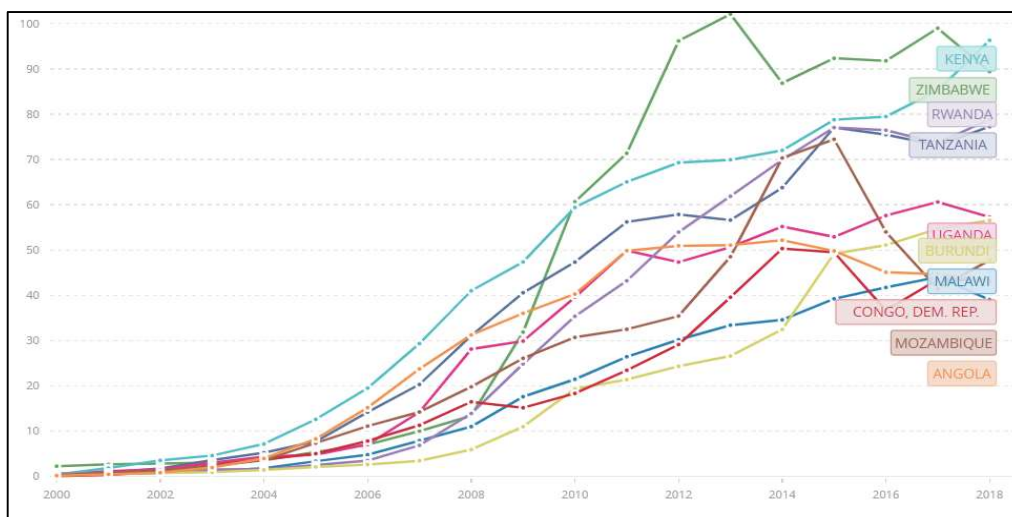
The motivation to undertake the current research is attributed to three factors. Firstly, the burden communicable diseases present a major public health challenge in Tanzania and other SSA countries [briefed in section 1.5]. Thus, implementations of digital solutions such as eIDSR come with high anticipations of introducing changes in the health of individuals or communities (Fraser et al., 2011; Khoja et al., 2013). In SSA where health systems are confronted with many constraints, the perceived benefits of mHealth solutions are likely to present alternative solutions that can rapidly be implemented while overlooking factors potential to influence effectiveness (Klein et al., 2001; Maditinos et al., 2011). Hence, establishing the value they add to the application domain is important to justify or replicate implementation efforts (Labrique et al., 2013).

Secondly, the efforts to deal with the threat attributed to communicable diseases are significantly affected by information-related challenges and the lack of innovative technological solutions to facilitate capturing, management, flow and use of information (Gueye et al., 2005; Mboera and Rumisha, 2005; Mboera et al., 2001; Mghamba et al., 2004; Phalkey et al., 2015). Thus, if effectively implemented, digital solutions stand a better chance of improving the information component of the DSS in SSA countries. Scientific studies on implementations of DHIs are therefore important to establish useful

insights to inform and improve the effectiveness of ongoing and new initiatives such as eIDSR.

Thirdly, the growth of the telecommunication industry in SSA countries provides a potential infrastructure for implementing mHealth and other digital health solutions (Betjeman et al., 2013; Lee, S. et al., 2017). For example, mobile phone penetration rate grew from 63% in 2013 to 84% in 2018 (Betjeman et al., 2013; GSM Association, 2019). As illustrated in Figure 1, which shows the increasing growth of mobile phone subscribers (teledensity) in ten neighbouring countries, the ICT sector in the region is still immature. Therefore, more research is required to expand the existing knowledge on how better the ICT infrastructure can be utilised to support effective implementation of DH solutions.

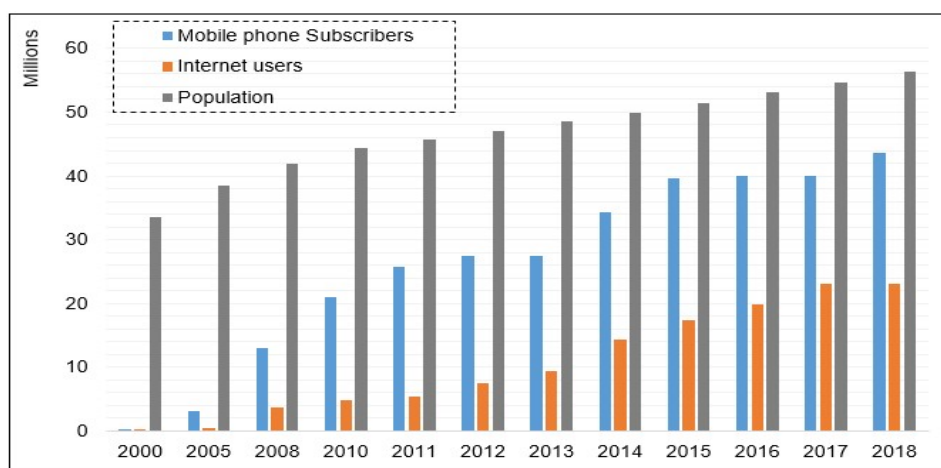
Figure 1: Growth of teledensity in Tanzania and neighbouring countries, 2000 to 2018



Source of data: (The World Bank, 2019b)

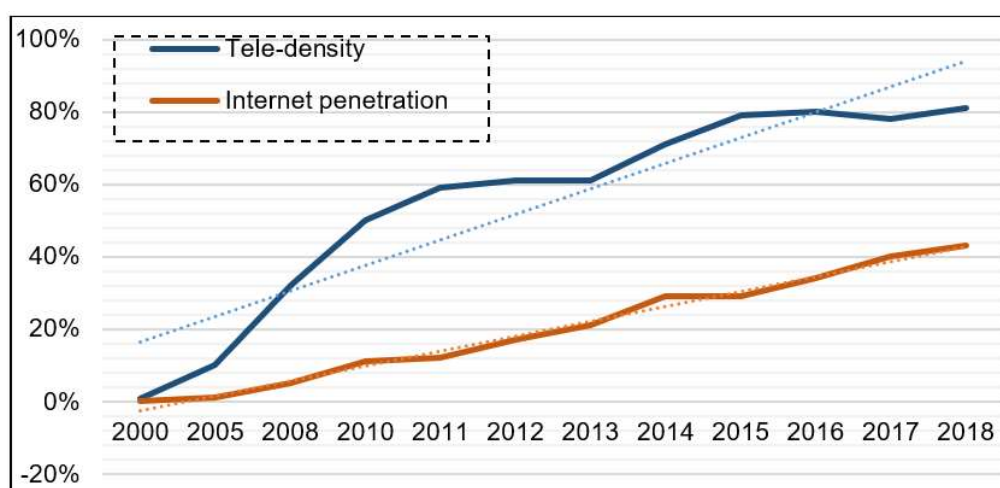
For example, Tanzania delayed making progress in embracing the potential of ICT solutions due to government prohibition on usage and importation of computers, televisions and other electronic technologies for nearly two decades (Mambo, 2001; Mgaya, 1994; MoCT-Tanzania, 2003; Shila, 1994). However, enormous strides have been made from the year 2000. The number of mobile phone providers increased from three in 2000 to seven in 2018 and subscribers and internet users increased from about 111,000 and 39,000 to 43M and 23M respectively (MoCT-Tanzania, 2016b; TCRA, 2018). Figure 2 indicates the trend of mobile phone subscription and internet usage and Figure 3 shows the corresponding penetrations.

Figure 2: Growth of mobile phone subscribers and internet users in Tanzania



Data source: (TCRA, 2018; 2019a; The World Bank, 2019b)

Figure 3: Growth of mobile phone network and internet penetrations in Tanzania



Source of data: (TCRA, 2018; The World Bank, 2019a)

1.5. Background and context

1.5.1. The situation of communicable diseases in SSA

The SSA is a region with 48 different countries characterised by, inter alia, the similarity in the level of development (developing countries) and the burden of diseases (The World Bank, 2018). The region is the origin of many communicable diseases accounting for about 75% of all causes of illness and 50% cause of all deaths (Fenollar and Mediannikov, 2018; Kwesigabo et al., 2012; Mbugi et al., 2012; Mugabe, 2005; The World Bank, 2013; 2010b; WHO/AFRO, 2014). Table 1 indicates the percentages of total deaths attributed to 6 communicable diseases which are among the leading cause of mortality in SSA for the year 2000 and 2016. Additionally, the region faces epidemic-prone diseases such as meningitis, severe acute respiratory infection (SARI), bloody diarrhoea, typhoid, cholera, and viral haemorrhagic fevers (VHI) such as Ebola (Mugabe, 2005; Wang, H. et al., 2016; 2014; WHO/AFRO, 2016).

Table 1: Percentage of total deaths caused by communicable diseases in SSA

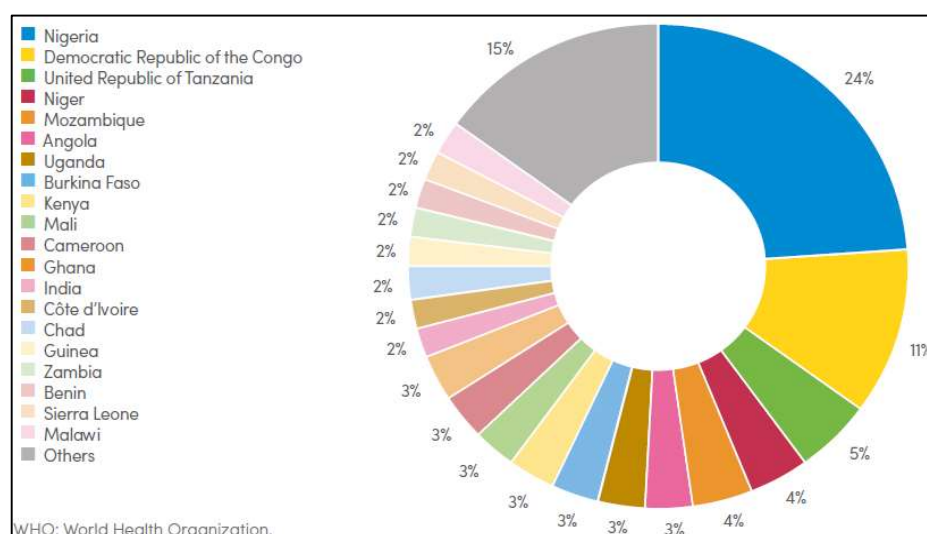
| Communicable disease | 2000 | 2016 |
|------------------------------|-------|-------|
| Lower respiratory infections | 10.6% | 10.4% |
| HIV/AIDS | 12.2% | 8.1% |
| Diarrhoeal diseases | 9.7% | 7.4% |
| Malaria | 7.3% | 4.6% |
| Tuberculosis | 4.0% | 4.6% |
| Meningitis | 2.5% | 2.1% |

Source: Atlas of African health statistics (WHO/AFRO, 2019a, pg.15)

In Tanzania, communicable diseases rank higher among the top ten hospital diagnoses and causes of deaths; and accounting to nearly 70% of mortality for children under 5 years and 36% for 5 years and above (2014; MoH-Tanzania, 2015a). Some of these diseases, such as malaria among endemic diseases and cholera among epidemic-prone diseases, present a pronounced public health threat than others. Up to 93% of the Tanzanian population is at risk of malaria of transmission with prevalence rates range between 1% and 50% across ecological zones (Ifakara Health Institute, 2014; PMI, 2014; USAID, 2018). As indicated in Figure 4, 18 countries in SSA contributed 85% of all malaria deaths worldwide in 2018, Tanzania ranked third with a 5% share (WHO, 2019).

Cholera is leading among epidemic-prone diseases for causing frequent outbreaks in Tanzania, some of them spread nationally with high fatality rates. For example, three major outbreaks were recorded in 1997 (40,249 cases and 2,231 deaths), 2006 (14,297 cases and 254 deaths), and 2016/2018 (more than 33,000 cases and 542 deaths) (McCrickard et al., 2017; Narra et al., 2017; Penrose et al., 2010; Rajasingham et al., 2019; WHO, 2018b).

Figure 4: Countries with nearly 85% of malaria deaths globally in 2018



WHO: World Health Organization.

Source: World malaria report (WHO, 2019c, pg.10)

1.5.2. Efforts to combat communicable diseases in SSA

Effective disease surveillance, preventive and control functions require, *inter alia*, the strengthening of fragile and fragmented health and surveillance systems (Travis et al., 2004; WHO, 2007; 2012; WHO/AFRO, 2001). For this reason, the effect of communicable diseases in SSA countries attracts numerous interventions from within the region and the global community focusing on strengthening health systems (APHA, 2008; Baingana and Bos, 2006; Nsubuga et al., 2009; Travis et al., 2004; WHO/AFRO, 2001). Tanzania, for example, has had several initiatives focusing on building health institutions, establishing structures, and consolidating the health information system (HIS) (MoH-Tanzania, 2001; 2011; 2013b; 2015b; 2015d; Rubona, 2001). National health policies have been periodically updated (MoH-Tanzania, 1990; 2003; 2007); health strategic plans are being executed in five years periods (MoH-Tanzania, 2009a; 2015b); and disease-specific and generic surveillance and control programmes have been operationalised (MoH-Tanzania, 2001; 2011; 2015d; 2016b).

At the regional level, the most notable initiative on the fight against diseases has been the Integrated Disease Surveillance and Response (IDSR) strategy. The strategy was developed in the late 1990s by the World Health Organisation Regional Office for African (WHO/AFRO), in collaboration with respective member states to provide technical guidelines for building integrated, action-oriented, and district-focused epidemiological surveillance and response systems (Lukwago et al., 2013; Nsubuga et al., 2009; Perry et al., 2007; Phalkey et al., 2015; WHO/AFRO, 2001; 2010a). The IDSR strategy is built on the idea that surveillance of different diseases involves similar health system structures, processes and personnel, hence the need for harmonisation of methods and tools, such as software, data collection forms, and shared standards; to prevent inconsistent information among multiple disease prevention programmes and stakeholders (WHO/AFRO, 2001). Likewise, it is district-focused to provide an efficient organisational arrangement close to communities for outbreaks preparedness and rapid response (2001; WHO/AFRO, 2010a).

The original IDSR strategy was revised in 2010 to accommodate changes such as the International Health Regulations (IHRs) which focus on preventing, protecting against, controlling and providing public health response to the international spread of diseases; the “One World-One Health” perspective which seeks to address events at the intersection of human, domestic animal, wildlife, and ecosystem health; and the increased number of priority diseases (WHO/AFRO, 2010a). The WHO/AFRO strategy provides a generic framework which is customised by individual member states to suit local surveillance needs, priority diseases, and other organisational arrangements (Nsubuga et al., 2009).

1.5.3. Operationalisation of the IDSR strategy in Tanzania

Tanzania was the first to adopt the IDSR strategy in 2001 and made it operational countrywide as a framework for strengthening the national DSS on prevention, control, eradication or elimination of existing diseases (Gueye et al., 2005; 2001; MoH-Tanzania, 2011; Nsubuga et al., 2009). The DSS operates as a vertical health programme. The latter refers to components of the health system targeting specific health problems and operate with specific objectives, centralised management, standalone information system, and discrete resources (Cairncross et al., 1997).

The DSS is coordinated from the community to the national level. It has 8 core functions which are identifying cases and events; reporting of suspected cases, conditions or events to the next level; analysing and interpreting findings; investigating and confirming suspected cases; early preparedness for possible outbreaks or public health events; public health response; providing feedback; evaluating and improving the DSS. Moreover, there are 4 supportive functions namely communication infrastructure and information dissemination; training and capacity building; supervision and resource management/mobilisation (MoH-Tanzania, 2011).

Tanzania customised the revised WHO/AFRO generic strategy in 2011 into 13 specific objectives and increased the list of priority diseases under surveillance from 13 to 36 which include a new category of non-communicable diseases. Communicable diseases are grouped into three categories based on the nature of their threat to life: epidemic-prone diseases, diseases targeted for elimination/eradication, and diseases of public health importance. Table 62 and Table 63 in appendix H provide the lists and groups of specific priority diseases for the first and the second IDSR strategies respectively.

1.5.4. The IDSR information system component

A functional information system (IS) is pivotal for the operationalisation of disease surveillance and response strategy (Lukwago et al., 2013; Mghamba et al., 2004; Nsubuga et al., 2009; WHO/AFRO, 2001). Studies which have examined the operationalisation of IDSR strategy in Tanzania and elsewhere in SSA, identify several weaknesses of the disease surveillance information systems (DSIS) as among main factors affecting its performance (Adokiya et al., 2015; Gueye et al., 2005; Joseph et al., 2018; Mboera et al., 2001; Mghamba et al., 2004; Nsubuga et al., 2009; Rumisha et al., 2007). Particularly, data capturing, reporting, analysis, use and dissemination practices have been poor at all levels; data are insufficient and of poor quality; information flow is untimely; feedback practices are insufficient, and DSIS operating as a standalone without linkage to the mainstream health information system (HIS). These challenges introduce a significant constraint in outbreaks preparedness, early detection, warning mechanism,

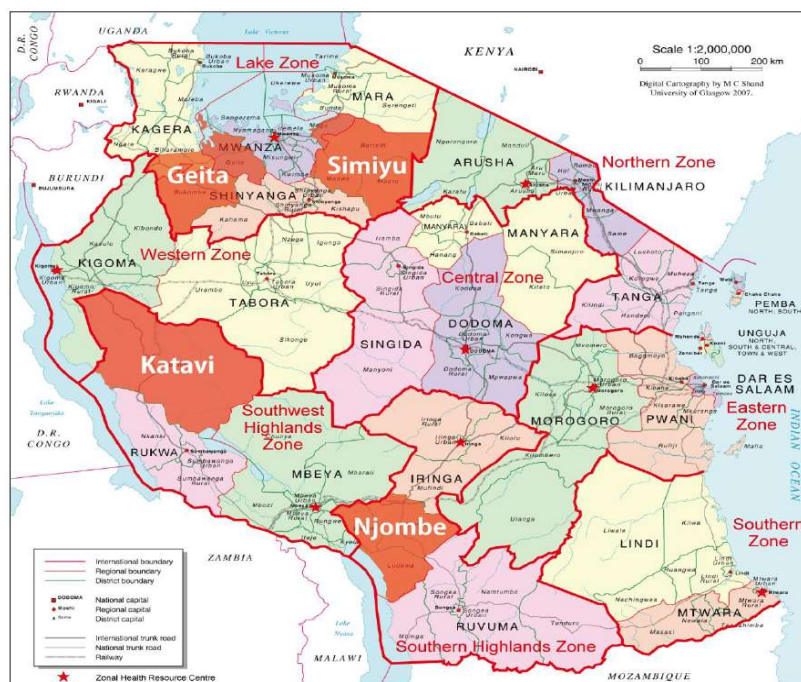
and timely response (Gueye et al., 2006; Mghamba et al., 2004; MoH-Tanzania, 2011; Rumisha et al., 2007). Accordingly, strengthening of DSIS has been a work-in-progress since the inception of the IDSR strategy: one of the four objectives in the original strategy and two in the revised one focus on improving the DSS information component (Grigorev et al., 2014; MoH-Tanzania, 2001; 2011).

Tanzania provided a useful case study to explore and understand implementations of mHealth interventions targeting national diseases surveillance and response functions, adopted in a wider SSA. This is because SSA countries share similar epidemiological features of communicable diseases, district-based DSS, technical guidelines for surveillance and response functions, and socio-economic features determining, inter alia, resources and means by which digital health interventions are implemented (Blaya et al., 2010; Brinkel et al., 2014; Marshall, C. et al., 2013b; MoH-Tanzania, 2001; 2011). Similarly, mHealth interventions in Tanzania and elsewhere in SSA are yet to be supported by concrete evidence of improved health outcomes [discussed in chapter 2].

1.5.5. Tanzanian geographical and administrative structure

The United Republic of Tanzania (referred to as Tanzania in this thesis) is a developing country in East Africa formed in 1964 after the union of Tanganyika (Tanzania mainland) and the Zanzibar archipelago (Figure 5).

Figure 5: Map of Tanzania, geographical zones and administrative regions



Source: MoH Tanzania (2015b)

According to the 2012 census, Tanzania has a population of 55M people of which 96.8% are in the mainland (National Bureau of Statistics, 2014). The country is bordered by the

Indian Ocean and 8 different countries: Kenya, Uganda, Rwanda, Burundi, Democratic Republic of Congo, Zambia, Malawi, and Mozambique. Zanzibar is a semi-autonomous state with its executive president in charge of non-union matters, health sector included. Thus, the union MoH (the focus of this thesis) excludes the political and administrative structure of Zanzibar.

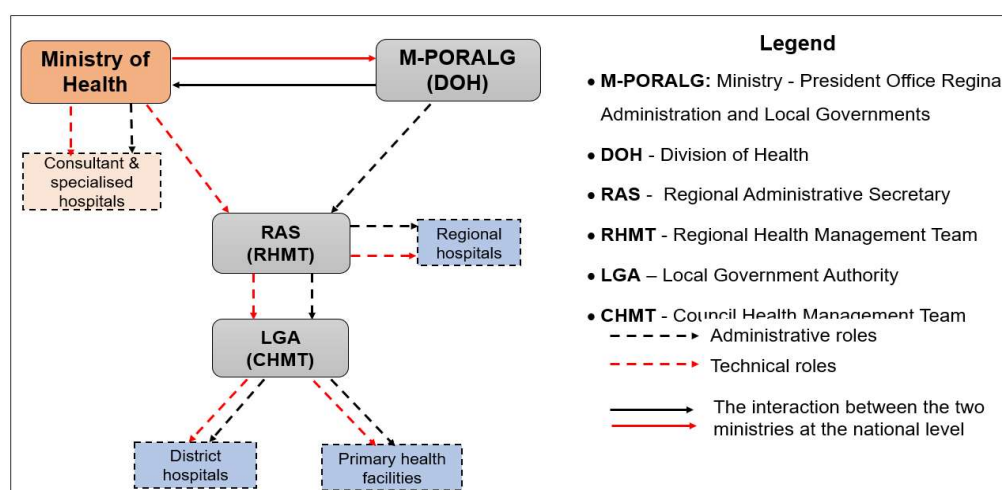
As featured in Figure 5, Tanzania mainland is divided into 8 ecological zones: Central, Eastern, Lake, Northern, Southern, Southern Highlands, Southwest Highlands, and Western. Zones are not administrative units but make important geographical references in describing the country's demographic features, and the distribution of development projects and social services. For example, referral consultant hospitals are distributed zone-wise (MoH-Tanzania, 2015b).

The country has devolved government functions through decentralisation by devolution (National Bureau of Statistics, 2014). There are 27 administrative regions divided into 139 administrative districts with a total of 185 councils (city, municipal, town or district councils) because some districts have 2 councils (PORALG, 2019). Each council is divided into two or more divisions; divisions into wards; wards into villages (rural area) or streets (urban areas); and villages into hamlets. The devolved functions are centrally coordinated under the ministry in president's office responsible for regional administration and local governments (PORALG) (PORALG, 2018). This structure is reflected in the healthcare system as described in the subsequent subsection.

1.5.6. Healthcare delivery system in Tanzania

Healthcare services are coordinated by the MoH and the PORALG (MoH-Tanzania, 2015b). The former develops policies, defines priorities and provides technical guidance to local government authorities (LGAs) and other institutions in the health sector. Also, it delegates some stewardship functions, sets quality standards and mobilises resources (MoH-Tanzania, 2007; 2015b). The PORALG supervises, coordinates, and monitors LGAs activities in planning, delivering, and overseeing social services in conformity with sectoral policies and guidelines (MoH-Tanzania, 2015b). Figure 6 shows the interaction between the MoH and the PORALG in delivering and coordinating healthcare services in regional and LGAs, reflecting the decentralisation by devolution policy of transferring authority and responsibilities from the central governments (Musau et al., 2011).

Figure 6: Management of health services in Tanzania.



Source: adapted from the MoH Tanzania (2015b)

Healthcare services are classified into four categories or levels: primary, regional, zonal and national HFs [Figure 47 in appendix G] (MoH-Tanzania, 2009a; 2015b). In the Tanzanian health system, the term “health facility” refers to consultant, specialised, zonal, regional or district/council hospitals; health centres; dispensaries; maternity homes; and other specialised clinics (MoH-Tanzania, 2015b).

District/council health management teams (D/CHMTs) form the department of health within LGAs structure led by the council / district medical officers (commonly known as DMOs). A CHMT is comprised of a multidisciplinary team of about 10 departmental managers who oversee primary healthcare services provided in primary HFs (PHFs) which include community health posts, dispensaries and health centres; and a district hospital as the first level of hospital services. The regional health management team (RHMTs) form departments of health in the regional administration structure, led by the regional medical officers (RMOs). RHMTs oversees CHMTs and regional hospitals. At the top of the hierarchy are HFs reporting directly to the MoH: zonal referral, specialised and national consultant hospitals.

Table 2: Health facilities in Tanzania mainland by 2015 - types and ownership

| Ownership | Hospitals | Health Centers | Dispensaries | Clinics | Total | % |
|--------------|-------------|----------------|--------------|-------------|---------------|---------------|
| Public | 249 | 635 | 5,987 | 12 | 6,883 | 83.8% |
| Private | 39 | 78 | 1,123 | 93 | 1,333 | 16.2% |
| Total | 288 | 713 | 7,110 | 105 | 8,216 | 100.0% |
| % | 3.5% | 8.7% | 86.5% | 1.3% | 100.0% | |

Source of data: Health Sector Strategic Plan IV (MoH-Tanzania, 2015b)

Table 2 provides a distribution of HFs based on types and ownership by 2015. Public HFs include those owned by the government, parastatals and faith-based organisations (FBOs). By 2017, 13.1% of all HFs and 42.5% of hospitals were owned by FBOs (CSSC-Tanzania, 2017). Under the public-private partnership (PPP) framework, most of the FBOs-owned hospitals in rural areas, are designated as public hospitals, hence partly funded by the government (MoH-Tanzania, 2015).

1.5.7. The mainstream health information system

The mainstream health information-system infrastructure in Tanzania is commonly known “Mfumo wa Utoaji wa Taarifa za Afya (MTUHA)” in Swahili, technically translated as “Health Management Information System (HMIS)”. IT was firstly introduced in 1993 as a hospital or medical records information system (MRIS) at HF level and as a management information system (MIS) at district, regional and national levels (Rubona, 2001). Since 2008, the HMIS has been revised to improve components such as datasets and data elements, capturing tools and reporting frequencies; and building an integrated digital health infrastructure to improve data management, analysis and use (MoH-Tanzania, 2009; Mahundi, 2010; Nyella and Mndeme, 2010; Mahundi et al., 2011; Nyella and Kimaro, 2015).

The HMIS is coordinated from HFs to the national level. There is a health facility HMIS focal person (HMIS-FP) responsible for the collection, management and reporting routine data. HMIS roles can be core responsibilities to a trained medical recorder (in hospitals) or as an additional designated role to clinical personnel in primary HFs (PHFs). At the district/ council and regional levels, there are district and regional HMIS focal persons (DHMIS-FP and RHMIS-FP, respectively). Centrally, HMIS activities are coordinated by the head of the monitoring and evaluation (M&E) section in the MoH who is the assistant director in the Policy and Planning Division (MoH-Tanzania, 2018a).

The HMIS is a paper-based in HFs where patient records are captured in HMIS register books. The number of books used in a HF varies from about 5 to 15 depending on its size/capacity. Records are aggregated into monthly summary reports and submitted to the district. Death records are submitted daily as identifiable records. At the district level, HF reports are entered into the web based DHIS2 database on which data are accessible by all levels of the health system. HFs with computers and internet connection (mostly hospitals) may enter their reports directly into the DHIS2, hence avoiding manual reporting to the district. HMIS is not used in specialised and consultant hospitals since they have different reporting mechanism directly to the MoH. The HMIS is the main source of disease surveillance data, extracted from several register books, as listed in Table 3, but mainly OPD and IPD books (MoH-Tanzania, 2011)..

Table 3: HMIS register books- data sources of diseases under surveillance.

| S/n | HMIS register books at health facilities | Type of captured records |
|-----|--|---------------------------------------|
| 1 | HMIS_ Outpatient Department (OPD) | All records at outpatient clinic |
| 2 | HMIS_ Inpatient Department (IPD) | Records of hospitalized patients |
| 3 | HMIS_ Death Registry | Captured all deaths |
| 4 | HMIS_ Antenatal Clinic (ANC) | Records of pregnant women |
| 5 | HMIS_ Labor and delivery (L&D) ward | Records in labour and delivery |
| 6 | HMIS_ Diarrheal Treatment Corner (DTC) | Diarrhoea for children < 5 years with |
| 7 | HMIS_ Child Health | Records at pediatric clinics |
| 8 | HMIS_ Laboratory | Lab test requests and results |
| 9 | MNCP_ Malaria laboratory test | Lab malaria test requests and results |

Source: (MoH-Tanzania, 2018).

1.5.8. Policy frameworks

The first national ICT policy in Tanzania was operationalised in 2003, to provide an enabling framework for ICTs to facilitate achievement of national development goals (MoCT-Tanzania, 2003). Before this policy, ICT and other electronic technologies were guided and regulated through the 1997 National Telecommunications Policy in which ICT was included as a component (MoCT-Tanzania, 1997).

The operationalisation of the ICT policy led to technological leapfrogging from a poorly digitised economy to an economy open and connected to the rest of the world through major ICT infrastructures, research and human capital development (MoCT-Tanzania, 2016b). The country is connected to the rest of the world through satellites and two major submarine cables; linked to five neighbouring countries through the national fibre-optic cable network; and regional capitals and some districts are connected (2016a; MoCT-Tanzania, 2016b). Also, the growth of the ICT sector increased from 17.4% in 2004 to 22.8% in 2013 (MoCT-Tanzania, 2016a)

The ICT policy was revised in 2016 to reposition the country's ICT landscape to meet the changing needs; adopting emerging technologies; optimising the potentials and opportunities provided by ICT for socio-economic development; and dealing with threats attributed to the technology (MoWTC-Tanzania, 2016). It acknowledges ICT as a leveraging economic-driver and enabler for delivering better social-services to the citizenry. Several strategic objectives were set focusing on transforming and advancing research and development; improve government operations; linking the government with the private sector and integrating the services of various ministerial departments and agencies. Likewise, regulations and legal frameworks have been introduced to promote electronic communication, ensure consumers' protection, address cybersecurity, enable

electronic sources usage for legal evidence and facilitate universal communications services access (MoCT-Tanzania, 2016a; 2016b).

Several institutions have been established to oversee, regulate, and implement different aspects of ICT frameworks. They include the national eGovernance agency (eGa) which coordinates ICT innovations usage in government departments and agencies and sets standards for technologies integration and interoperability; Tanzania Telecommunication Regulatory Authority (TCRA); and the ICT incubator for stimulating innovations and investment in ICT (MoCT-Tanzania, 2016b; POPSM-Tanzania, 2013).

Implementation of digital health solutions is supported by the National Health Policy and Health Sector Strategic Plans three (HSSPIII) (MoH-Tanzania, 2007; 2009a; 2015d). In an effort to streamline and standardize existing and future DHIs, the national eHealth strategy was introduced in 2013 to integrate ICT infrastructure and applications into the health sector (MoH-Tanzania, 2013a). The strategy promotes, among its strategic objectives, the adoption of mHealth solutions for patients care, services delivery, data capturing, and diseases surveillance. The eHealth strategy was revised in 2019 into a digital health strategy focusing on accelerating increased access and improved quality of effective and efficient healthcare through the application of strategic digital health technologies such as eIDSR (MoH-Tanzania, 2019).

1.5.9. Digital health infrastructure

The MoH has so far implemented several digital health solutions using the District Health Information System (DHIS2) as a centralised database for routine health data. DHIS2 is a web-based open source HIS software developed and promoted by the HISP research group at the University of Oslo for strengthening HIS in developing countries; currently implemented in more than 40 countries in SSA, Asia and Latin America (Adu-Gyamfi et al., 2019; HISP, 2018). In Tanzania, DHIS2 is implemented to scale as a national HIS database since 2014 (MoH-Tanzania, 2013a; University of Oslo, 2018). The system has a built-in interoperable design that provides linkage opportunities with other solutions such as electronic medical records (EMR) and other digital health solutions (HISP, 2018; MoH-Tanzania, 2018b; University of Oslo, 2018).

Other initiatives implemented at the national scale include Health Facilities Registry (HFR) as an online web-based portal for information about approved HFs; Training Institutions Information System (TIIS) for managing health training institutions; the HMIS Web portal that gives the public access to approved health statistics; Human Resource for Health Information System (HRHIS) for capturing identifiable records of personnel in the health sector; and electronic Logistic Management System (eLMS) (Ishijima et al., 2015; MoH-Tanzania, 2018b).

1.6. Structure of the thesis

This thesis is organised into nine chapters. Chapter 2 discusses the literature review of related work. It gives a critical view on issues around implementations and evidence of mHealth interventions in SSA and implementation effectiveness of mSurveillance interventions. Also, a research gap attended in this thesis is established. Chapter 3 describes the philosophical assumptions guiding the current research; develops a conceptual framework, and outlines the methodological approach employed for data collection and analysis.

The first objective is addressed in chapter 4 and 5. Chapter 4 sets the scene by discussing the adoption of the eIDSR intervention in view of technological organisational changes. The context, contents and technological design of the eIDSR change initiative are discussed. Chapter 5 discusses the eIDSR implementation approach, process and practices from piloting deployment up to nearly 50% coverage of all HFs in the country.

Chapter 6 addresses the second objective. It examines the value and accuracy of clinical records captured in HFs before being reported through eIDSR to substantiate the relevance of the change anticipated through eIDSR.

The third objective is addressed in chapter 7 and 8. Chapter 7 examines the value added by eIDSR usage on data quality. Chapter 8 examines the influence of eIDSR usage on data analysis and use practices.

Chapter 9 provides an overall discussion of amalgamated results presented in results chapters. Likewise, it addresses the fourth objective by providing recommendations for effective implementation of eIDSR-related interventions in SSA.

1.7. Chapter summary

This chapter has provided an introduction and background of the thesis. It has identified the originality and direction of the thesis; set out the research aim and objectives; described the rationale of developing this thesis; and described the research setting.

The next chapter discusses the related work focusing on implementations and evidence of mSurveillance interventions in SSA. Likewise, it establishes the research gap shaping the direction of this thesis.

CHAPTER 2

Literature Review

2.0. Introduction

This chapter summarises the literature on mHealth interventions implemented in the SSA to serve four purposes, reflected in the structure of the chapter. Firstly, to review types of mHealth interventions in the SSA. Secondly, to identify and critically review the implementation of mHealth interventions focusing on diseases surveillance (mSurveillance). Thirdly, to examine the implementation effectiveness of mSurveillance interventions for national diseases surveillance. Fourthly, to synthesise the review and establish research gap(s).

2.0.1. The focus and reviews methods

The present review consulted three types of studies searched in academic databases. First, studies providing a general overview of mHealth initiatives in SSA context. Second, studies about implementation of mSurveillance interventions in SSA. Third, studies providing a theoretical perspective through which factors affecting mHealth implementation effectiveness are discussed. Relevant articles in the third group were searched systematically using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. This was meant to objectively and exhaustively identify relevant information about mSurveillance implementation effectiveness in SSA; from which a research gap was established.

The literature search was guided by four main concepts: technology (mHealth solutions); mHealth application domain (communicable diseases surveillance); context (developing countries in SSA) and theme (implementations). A search of the literature on the implementation of digital health interventions for diseases surveillance in the context developing countries was done on academic databases, Google Scholar and Google search engine. Thereafter, titles and abstracts of identified articles were scanned to identify common terms and keywords related to the four concepts of interest. Most of the relevant search terms were collected from systematic reviews on implementation of digital health systems in developing countries because they analyse several related studies. The relevant search terms used for the systematic search of the literature are listed in Table 4 under the four main concepts.

Table 4: Terms used for systematic literature search

| Subject | Technology | Health domain | Context |
|--|--|---|--|
| implement* effective* success* evidence outcome* impact* intervention* initiative* solution* | mHealth m-health mobile health technolog* SMS message* text* app* smartphone* eIDSR digital | communicable disease* infect* contagious outbreak* IDSR* integrate* surveillance* priority malaria cholera control prevention eradication elimination ncd* non-communicable | developing countr* world Africa* Sub-Sahara* Imic* low middle income poor resource* limited setting* |

The literature search was done on the Web of Science, Scopus and Medline databases. mHealth and other DHIs implemented in SSA are considerably documented in different formats such as working papers, reports, policies, conference papers, books and guidelines; by governments, multilateral organisations and non-governmental organisations supporting healthcare systems in the region. Thus, besides the systematic search in academic research databases, a snowballing search was used to identify more sources on the Google search engine and Google scholar. The systematic search was done in 2017 and search terms were updated and rerun in March 2020. The inclusion criteria for selected studies were:

- targeting communicable disease surveillance-related functions,
- written in English and published between the year 2000 to 2020 subject to the growing trend of ICT infrastructures in SSA presented in chapter 1.
- exclusively reported from SSA or developing countries wherein SSA is included,
- focusing on implementation perspectives such as effectiveness, adoption, success, evidence, outcomes, challenges, evaluations, scaling, piloting and feasibility,
- reported in any format (such as reviews, reports, official webpages, conference abstracts, or technical guidelines). Also, mHealth systematic reviews covering communicable diseases surveillance in SSA, exclusively or otherwise, were included.

Studies were excluded from the review if do not cover mHealth implementation aspects in SSA or they focus on mHealth interventions for non-communicable diseases.

2.0.2. Literature search results

Figure 7: PRISMA Diagram – articles searching and inclusion process

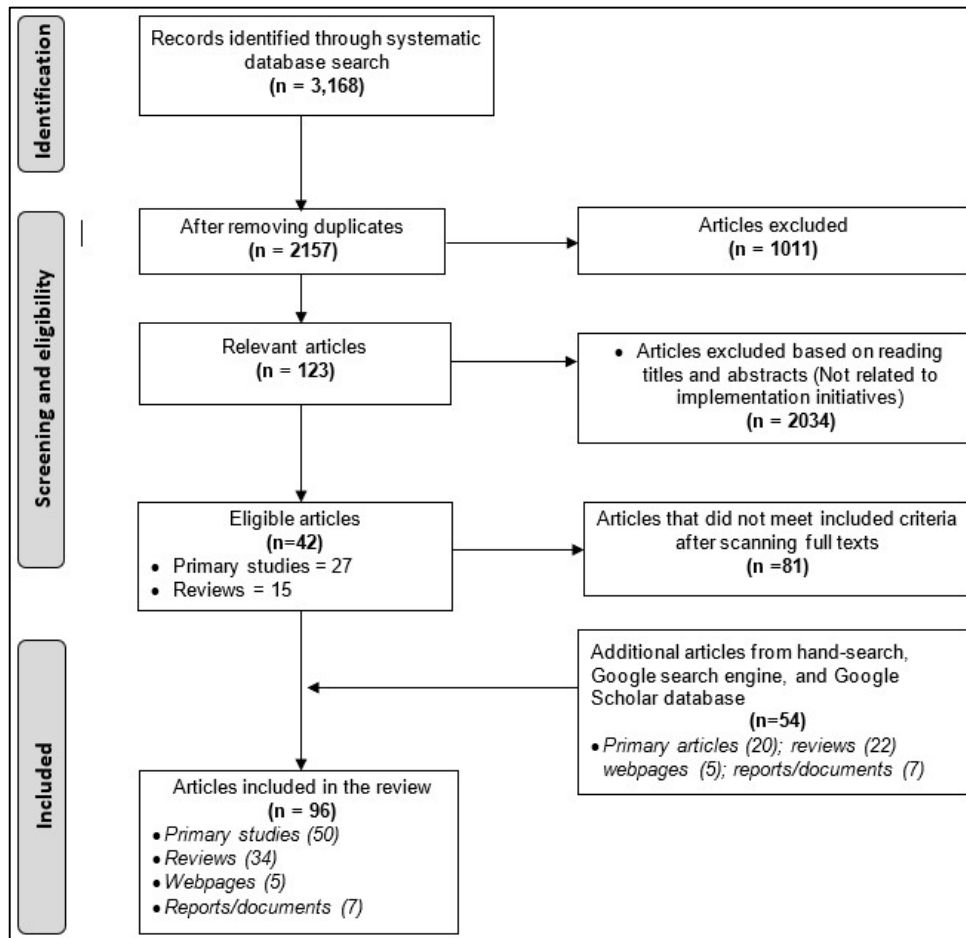


Figure 7 is a PRISMA diagram summarising search results and number excluded and include studies. A total of 3,168 articles were identified in which 1,011 were duplicates. From 2,157 remaining articles, 2,034 were excluded based on reading titles and abstracts. Full-text reading was done, and 42 articles were selected of which 27 articles were primary studies (7 being conference abstracts) and 15 were systematic reviews and other types of reviews. Only 4 reviews exclusively focus on public health surveillance (not all are exclusively in SSA) while the rest combine surveillance with other mHealth application domains. Additional search from Google search engine, Google scholar, and hand-search resulted in 52 additional articles of which 30 are primary studies (peer-reviewed and grey literature) and 22 are reviews on implementations of mHealth in SSA. In most of the systematic reviews, surveillance-related functions were covered as a section and discussed in combination with other mHealth application domains. A total of 96 articles were used to review the implementation effectiveness of mSurveillance interventions in SSA discussed in section 2.4.

2.1. The categorisation of mHealth interventions

The analysis of mHealth studies revealed that mHealth interventions can be categorised using three main criteria. First is the categorisation based on the types of applied mobile communication technologies. These include social-media applications such as WhatsApp; short message services (SMS) text messages; geographic information systems (GIS); Unstructured Supplementary Service Data (USSD) communication protocol; internet supported applications; mobile application (apps); phone calls; multimedia, and voice note (Agarwal et al., 2016a; Davis et al., 2016; Tom-Aba et al., 2015). These technologies determine the types of mobile devices to be used. For example, mobile apps are feasible through smartphones and other internet-enabled portable devices (Davis et al., 2016; Perrier et al., 2015) while SMS-based solutions can be deployed using any mobile phone irrespective of specifications (featured and smartphone) or models (Perrier et al., 2015).

Second is the categorisation based on health programmes or application domains to be supported by mHealth interventions (Abaza and Marschollek, 2017; Krah and de Kruijf, 2016; Labrique et al., 2013). These include health monitoring and promotion (Abaza and Marschollek, 2017); supply chain management, decision support systems, education, training, behavioural change, vital registration, data collection and reporting (Aranda-Jan et al., 2014; Asangansi et al., 2013; Labrique et al., 2013); disease prevention, control or surveillance (Aranda-Jan et al., 2014; Brinkel et al., 2014; Déglise et al., 2012a; Déglise et al., 2012b); self-management/ personalised care, immunisation, reminders for medication compliance, clinic attendance, or treatment regimens (Agarwal et al., 2016a; Aranda-Jan et al., 2014; Krah and de Kruijf, 2016); emergency and disaster response (Betjeman et al., 2013; Tom-Aba et al., 2018a) .

The third is the types of communication approaches by which mHealth solutions bridge communication gaps between its users. They include one-way communication in which information is sent to beneficiaries or the mHealth application without interacting with the source of data or the health intervention team (eg. health promotion, reminders or data collection); two-way communication enabling interaction between individuals and health intervention team (eg. personalised healthcare); making calls; or interaction between users and an mHealth application through means of providing feedback or answers to user questions such as quizzes (Déglise et al., 2012b; Hounmanou et al., 2016; Krah and de Kruijf, 2016; Marshall, C. et al., 2013a).

Notwithstanding the categorisation above, different strategies can be applied in a single mHealth intervention, hence using more than one technologies, target more than one health application domains or employ more than one communication approaches (Abaza

and Marschollek, 2017; Francis et al., 2017; Tom-Aba et al., 2018a). Likewise, there are mHealth interventions integrated into other digital health (DH) solutions such as web-based databases to facilitate data storage, integration, analysis or presentation (Ayebazibwe et al., 2019; Mbelwa et al., 2019; Tom-Aba et al., 2018a). The next section explores mHealth interventions implementation in the context of SSA irrespective of the categorisation in order to provide the context in which mSurveillance interventions are implemented.

2.2. The mHealth space in the context of SSA

mHealth interventions are increasingly implemented in SSA for a wide range of health application domains using different communication technologies. Implemented interventions predominantly use featured mobile phones as compared to smartphones, tablets or other mobile devices (Abaza and Marschollek, 2017; Kim et al., 2017; Krah and de Kruijf, 2016; Perrier et al., 2015). The preference is attributed to three factors. First is the rapid growth of mobile phones network penetration and subscription in the region (Deloitte, 2014; Leon et al., 2012; O'Donovan and Bersin, 2015). Second, built-in mobile phone communication protocols such as SMS and USSD give a wide choice of devices because they are not limited to phone models or specifications (Brinkel et al., 2014; Déglise et al., 2012a; Déglise et al., 2012b; Kruse et al., 2019; Lemaire, 2013; Perrier et al., 2015; Zhou et al., 2015). Third, SMS and USSD protocols provide cost-effective approaches to reach large audiences because they enable direct and instant communication with individuals without the need for internet connectivity (Abaza and Marschollek, 2017; Brinkel et al., 2014; Déglise et al., 2012a; Déglise et al., 2012b; Perrier et al., 2015). Fourth, advanced devices such as tablets are expensive and require relatively advanced skills to use sophisticated applications installed in them (Adeoye et al., 2017; Danquah et al., 2019; Francis et al., 2017).

Fundamentally, mHealth studies reported from SSA focus on implementation feasibility, design, acceptability, user satisfaction and potential benefits of mHealth solutions to address health system challenges (Agarwal et al., 2015; Blaya et al., 2010; Krah and de Kruijf, 2016; Labrique et al., 2013; Marshall, C. et al., 2013a; Mbelwa et al., 2019; Tom-Aba et al., 2018a). While these features are desirable to inform implementation initiatives, they do not attract attention for research, much as it is for the focus on strengthening the quality and quantity of the evidence base (Agarwal et al., 2015; Agarwal et al., 2016b; Aranda-Jan et al., 2014; Brinkel et al., 2014; Déglise et al., 2012b; Labrique et al., 2013; Leon et al., 2012; Piette et al., 2012; van Velthoven et al., 2013) and factors influencing effective implementation initiatives (Bardosh et al., 2017; Krah and de Kruijf, 2016; Leon et al., 2012). The latter is the focus of the current review, hence discussed in the subsequent sections.

2.3. Implementation of mSurveillance interventions in SSA countries

The nature of communicable diseases in SSA requires good quality and real-time information to understand the epidemiological dynamics and support effective surveillance control, treatment, prevention, outbreaks preparedness, and response functions (Fall et al., 2019; WHO/AFRO, 2015). mSurveillance solutions have shown to have the potential to improve such functions (Brinkel et al., 2014; Githinji et al., 2014; Lemaire, 2013; Malila et al., 2019; Mechael et al., 2010; Vasudevan et al., 2016). They present a considerable advantage in data capturing, reporting, and transmission; reducing data transmission delays and error rates; and reaching large populations during outbreaks for alerts and public health education (Déglise et al., 2012b; Krah and de Kruijf, 2016; Malila et al., 2019; O'Donovan and Bersin, 2015; Pascoe et al., 2012; Qiang et al., 2012; Tom-Aba et al., 2018a; Tom-Aba et al., 2015; Tom-Aba et al., 2018b). Likewise, mSurveillance interventions can potentially facilitate providing supervisory support, real-time feedback, contact tracing and communication between managers and surveillance officers at the community level (Francis et al., 2017; Hampshire et al., 2017; Madon et al., 2014; Tom-Aba et al., 2015; Vasudevan et al., 2016). Functionally, they enhance the ability of DSS to detect, report and respond on time to threatening diseases and other health conditions (Fall et al., 2019; WHO/AFRO, 2015).

mHealth reviews identify limited implementation of mSurveillance interventions reported from SSA (Aranda-Jan et al., 2014; Brinkel et al., 2014; Déglise et al., 2012b; Krah and de Kruijf, 2016; Marshall, C. et al., 2013a; Ouedraogo et al., 2019). The limitation is attributed to underreporting of implementation initiatives in the peer-reviewed literature (Tom-Aba et al., 2018a). Some of the reported interventions seem to be implemented exclusively for surveillance purposes while others combine surveillance with other applications such as remote data collection, stock level management, treatment adherence, malnutrition or maternal health (Asiimwe et al., 2011; Brinkel et al., 2014; Francis et al., 2017; Huang et al., 2017; Krah and de Kruijf, 2016; Marshall, C. et al., 2013a; MoH-Uganda, 2012). Suggestively, this approach is attributed to the need for optimising adopted mHealth solutions to address as many challenges facing health systems as possible (Lee, S.H. et al., 2016; MoH-Uganda, 2012; Peter et al., 2016; UNICEF, 2016).

2.3.1. Diseases and technological focus of mSurveillance interventions

The mSurveillance interventions in SSA are implemented either for one or multiple diseases. The former is prevalent for disease-specific control programmes and epidemic outbreak responses (Madon et al., 2014; Martindale et al., 2018; Mwingira et al., 2017; Tom-Aba et al., 2018a), while the latter is commonly for interventions implemented to reinforce or complement IDSR functions at the national scale (Adeoye et al., 2017;

Asiimwe et al., 2011; Lemaire, 2013; MSH-Rwanda, 2018; Pascoe et al., 2012; Randriamiarana et al., 2018). Prominent diseases prioritised for mSurveillance interventions include malaria, avian influenza, HIV/AIDS, tuberculosis, dengue, ebola, cholera, dysentery, animal bites, measles and neglected tropical diseases (Adeoye et al., 2017; Aranda-Jan et al., 2014; Asiimwe et al., 2011; Brinkel et al., 2014; Chib et al., 2015; Danquah et al., 2019; Déglise et al., 2012b; Francis et al., 2017; Githinji et al., 2014; Lemaire, 2013; Madon et al., 2014; Martindale et al., 2018; Tom-Aba et al., 2018a). In this list, Ebola and malaria are more noticeable in mHealth studies from SSA.

During the Ebola outbreak in West Africa, mSurveillance solutions extensively implemented to facilitate mass education, outbreak preparedness, response and control (Otu et al., 2016; Tom-Aba et al., 2018a; Yavlinsky et al., 2020). Also, for capturing and reporting Ebola cases, contact tracing, mapping outbreaks, providing reference material and guidelines to frontline healthcare workers (FHWs), case management, transmitting laboratory results, and enabling rumours reporting from the community (Cáceres et al., 2016; Dahiya and Kakkar, 2016; Danquah et al., 2019; IBM, 2014; O'Donovan and Bersin, 2015; Sacks et al., 2015; Tom-Aba et al., 2015; Tom-Aba et al., 2018b; Yavlinsky et al., 2020). Similarly, malaria interventions focus on improving data collection and reporting; household surveillance; cases detection, notification and management; treatments; residual spraying and vectors control (Alidina et al., 2014; Asiimwe et al., 2011; Bervell and Al-Samarraie, 2019; Eskenazi et al., 2014; Francis et al., 2017; Githinji et al., 2014; Hamainza et al., 2014; Jones, C.O.H. et al., 2012; Kaunda-Khangamwa et al., 2018; Mangam et al., 2016; Ouedraogo et al., 2019; Vasudevan et al., 2016).

The community level is the main source of disease surveillance data (WHO/AFRO, 2010a). Thus, mSurveillance solutions are largely used by FHWs in HFs or village/community healthcare workers (CHWs) reporting data from households (Brinkel et al., 2014; Francis et al., 2017; Hall et al., 2014; Lemaire, 2013; Madon et al., 2014; Mangam et al., 2016; Nanyombi and Ejiri, 2016; Shuaib et al., 2018). Application for reporting suspected epidemics in the community is being through controlled studies and randomly by collecting data from community members (crowdsourcing surveillance data) allowing them to report rumours of suspected epidemic cases such as during the Ebola outbreak (Adeoye et al., 2017; IBM, 2014; Karimuribo et al., 2017; Nanyombi and Ejiri, 2016).

Two-way communication approaches are prominent in providing instant feedback messages to users or delivering directives during outbreaks (Brinkel et al., 2014; Déglise et al., 2012b; Ngwa et al., 2016). One-way communication approach is also used when the interest is to allow FHWs, VHWs or the general public to submit surveillance data without feedback (Francis et al., 2017; Githinji et al., 2014; IBM, 2014; Pascoe et al.,

2012; Tom-Aba et al., 2018a). Also, there are project-initiated communications in which messages are sent in bulk to a specific population or tailored for vulnerable people (Déglise et al., 2012a). One study reports experimentation of technologically advanced approach to capture surveillance data using optical and smartphone embedded sensors (crowdsensing) to overcome limitations of conventional epidemiological surveillance (Edoh, 2018). However, SMS-based interventions are more prevalent for all types of mSurveillance interventions (Abaza and Marschollek, 2017).

The features above are largely for mSurveillance interventions implemented either for disease-specific programmes or in response to epidemic outbreaks. The next section discusses the implementation of mSurveillance interventions adopted to support national disease surveillance systems.

2.3.2. Implementation of mSurveillance interventions at the national scale

In realising the potential for DHIs to improve diseases surveillance, the WHO/AFRO (2015) put in place structure and strategy for advocating, leading, guiding and providing technical support to SSA countries to implement digital solutions in line with the IDSR framework, DH strategies and other related protocols. As of 2019, about 70% of SSA countries were reported to be implementing or scaling up some form of DHIs to enhance national disease surveillance and response functions (Fall et al., 2019; WHO/AFRO, 2019c). In the present review, these DHIs for surveillance purpose are referred to as eIDSRs, reflecting the underlying IDSR technical guidelines for nations DSS (Fall et al., 2019; WHO/AFRO, 2019c). The next sub-section examined the progress of implementations of eIDSRs.

Despite the reported number of countries implementing eIDSRs, few interventions are reported in the public domain (Fall et al., 2019), a feature common for mHealth interventions implemented across mHealth application domains in SSA. The WHO-recommended guidelines for mHealth evidence reporting and assessment checklist (Agarwal et al., 2016a) are illustrative. Countries implementing mSurveillance solutions at the national scale are giving them different names such as mTrac in Uganda; mSOS in Kenya; eIDSR in Tanzania and Sierra Leone; TRACnet in Rwanda; SORMER in Nigeria and Ghana; DHIS2 in Guinea; and reinforced in Madagascar.

The information in the public domain shows only Rwanda, Uganda and Sierra Leone have reported having achieved full-scale implementations, capturing all priority disease and conditions under surveillance (Gleason et al., 2019; Kizito et al., 2013; Martin et al., 2020; MoH-Uganda, 2012; MSH-Rwanda, 2018; Thierry et al., 2014; UNICEF, 2016). The eIDSRs capture data for 24 diseases in Rwanda and 26 in Sierra Leone, in Uganda the actual number is not provided. Additionally, the Ugandan eIDSR is used for stock

management in HFs; malaria case management; and for unanimous reporting of any health service deliver issue from the public using toll-free SMS messages (Huang et al., 2017; UNICEF, 2016; Waiswa and Okello-Obura, 2014). Using the same model, Tanzania is scaling up an eIDSR capturing about 23 priority diseases and conditions under surveillance (Mbelwa et al., 2019; PMI, 2014; PMI Tanzania, 2018).

Reported eIDSR interventions from other countries are either pilot projects or ongoing scaling up implementations complementing or operating parallel to the conventional IDSR paper-based system (Fall et al., 2019). For example, eIDSR is being scaled out in Guinea but only for capturing weekly aggregated data at the district level using DHIS2 because a case-based module is yet to be implemented (Reynolds et al., 2019). In Ghana, Nigeria and Liberia, eIDSR interventions have passed piloting stages, but they have not yet included all priority diseases under surveillance nor achieved full-scale implementation (Adeoye et al., 2017; eHealth Africa, 2018; GHPC, 2020; SORMAS, 2019; Tom-Aba et al., 2018a; Tom-Aba et al., 2018b). Madagascar is scaling up an intervention capturing all priority diseases (Rajatonirina et al., 2012; Randriamiarana et al., 2018) while Benin has reported a feasibility study for eIDSR implementations (Hounmanou et al., 2016). The implementation status of the Kenyan eIDSR is unclear because it was reported for the last time in 2017 when plans were underway for scaling up (Toda et al., 2017).

Besides mHealth, eIDSRs are implemented using other DH technologies. For example, the eIDSR in Rwanda, Sierra Leone, Nigeria, Uganda and Ghana integrated mHealth technologies such as SMS, USSD or mobile Apps, and web for data capturing; SMS and emails for alerts and report submission reminders; and DHIS2 for data storage, analysis and visualisation (GHPC, 2020; Gleason et al., 2019; Martin et al., 2020; MSH-Rwanda, 2018; Tom-Aba et al., 2018b). Other interventions employ either mobile app, SMS or the web-based DHIS2 (El-Khatib et al., 2018; Ngwa et al., 2016; Randriamiarana et al., 2018; Reynolds et al., 2019). Thus, eIDSR interventions deploy a combination of mobile and immobile devices.

Implementation of eIDSRs seem to share two similar features. Firstly, the web-based DHIS2 is used as a data storage database integrating surveillance data with other routine healthcare data (eHealth Africa, 2018; GHPC, 2020; Huang et al., 2017; MoH-Uganda, 2012; MSH-Rwanda, 2018; Reynolds et al., 2019; SORMAS, 2019; Tom-Aba et al., 2018a). The integration of eIDSRs into the DHIS2 signifies the database is increasingly becoming a HIS standard database in SSA (Ayebazibwe et al., 2019; HISP, 2018), hence useful and potential for standardising and replicating adopted eIDSR technologies and application designs.

Secondly, all eIDSRs initiatives are not introduced as part of the national DH strategies, but as donor-funded interventions (MSH-Rwanda, 2018; Ngwa et al., 2016; PMI, 2014; Randriamiarana et al., 2018). Also, the initial versions were implemented for disease-specific health programmes (Toda et al., 2017; Toda et al., 2016) or as tools in response to epidemic outbreaks such as Ebola (Adeoye et al., 2017; GHPC, 2020; Huang et al., 2017; UNICEF, 2016). Thus, none of the reported interventions attributes eIDSR implementation to national digital health strategy and how they are strategically designed to be sustainable and free from donor support.

2.4. The implementation effectiveness of eIDSR interventions

Theoretically, the adoption of DH solutions in healthcare systems falls under implementation science, particularly in innovation adoption and implementation in organisations. Therefore, the present review employs the organisational perspective of innovations to discuss implementation effectiveness of eIDSR interventions in SSA.

2.4.1. The organisational perspective of innovation implementations

The term implementation is commonly used concerning innovations adoption in organisations (Klein et al., 2001; Klein and Sorra, 1996). Innovation is a new product, technology, practice or service created or introduced by an organisation and innovation adoption is the initial decision made to employ or use an innovation (Klein and Knight, 2005; May and Finch, 2009; Proctor et al., 2011). Thus, innovation implementation is the process of putting to use or integrating innovations in organisational settings (Helfrich et al., 2007; Klein and Sorra, 1996; Nilsen, 2015). Implementation is a transition period during which intended users ideally become increasingly skilful, consistent and committed in their use of innovation such that it becomes an integral part of the organisational business processes (Helfrich et al., 2007; Klein and Sorra, 1996); otherwise, the innovation ceases to be new or is abandoned (Linton, 2002).

The term effectiveness is used to explain the results of innovation adoption (innovation effectiveness) or implementation efforts (implementation effectiveness) (Klein and Knight, 2005). The former is the benefit an organisation receives as a result of implementing an innovation, measured in terms of change in performances such as improvement in health outcomes, accessibility or quality (Klein et al., 2001; Klein and Knight, 2005; Klein and Sorra, 1996; Weiner et al., 2009). Implementation effectiveness refers to the pooled or aggregate consistency and quality of innovation users' usage of an innovative solution and their commitment to consistent and quality of use the solution for designated organisational business processes (Helfrich et al., 2007; Jacobs, S.R. et al., 2015a; Klein et al., 2001).

Innovations may fail for being either fundamentally unsound for a given organisational context or operational challenges or ineffectively implemented (Helfrich et al., 2007; Khandekar et al., 2019; Klein and Sorra, 1996). Studies show that the latter is more likely than the former because organisations tend to adopt innovation beyond their ability to implement (Klein et al., 2001; Klein and Sorra, 1996) hence making frequencies of adopting innovations higher than the rates of successful implementations (Klein and Sorra, 1996). Therefore, though not necessarily a sufficient determinant, implementation effectiveness is a prerequisite attribute for innovation effectiveness (Helfrich et al., 2007; Jacobs, S.R. et al., 2015b; Klein et al., 2001; Weiner et al., 2011).

In the present study, innovation refers to mHealth or DH interventions and organisation refers to healthcare systems or programme, in which mHealth interventions are being implemented. Intended innovation users are individuals in a healthcare system or programme expected to use mHealth solutions or its information output (FHWs and health managers) and those supporting mHealth usage such as technical support team, HF leaders, and health managers (Klein and Sorra, 1996). Thus, mHealth effectiveness is the attainment of anticipated health outcomes following mHealth adoption and implementation effectiveness is aggregated consistency, quality and appropriateness of mHealth use in a given health application domain (Weiner et al., 2009).

2.4.2. The evidence base of mSurveillance implementation effectiveness

The concept of implementation effectiveness of mSurveillance and other mHealth interventions in SSA is not explicitly, exclusively and adequately discussed in the available mHealth literature (Agarwal et al., 2016b; Brinkel et al., 2014; Tom-Aba et al., 2018a). Notwithstanding the emphasise in the literature on the need to improve mHealth implementations initiatives and processes (Agarwal et al., 2016a; Krah and de Kruijf, 2016), and the fact that implementation effectiveness is a precondition for anticipated mHealth gain, the mHealth research is inclined on investigating other implementation outcomes and factors affecting mHealth benefits. Previous studies on innovations adoption establish this problem in implementation research and practice (DeLone and McLean, 2003; Klein and Knight, 2005; Klein and Sorra, 1996), hence a theoretical and empirical gap in examining, understanding, theorising or addressing factors influencing the nature of observed implementation effectiveness of mHealth interventions (Heeks, 2002; Klein and Sorra, 1996; Krah and de Kruijf, 2016).

Nevertheless, mSurveillance implementation effectiveness in SSA can be indirectly judged from the reported evidence base as follows. Firstly, the potential of mSurveillance interventions to improve disease surveillance-related functions is acknowledged (Aranda-Jan et al., 2014; Brinkel et al., 2014; Chib et al., 2015; Dahiya and Kakkar, 2016;

Déglise et al., 2012a; Déglise et al., 2012b). However, the evidence of good quality results is narrowly reported, mostly for disease-specific mHealth intervention mainly implemented for a short time and in small scale (Agarwal et al., 2016b; Aranda-Jan et al., 2014; Brinkel et al., 2014; Dahiya and Kakkar, 2016; Déglise et al., 2012a; Hurt et al., 2016; Krah and de Kruijf, 2016; Labrique et al., 2013; Lemaire, 2013; Piette et al., 2012; Tom-Aba et al., 2018a). The available evidence of interventions implemented to scale for robust national surveillance functions is either unreported, insufficiently reported or weak (Brinkel et al., 2014; Déglise et al., 2012a; Krah and de Kruijf, 2016).

Secondly, reviews that have examined the mHealth evidence base in SSA, do not suggest distinctive implementation features of mSurveillance interventions from other mHealth application domains (Aranda-Jan et al., 2014; Brinkel et al., 2014; Chib et al., 2015; Hall et al., 2014; Krah and de Kruijf, 2016; Kumar et al., 2013; Latif et al., 2017; Lemaire, 2013; Leon et al., 2012; Marshall, C. et al., 2013a; Tomlinson, M et al., 2013). They are all subjected to and influenced by related contextual conditions determining the achievement of anticipated outcomes (Amoakoh-Coleman et al., 2016; Aranda-Jan et al., 2014; Hall et al., 2014; Krah and de Kruijf, 2016). Similarly, related recommendations are given on the need to improve implementation initiatives to increase the likelihood of achieving better results (Amoakoh-Coleman et al., 2016; Aranda-Jan et al., 2014; Brinkel et al., 2014; Free et al., 2013a; Free et al., 2013b; Krah and de Kruijf, 2016; Latif et al., 2017; Lee, S.H. et al., 2016; Marshall, C. et al., 2013a), hence strong evidence base.

Therefore, given that implementation effectiveness is a prerequisite characteristic for achieving mHealth effectiveness (Helfrich et al., 2007; Weiner et al., 2011), it can be argued, mSurveillance interventions in SSA are ineffectively implemented. The evidence is plenty that the increasing motivation to implement mSurveillance is based on the optimism about the capabilities and presumptive benefits of DH solutions as opposed of evidence of improved outcomes (Aranda-Jan et al., 2014; Chib et al., 2015; Krah and de Kruijf, 2016; Leon et al., 2012) Toda, 2017. For instance, the pilot implementation of eIDSR in Kenya was proved to be ineffective, but stakeholders were enthusiastic about scale-up because they believe it would eventually help to contain disease outbreaks and improve surveillance practices (Toda et al., 2017). Also, it can be attributed to external forces such as technological market pressure or donors whose experience of digital intervention implementation might underestimate the influence of contextual factors specific for SSA (Avgerou, 2001).

Available studies reporting eIDSR implementations suggest an improvement in reporting completeness (RC) and reporting timeliness (RT) of disease surveillance data attributed to eIDSRs usage. For instance, Rwanda, Madagascar and Uganda report RC and RT

improvement attributed to eIDSR usage as 100% and 98%; 73% and 47%; and 78% and 68%, respectively (Kizito et al., 2013; Masiira et al., 2019; MSH-Rwanda, 2018; Randriamiarana et al., 2018). Also, Rwanda suggests an improvement in outbreak detection sensitivity and specificity to 100% and 70% respectively (Kizito et al., 2013). In Sierra Leone, RC and reports correctness increased to 74% and 67% respectively (Martin et al., 2020) while data entry time and errors decreased by 63% and 45% respectively (Gleason et al., 2019).

The abovementioned results can be potential indicators of implementation effectiveness because they show the rate in which eIDSRs are consistently used for capturing and reporting surveillance data. Nevertheless, the results are still insufficient to prove effectiveness because the cited studies employ different approaches, study durations, data type, methods, and geographical sizes to measure eIDSR performances. Also, the eIDSRs capture different diseases, number of diseases, reporting frequencies and formats. Some studies cover data captured in a short period from sampled units while others do not state the timeline for data inclusion.

Similarly, the degree in which eIDSRs contribute to the improvement in reporting is unclear because they were deployed alongside other health interventions for improving disease surveillance such intensive training on IDSR technical guidelines and standard case definitions; increased supply of data collections tools, or recruitment of system users (Masiira et al., 2019; Randriamiarana et al., 2018; Toda et al., 2017). In Uganda, for example, there is no significant difference in reporting performance 2004 when using a paper-based system and 2016 when using eIDSR (Masiira et al., 2019). Likewise, there was an improvement in reporting epidemic cases in Kenya, but the response to notification remained suboptimal (Toda et al., 2016). Moreover, most of these results were produced at piloting stage, some of them as conference abstracts without full publications (Alidina et al., 2014; Gleason et al., 2019; Kizito et al., 2013; Oresto et al., 2014; Reynolds et al., 2019; Thierry et al., 2014), probably, to justify the investment case or the need for scaling up. None of the studies reports the impact of eIDSRs on surveillance outcomes.

2.4.3. Assessing determinants of implementation effectiveness

The literature highlights the absence of standardised or dominant theoretical frameworks specific for guiding or explaining implementations of mSurveillance interventions in the context of SSA (Aamir et al., 2018; Chib et al., 2015; Khoja et al., 2013; van Dyk, 2014). The situation is attributed, inter alia, to mSurveillance being an emerging research field; the pace of technological change outpacing the ability to generate quality evidence; the complexity of contextual factors influencing implementation initiatives; lack of

standardised mHealth applications; short time implementations ending up at pilot stage; and the multidisciplinary nature of DH solutions normally combining different approaches, methods, and specialities (Agarwal et al., 2016a; Betjeman et al., 2013; Chib et al., 2015; Tom-Aba et al., 2018a; Tom-Aba et al., 2015).

mHealth solutions are implemented in the healthcare environment which is conceivably a complex adaptive system (CAS): encompasses many parts which interact independently, with varying degrees of complexity, with one another and their environment (Day and Norris, 2008; Tan et al., 2005). Also, CAS has structures and behaviours difficult to understand and exhibiting rapid and unpredictable changes with no apparent pattern (Tan et al., 2005). When mHealth solutions are implemented in this environment they inherently becoming complex systems on their right. They introduce disruptions resulting in changed organisational and individual behaviours, processes, practices, or relationships (Day and Norris, 2008). For such interventions to be effective, a careful process is necessary to coordinate multiple individuals, within and outside healthcare systems required to put them into use (Helfrich et al., 2007; Poole, 2004; Turner et al., 2018).

Therefore, the organisational change theory of innovation implementation provides a relevant framework to examine the implementation effectiveness of mSurveillance interventions (Klein and Sorra, 1996; Weiner et al., 2009). The theory uses concepts and arguments to predict or describe a causal change of events used to put innovations into use and result into an observed pattern of use (Weiner et al., 2009); a de facto indicator of implementation effectiveness. The “organisational framework of innovation implementation effectiveness” is applied to capture key determinants or organisational factors and underlying relationships influencing implementation effectiveness (Helfrich et al., 2007; Klein et al., 2001; Klein and Knight, 2005). It was developed by Klein and Sora (1996), validated in a manufacturing environment (Klein et al., 2001) and has been further validated, applied and revised in multiple studies focusing on implementing complex interventions, mostly in the healthcare system (Harding and Oetzel, 2019; Helfrich et al., 2007; Jacobs, S.R. et al., 2015b; Turner et al., 2018). The present review did not identify its application for implementation of mHealth interventions in the context of SSA. In the subsequent sections, it is used to examine, from reported studies, the implementation effectiveness of mSurveillance interventions in SSA focusing on eIDSRs.

2.4.4. The theoretical framework of implementation effectiveness

The original framework establishes about seven main determinants cumulatively shaping the process and outcomes of innovation implementation (Klein et al., 2001; Klein and Knight, 2005; Klein and Sorra, 1996; Weiner et al., 2009). It posits that implementation

effectiveness of innovations is the function of (i) implementation policies and practices (IPPs); (ii) organisation's climate for innovation implementation; (iii) management support of the innovation; (iv) availability of financial resources; (v) innovation-value fit (vi) learning orientation; and (vii) managerial patience for a long-term time orientation. The validation and application of the framework, mostly in the healthcare domain, (Helfrich et al., 2007; Jacobs, S.R. et al., 2015a; Jacobs, S.R. et al., 2015b; Turner et al., 2018; Weiner et al., 2009) resulted into additional factors such as organisational readiness for change and the role of innovation champions; which are also considered in the present review.

Different relationships are being established between the implementation effectiveness determinants and how they directly or indirectly affecting implementation effectiveness. For example, implementation readiness, management support and availability of financial resources have indirect positive effects on implementation effectiveness through IPPs and implementation climate (Helfrich et al., 2007; Jacobs, S.R. et al., 2015b; Klein et al., 2001; Turner et al., 2018; Weiner et al., 2009). IPPs and champions have an indirect positive relationship on implementation effectiveness through implementation climate (Helfrich et al., 2007; Jacobs, S.R. et al., 2015b) which in turn has a direct positive effect on implementation effectiveness (Klein et al., 2001; Weiner et al., 2009). The innovation-value fit has either a direct or indirect positive effect through implementation climate on implementation effectiveness (Dong et al., 2008; Helfrich et al., 2007; Jacobs, S.R. et al., 2015a; Klein and Sorra, 1996; Turner et al., 2018). A different perspective indicates it modifies the direct positive effect of implementation climate on implementation effectiveness because even when the former is strong, the latter depends on innovation goodness fit with targeted users' values (Weiner et al., 2009). Similarly, implementation effectiveness positively affects values-fit, implementation climate and IPPs because it gives users a sense of return on the effort invested in implementing an innovation, hence the needs for strengthening the IPPs (Helfrich et al, 2007; Weiner et al, 2009).

The factors outlined above are hereunder used to examine the implementation effectiveness of mSurveillance interventions in SSA. The identified implementation factors are not necessarily exclusive for mSurveillance interventions; they apply across mHealth application domains as established in several previous reviews (Brinkel et al., 2014; Déglise et al., 2012a; Déglise et al., 2012b; Krah and de Kruijf, 2016; Marshall, C. et al., 2013a). As established earlier, the literature shows many mSurveillance interventions in SSA are implemented combined with other healthcare application domains.

(1)The readiness of the healthcare system for mHealth change initiatives

Health systems readiness for mHealth change initiatives refers to the extent to which mHealth users (decision makers, implementers and peripheral users) are psychologically and behaviourally prepared to introduce or make changes in health policies and practices to support mHealth implementation (Frost et al., 2018; van Dyk, 2014; Weiner et al., 2009). The readiness makes mHealth implementations part of operationalising DH strategies as opposed to impromptu reactive and opportunist project in response to external forces or public health emergencies (Frost et al., 2018; Khoja et al., 2013; Leon et al., 2012; Marshall, C. et al., 2013a; van Dyk, 2014). Particularly, health systems are tempted to implement mHealth interventions in response to the increasing application of related technological solutions in other sectors such as financial transactions (Deloitte, 2014; Fanta et al., 2018; IBM, 2014) or pressure from donors supporting health programmes (Aamir et al., 2018; Blaya et al., 2010; Brinkel et al., 2014; Fanta et al., 2018; Krah and de Kruijf, 2016; Leon et al., 2012; Peter, 2018).

The organic fledging mHealth ecosystem can hardly develop into a conducive environment that fully capitalises the potential of mHealth solutions (Frost et al., 2018). This is because it is more likely to face poor organisational support, insufficient resources, poor infrastructure, inadequate technical capabilities, uncoordinated initiatives, duplication of efforts, and lack of government support (Brinkel et al., 2014; Fanta et al., 2018; Frost et al., 2018; Krah and de Kruijf, 2016; Marshall, C. et al., 2013a; Peter, 2018; Tomlinson, M et al., 2013). Also, it may conflict existing legal policy frameworks related to healthcare systems (Frost et al., 2018; Mundaca-Shah et al., 2016).

(2)Implementation policies and practices (IPPs)

IPPs are a set of comprehensive means or national actions and policies by which a healthcare system assimilates mHealth solutions to achieve immediate and long-term health outcomes (Aranda-Jan et al., 2014; Frost et al., 2018; Weiner et al., 2009). They include legal and policy frameworks, regulations, plans, practices, structures, standards and strategies; which ensure the appropriate, sustainable, routine, and safe implementation and use of mHealth solutions in the healthcare system (Frost et al., 2018; Klein and Sorra, 1996; Weiner et al., 2009). IPPs are a strong indication of healthcare systems readiness (Weiner et al., 2009) and set facilitative governance structures for mHealth implementations (Frost et al., 2018); thus creating a conducive organisational environment for implementing and using of mHealth solutions (Aamir et al., 2018; Brinkel et al., 2014; Frost et al., 2018).

IPPs are tools to improve the limited awareness of mHealth solutions among health system stakeholders; allow users to take responsibilities for their usage; signifies accountability for user's actions and inactions; and can be used to reward performances (Brinkel et al., 2014; Mundaca-Shah et al., 2016). Likewise, they prompt government commitments to support mHealth initiatives even when they are externally introduced or funded (Peter, 2018) and commit to allocating implementation resources (GHPC, 2020; Martin et al., 2020; Randriamiarana et al., 2018; SORMAS, 2019). For example, countries enacting national DH strategies such as Tanzania, Uganda, Nigeria, and Benin report a positive climate for mHealth implementation initiatives (Huang et al., 2017; Kiberu et al., 2017; Ngoc et al., 2018; Niamh et al., 2014).

mHealth adoption without the support of IPPs has proved to negatively affect implementation effectiveness due to possible legal, political and policy complications not considered at the adoption stage (Bengtsson et al., 2015; Frost et al., 2018; Sacks et al., 2015). Also, the majority of mHealth interventions are implemented or reported with a week or without a link to the provisions of IPPs. To some, the need to enact IPPs does not indicate DH implementation readiness but comes as an inevitable necessity after facing complications when implementing DHIs (Huang et al., 2017; Niamh et al., 2014).

(3) Management support of the mHealth interventions

Users are likely to embrace mHealth solutions when there is a strong, convincing, informed and demonstrable management support for mHealth implementation (Helfrich et al., 2007; Klein et al., 2001; Klein and Knight, 2005; Klein and Sorra, 1996). Decisions to implement mHealth solutions are commonly made by senior health or programme managers at the national levels but implementation and usage depend on the participation of junior managers at district and regional levels and FHWs or CHWs (MoH-Uganda, 2012; Tom-Aba et al., 2018a; Weiner et al., 2009). mHealth interventions receiving political leadership from, owned and backed up by government responsible departments, are likely to be effectively implemented and used (Aranda-Jan et al., 2014; Brinkel et al., 2014; Krah and de Kruijf, 2016; Lemaire, 2013; Mundaca-Shah et al., 2016; Peter, 2018).

Countries in which IPPs are operationalised, appear to have stronger political and management support for mHealth implementations and interventions are being scaled up (Aamir et al., 2018; Frost et al., 2018; Katuu, 2019; Lemaire, 2013; Leon et al., 2012; MSH-Rwanda, 2018; Peter, 2018). Similarly, governments are tempted to make commitments or contribute implementation resources to donor-lead or initiated mHealth initiatives (GHPC, 2020; Leon et al., 2012; Ngoc et al., 2018; Niamh et al., 2014). For example, in donor-initiated eIDSR implementation, the Ugandan MoH contributed to the

recurrent costs covering internet connection and software maintenance (Huang et al., 2017) while Nigerian and Ghanaian governments contribute resources for upscaling efforts (GHPC, 2020). Conversely, the lack of government support and ownership in Guinea is mentioned as one of the factors challenging eIDSR implementation efforts (Gleason et al., 2019).

(4) Availability of mHealth implementation resources

These are resources needed to support implementation activities such as offering the needed training; providing user support; conducting supportive supervision; promoting mHealth use; and setting up technical and technological infrastructure (Klein et al., 2001; Klein and Knight, 2005). The mHealth literature in SSA attributes ineffective implementations of mHealth, *inter alia*, to the insufficient and unreliability of resources for supporting infrastructure, technologies, implementations and maintenance activities (Leon et al., 2012; Marshall, C. et al., 2013a; Peter, 2018). Specific challenges include poor mobile phone network and internet coverages; network fluctuations; insufficient human resources, skills and technical capabilities; poor user support; and inconsistency access to electricity (Brinkel et al., 2014; Githinji et al., 2014; Randriamiarana et al., 2018). mHealth implementers are failing to prove, before implementation decisions, to have the necessary implementation resources (Fanta et al., 2018; Leon et al., 2012; Mundaca-Shah et al., 2016). This includes lack of relevant leadership capabilities to align technological change with the strategic healthcare system or programme goals (Aranda-Jan et al., 2014; Labrique et al., 2018; Leon et al., 2012).

Resources limitation affect evaluations practices, which are critical to achieving effectiveness, because evaluations have long time lags and proved to be expensive (Kumar et al., 2013; Leon et al., 2012; Petter et al., 2013). (Krah and de Kruijf, 2016). Similarly, unavailability of implementation resources might shift the burden to system users, hence affecting system usage. In Uganda and Madagascar, eIDSR usage is reported to be negatively affected by the unaffordable cost of mobile phone ownership and energy for charging phones (Nanyombi and Ejiri, 2016; Randriamiarana et al., 2018).

As a result of lack of internally funding mechanism, mHealth implementations in SSA highly depend on donor support (Mangam et al., 2016; Marshall, C. et al., 2013a; Mundaca-Shah et al., 2016; Peter, 2018) as established earlier for all reported eIDSR interventions (Martin et al., 2020; MSH-Rwanda, 2018; PMI, 2014; PMI Tanzania, 2018; Randriamiarana et al., 2018; Reynolds et al., 2019; Sloan et al., 2020). Despite the claimed benefits, donor dependence raises questions on the scalability, maintainability and sustainability of eIDSRs (Martin et al., 2020). Similarly, donor dependency causes mHealth silos and duplication of efforts since eIDSRs are implemented, uncoordinatedly,

alongside other surveillance-related mHealth interventions. In Tanzania, Madagascar, Uganda and Nigeria, eDSRs were being scaled up alongside several other mHealth interventions implemented by different organisations, disease-specific programmes (Behumbiize et al., 2019; Francis et al., 2017; GHPC, 2020; Karimuribo et al., 2017; Mtema et al., 2016; Mwabukusi et al., 2014; Mwingira et al., 2017; PMI, 2014; Randriamiarana et al., 2018; Shuaib et al., 2018; Tom-Aba et al., 2018a) or for outbreaks response initiatives (Tom-Aba et al., 2018a).

(5) Learning orientation

Learning orientation constitutes a set of interrelated practices and beliefs that support and enable users in organisational skills development, learning, and growth; potential in helping them overcome obstacles, experimenting, adapting, and persevering in using the innovation (Helfrich et al., 2007; Klein et al., 2001). Several challenges are reported regarding learning orientation practices in mHealth implementation in SSA. First, user participation in designing mHealth solutions and implementation approaches is poor, suggestively, attributed to, inter alia, the common tradition of introducing health-related interventions using a top-down approach (Asangansi, 2016; Harding and Oetzel, 2019). mHealth studies focusing on feasibility, user acceptance, user-friendliness and usage challenges are prominent (Agarwal et al., 2015; Betjeman et al., 2013; Chib et al., 2015; El-Khatib et al., 2018; Hall et al., 2014; Harding and Oetzel, 2019; Mangam et al., 2016; Marshall, C. et al., 2013a; Martin et al., 2020; van Velthoven et al., 2013), suggesting poor user participation which results in user inputs being sought or challenges being identified after usage starts.

Second, there is a poor culture of using health information for decision making (Leon et al., 2012; Ngwa et al., 2016; Nutley and Reynolds, 2013) which affects even approaches used to implement mHealth interventions. Implementation decisions are not made based on the evidence proven through rigorous evaluation practice but on assumptions made about the novelty of mHealth solutions or expectations about their capacity to introduce changes (Fraser et al., 2011; Hall et al., 2014; Labrique et al., 2013; Leon et al., 2012; Tomlinson, M et al., 2013; Weiner et al., 2009). As a result, mHealth implementers fail to identify and minimise risk factors potential to weaken the likelihood of implementation effectiveness (Marshall, C. et al., 2013a).

Third, the application of sophisticated technologies, devices or interventions relative to users' competence negatively affect mHealth use. It requires competent users and intensive user training which are both difficult to achieve. eDSR implementation reports from Uganda, Madagascar, and Sierra Leone attribute the poor data quality to users' competence and insufficient training (Huang et al., 2017; Martin et al., 2020;

Randriamiarana et al., 2018). Users were concerned that the time allocated from eIDSR training was insufficient (Martin et al., 2020; Randriamiarana et al., 2018; Toda et al., 2017). Furthermore, staff turnover is a challenge because trained eIDSR users are frequently changing locations while on the job training is rarely provided because of inadequate supportive supervisions and technical support (Nanyombi and Ejiri, 2016).

(6) Managerial patience for a long-term time orientation

This determinant posits the need for managers to understand mHealth implementation process takes time and may diminish individual or unit performance standards and efficiency in the short term, hence avoiding pushing users to maintain or improve immediate task performance (Klein et al., 2001; Klein and Sorra, 1996). This managerial perspective enables users to devote more time and energy for implementation of mHealth interventions, hence attaining anticipated outcomes. Implementation plans should consider giving mHealth users time and space to familiarise to the change and built competence (Helfrich et al., 2007; Klein and Knight, 2005).

Managerial patience and long-time orientation might be a difficult practice in SSA since mHealth implementers have a strong desire to address pressing health system challenges. Similarly, they might seek immediate results to justify implementation decisions and expenditures or requests for financial resources. Short time mHealth interventions terminated at piloting stages are voluminous (Dahiya and Kakkar, 2016; Sacks et al., 2015; Shuaib et al., 2018; Tomlinson, M et al., 2013). Notably, even those showing to be effective in small scale, the majority are not scaled up (Agarwal et al., 2016b; Khoja et al., 2013; Mehl and Labrique, 2014; Piette et al., 2012) largely for resource limitations. Furthermore, learning orientation practices become impractical because oftentimes trained users change locations, responsibilities or employers.

The question as to how long is needed for eIDSRs to start proving being consistently and adequately used is not known. For example, Rwanda implemented eIDSR to scale within 3 years (MSH-Rwanda, 2018; Thierry et al., 2014) and Sierra Leone within 4 years (Martin et al., 2020); capturing all priority diseases under surveillance. Alternatively, eIDSRs in other countries such as Kenya and Madagascar implementation have taken more than 5 years but they are yet to provide convincing results or implemented to scale (Nanyombi and Ejiri, 2016; Rajatonirina et al., 2012; Randriamiarana et al., 2018).

Lastly, eIDSR interventions are impromptu introduced without long time plans for scaling up, maintenance and sustainability even after successful pilot projects (Peter, 2018; Randriamiarana et al., 2018; Toda et al., 2017). They are rushed and informed implementation frameworks are not used to guide the process and prepare mitigation strategies for unexpected results (Karimuribo et al., 2017; WHO, 2015).

(7) Innovation champions

Innovation champions are members within the organisation who are committed to lead, support, promote and advocate innovation implementation, hence overcoming the indifference or organisational resistance to change provoked when new ideas are introduced (Helfrich et al., 2007; Jacobs, S.R. et al., 2015a; Klein and Sorra, 1996). In the implementation of mHealth interventions champions can either be politicians; donors or members of health programmes introducing mHealth solutions; decision makers in the MoH; health managers who are likely to be implementers; or FHWs intended to be main system users (Aranda-Jan et al., 2014; Mechael et al., 2010; Mundaca-Shah et al., 2016; WHO, 2015). mHealth champions can be either self-motivated motivated individuals or cultivated, particularly for frontline users (Aranda-Jan et al., 2014; Mundaca-Shah et al., 2016; WHO, 2015).

The review of reported eIDSR interventions, do not report the role of champions in implementation processes, apart from donors. This observation might be attributed to the underreporting problem common for mHealth intervention studies (Agarwal et al., 2016a), hence insufficient information about implementation initiatives. However, even when champions exist their influence on eIDSR implementation effectiveness might be limited due to the multiplicity of users within the health system and other factors negatively affecting the implementation climate as argued in the next point.

(8) mHealth implementation climate

This is the shared perception among decision makers, mHealth implementers, technical support teams, and users that implementation of mHealth interventions is a major priority promoted, supported and rewarded by the healthcare system, programme or HFs (Klein and Knight, 2005; Klein and Sorra, 1996; Weiner et al., 2011). It is a cumulative effect of the organisational, social, technical and behavioural environment supporting and facilitating mHealth implementation and use. It protects users from looking at mHealth solutions as destructions from or obstacle to the performance of the core responsibilities (Helfrich et al., 2007).

Implementation determinants number 1 to 7 described above, present a mix of circumstances characterising the implementation climate, either as facilitating or inhibiting the implementation effectiveness of eIDSRs. Principally, there is a certain degree of health systems' readiness for eIDSR implementation, operationalisation of IPPs, support from governments/MoH and realisation of eIDSR benefits. But challenges negatively affecting the implementation climate are overwhelming. Particularly, eIDSR implementation is yet to be sufficiently prioritised; eIDSR use is not adequately promoted, supported or rewarded; donor dependence is high; and organisational challenges such

as staff turnover, workload, users' competence, and information culture affecting eIDSR implementations are many. Additionally, the inability of implementers and technical teams to provide technical support and supportive supervision to users is reported as negatively affecting eIDSRs use (Randriamiarana et al., 2018; Toda et al., 2017). Therefore, in aggregate, the eIDSR implementation climate in majority of the countries is not positive enough to positively effecting implementation effectiveness.

(9)mHealth intervention-values fit to users

This is an extent to which organisational members perceive that use of mHealth solution fits professional or organisational interests, values, responsivities, mission, or competencies (Heeks, 2006; Klein and Sorra, 1996). Studies indicate mHealth solutions can potentially be effectively implemented when contextual factors such as organisational culture, information culture, working practices, workload, user competences and organisational logics are considered (Aamir et al., 2018; Aranda-Jan et al., 2014; Asangansi, 2016; Bervell and Al-Samarraie, 2019; Déglise et al., 2012a; Déglise et al., 2012b; Githinji et al., 2014; Krah and de Kruijf, 2016; Madon et al., 2014; Marshall, C. et al., 2013a).

Also, the mHealth goodness fit can be established across mHealth users when they participate in the implementation process. The latter seems to be rarely practised in SSA because DH solutions are largely imposed to users in lower levels instead of being flexibly designed with them (Aamir et al., 2018; Aranda-Jan et al., 2014; Nanyombi and Ejiri, 2016). Oftentimes, this results in the possibility of design-actuality gaps whereby mHealth solutions become incompatible to users context, competence, information requirements or value (Heeks, 2002) or task characteristics (Petter et al., 2013). Additionally, mHealth solution flexibly designed to accommodate imminent technological, technical and information requirement changes are likely to be user-friendly and acceptable (Aranda-Jan et al., 2014; Peter, 2018). Flexible designs provide integration and interoperability features facilitating data and infrastructure sharing, which are critical for effectiveness implementation (Marshall, C. et al., 2013a; Peter, 2018). They facilitate improvement, consistency and sustainable use of mHealth solutions even when requirements, technology, applications or users change (Mundaca-Shah et al., 2016; Peter, 2018).

The available eIDSR implementation studies do not report sufficient information on how implementation processes insured users' values-fit are considered. Studies focus on intervention technologies and how they are conceived; and implementers engagement with MoH, donors or service providers, for example, through the formation of technical working groups (TWGs), playing a role of aligning eIDSR implementations with users'

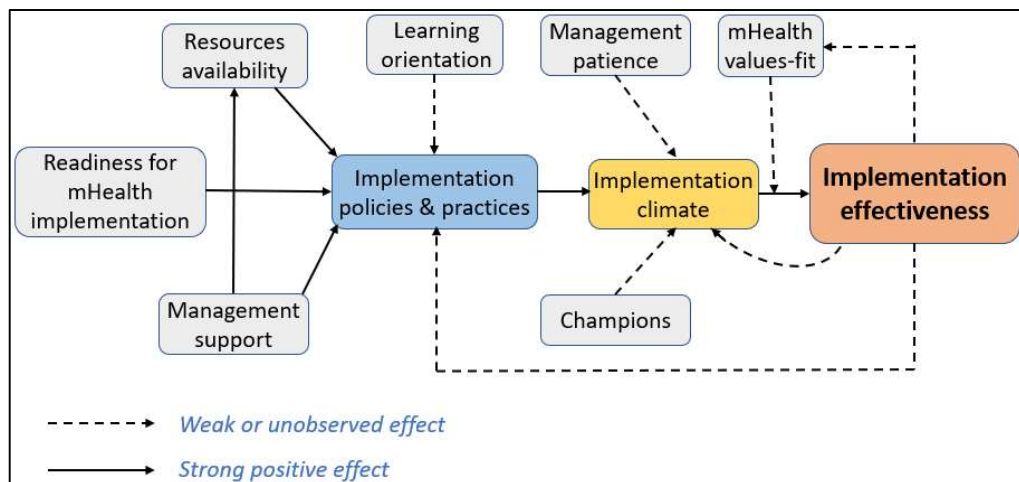
needs and the complexity of healthcare systems (GHPC, 2020; Martin et al., 2020; mSOS, 2016; Tom-Aba et al., 2018b). However, the evidence of user participation in lower levels such as HFs or communities in designing eIDSR solutions and implementation approaches is weak, missing or inadequately reported. When users are involved, it is mainly informally to understand information-related challenges and the feasibility of eIDSR solutions (Hounmanou et al., 2016; mSOS, 2016; Toda et al., 2016).

Reported implementations provide sufficient information indicating none or suboptimal application of user participation principles. In Uganda, for example, health providers in HFs distanced themselves from eIDSR usage because it was assumed to be the responsibility of surveillance assistants only and users in the community had no idea of eIDSR existence (Nanyombi and Ejiri, 2016). Similarly, basic user concerns or needs, implementation requirements and design technicalities seem to be identified and partly attended after putting the systems into use (Martin et al., 2020; Nanyombi and Ejiri, 2016; Randriamiarana et al., 2018; Toda et al., 2016). Additionally, studies indicate most of eIDSR technological challenges are inconsequential implementation issues compared to contextual and multifaceted health system challenges (Nanyombi and Ejiri, 2016; Toda et al., 2017; Toda et al., 2016). Users are not receiving feedback and disease surveillance is not seemed to be a priority because even when eIDSRs help in timely notification of epidemic cases, responses remain suboptimal (Toda et al., 2017; Toda et al., 2016). Thus, there is a serious gap of how eIDSR use fit the values, interest and priorities of users with a direct negative effect on implementation effectiveness.

Section summary

The application of an organisational change framework of innovation implementation effectiveness has shown to be relevant to identify factors explaining the ineffective implementation of eIDSRs interventions in SSA. The ineffectiveness is directly attributed to a substandard implementation climate which is cumulatively characterised by implementation unpreparedness; insufficient operationalisation of IPPs; unavailability and unreliability of resources, and insufficient government support. Also, goodness fit of eIDSR use among key users is missing, particularly at HF and community levels, attributed by top-down management rationalities in which solutions are introduced to peripheral users without their effective participation, hence overlooking their values, priorities and working circumstances. The context does not sufficiently support, prioritise, promote or reward eIDSR use. Using the argument by Weiner and colleagues (2009), the missing good fit of eIDSR further modifies and amplifies the effect of the substandard implementation climate on implementation effectiveness.

Figure 8: A summary of factors determining eIDSRs implementation effectiveness in SSA



Adapted from Weiner et al (2009); Helfrich et al (2007); Klein et al (2001); Klein & Knight (2005)

Figure 8 summarises factors which determine the implementation effectiveness of eIDSRs in SSA and their relationship. The effects of learning orientation, champions, management patience and long-term learning orientation on implementation effectiveness is not obvious in the reviewed studies. Firstly, these factors are either sparsely reported or unreported. Secondly, the healthcare system environment, priorities and constraints make some of them irrelevant to consider as key determinant for implementation effectiveness. Understaffing in HFs, staff turnover, and frequent transfer and change of roles among FHWs, challenge the nurturing and learning orientation or creating and maintaining champions. The desire for immediate benefits and donor dependence inhibits long-time patience in waiting for results. In the end, the poor implementation effectiveness weakens the implementation climate, demoralises users for uncredited efforts, and does not motivate improvement or operationalisation of IPPs.

2.5. Synthesis of the reviewed literature

The increasing implementation of mSurveillance and other DH interventions in SSA, supports the regional agenda for implementations of eIDSRs to improve disease surveillance functions (Fall et al., 2019; WHO/AFRO, 2015; WHO/AFRO, 2019b). However, eIDSR implementation efforts suffer the problem of unrealistic expectations since DH solutions are being wrongly perceived as a panacea for many health system challenges and enabler of doing what was previously impossible (Aranda-Jan et al., 2014; Leon et al., 2012; Marshall, C. et al., 2013a). eIDSRs implementations reports are overexciting and hyperenthusiastic about their potential benefits, a contrast to the stressed weak evidence base and negative outcomes of DHIs reported in the literature (Krah and de Kruijff, 2016; Leon et al., 2012; Piette et al., 2012; Randriamiarana et al.,

2018; van Dyk, 2014). Probably, the severity of communicable diseases and persisting surveillance challenges, justify eIDSR implementations as the only practical alternative.

Efforts to scale up eIDSRs interventions are underway and promoted (Randriamiarana et al., 2018; Toda et al., 2017), despite the missing evidence, arguably, because scaling up initiatives signify and provide a good environment to establish implementation effectiveness or achieving anticipated benefits (Fruchtman et al., 2018; Labrique et al., 2018; Lemaire, 2013; Leon et al., 2012; Tomlinson, M et al., 2013). However, at present, the evidence of good quality outcomes might exist but unknown or unreported. The present review has established that lack of good quality is mainly attributed to the ineffective implementation of the eIDSRs. The quality and consistency use are poor, despite some positive results reported about collection and reporting of surveillance data.

eIDSR implementations are complex processes having different inputs and outputs, involving multiple stakeholders, and subjected to multifaceted factors specific to time and space (Krah and de Kruijf, 2016). Achieving implementation effectiveness requires the consideration of social, political, technical, organisational, infrastructural, and cultural factors before and throughout the implementation process. Also, it requires the application of informed implementation approaches and coordinated process.

Examining the evidence base of implementation effectiveness of eIDSRs, is problematic. Firstly, the topic is not explicitly nor sufficiently explored in the literature as opposed of other mHealth implementation aspects (Khoja et al., 2013; Labrique et al., 2013; Leon et al., 2012). Secondly, eIDSR interventions are poorly reported and lack sufficient information about processes and factors determining implementation effectiveness (Agarwal et al., 2016a; Betjeman et al., 2013; Khoja et al., 2013; Tom-Aba et al., 2018a). The underreporting of mHealth-related interventions is common, attributed to the discomfort to report failed initiatives (Agarwal et al., 2016a; Brinkel et al., 2014; Déglise et al., 2012b; Piette et al., 2012); implementations being done for short periods or addressing immediate problems without plans for continuity or publication; protection of innovations (Tom-Aba et al., 2018a); techno-centric inclination, hence underestimation of the role and influence of context-based organisational and implementation complications (Agarwal et al., 2016b; Krah and de Kruijf, 2016).

Thirdly, eIDSRs are implemented without rigorous evaluation studies or narrowly evaluated focusing on justifying their expected implementation benefits. Previous reviews attribute inadequacy mHealth evaluation practices to weak implementation designs and validation frameworks; high cost of conduction evaluations; short-time implementations; pilot projects not implemented to scale; incongruence relationship between evaluation frameworks and those used to guide implementations; and

unstandardised evaluation indicators and metrics (Agarwal et al., 2016b; Blaya et al., 2010; Fraser et al., 2011; Labrique et al., 2013; Njoroge et al., 2017; Piette et al., 2012; van Dyk, 2014; WHO, 2011). When evaluations are reported, they are predominantly focusing on technological feasibility, acceptability, functionality and fidelity; contrasted implementation effectiveness or quality and quantity of achieved health outcomes (Brinkel et al., 2014; Cáceres et al., 2016; El-Khatib et al., 2018; Eskenazi et al., 2014; Ha et al., 2016; Hounmanou et al., 2016; Shuaib et al., 2018). Similarly, evaluation methods are either unclear or unreported and there is a risk of skewed evaluation results for being produced by eIDSR implementers or conflicting interests (Agarwal et al., 2016b).

The organisational theory of innovation implementation effectiveness provides key determinants for examining mHealth adoption and implementation process attributed to the quality and consistency of use of mHealth solutions. In view of this framework, the available information about eIDSR implementations do not provide sufficient evidence proving effective implementations, largely because of a negative implementation climate and poor goodness fit to users' values.

2.5.1. Research gaps

The present review established three inter-related research gaps related to the implementation effectiveness of eIDSRs in SSA countries. Firstly, the implementation effectiveness perspective of eIDSR interventions has not been explored. Given the emphasis and increasing rate of implementing eIDSRs across the region, there is an immediate need for empirical studies on implementation effectiveness. While technological, technical and infrastructural complications facing eIDSR implementations are relatively discussed extensively in mHealth literature, context-based circumstantial complications are insufficiently explored and implementation processes sparsely documented, thus presenting a knowledge gap about eIDSR implementation approaches, processes, activities and the subsequent causality relationship with implementation effectiveness.

Secondly, based on reported studies, all eIDSR implementation initiatives are donor-initiated and funded; impromptu introduced to address short-time health emergencies such as epidemic outbreaks, or as pilot studies without long-term implementation plans. Consequently, none of the available studies has investigated eIDSR implementation in view of organisational change perceptiveness notwithstanding the complexity of the context in which eIDSR solutions are implemented and the functions they are expected to support and improve. Understanding eIDSR implementation as an organisational change initiative is a gap need to be addressed.

Thirdly, the relevance of the IDSR technical guidelines in guiding technological and implementation designs of eIDSRs is not adequately researched in the reported studies. Therefore, it is not yet known whether IDSR-guided designs are affecting eIDSR implementation initiatives and weakens implementation effectiveness.

2.6. Conclusion

This chapter has presented the review of implementation effectiveness of mSurveillance for national diseases surveillance functions in SSA countries, called eIDSRs. As a point of departure, the present review has provided an overview of the mHealth space in SSA and extensively discussed the implementation of mSurveillance. Then, a specific discussion on eIDSR implementation was provided, from which weak evidence of good quality implementation effectiveness was established. Using the organisational change framework of innovation implementation effectiveness, determinant factors affecting implementation effectiveness of eIDSRs were identified. Lastly, the chapter presented the research gap attended in this thesis.

The next chapter presents a theoretical framework guiding this thesis and methods used for empirical data collections, analysis and presentation of results.

CHAPTER 3 Theoretical framework and methodology

3.0. Introduction

This chapter presents the approach and methods used to conduct the study. It is organised as follows. Section 3.1 presents the theoretical framework which guided the study and the structure of the results. Section 3.2 sets forth the ontological and epistemological views within which the research was framed. Section 3.3 presents the study design and 3.4 describes the data collection processes. Ethical considerations are outlined in section 3.5. Sections 3.6 and 3.7 describe the qualitative and quantitative components of the study, respectively, covering data collection methods and data analysis approaches. The chapter concludes by providing a reflection of methodological issues immersing during the study.

3.1. Theoretical framework

The conceptual framework intended to serve two main purposes. First, to inform the study in key theoretical constructs, and second to inform the choice of research design.

3.1.1. The choice of a theoretical framework

As a growing and fast changing research field, there is no consensus as to what theoretical frameworks are more relevant for studying mHealth and other DHIs. Accordingly, different theoretical lenses are variably adapted, and the choices are context specific. For example, common theories applied in studying DHIs in developing countries seem to fall into two main categories. First, theories focusing on behaviours determining the acceptance, behaviour change, and use of DH solutions (micro-level analysis). Such theories and studies in which they are applied include Unified Theory of Acceptance and Use of Technology (Safie et al., 2017; van Dyk, 2014; Venkatesh et al., 2003); Technology Acceptance Model (Hoque, 2016; Kivunike et al., 2017); Theory of Reasoned Action; Theory of Planned Behaviour, and Social Cognitive Theory (Safie et al., 2017). Second, theories focusing on social and health system organisational changes to improve management structures and functions (meso and macro levels analysis). Prominent models include Actor-Network-Theory (Greenhalgh and Stones, 2010; Nyella and Kimaro, 2015); Technology Acceptance Model (Hoque, 2016; Kivunike et al., 2017); Information Infrastructure Theory (Nguyen, T. and Nyella; Nyella, 2007); Institutionalisation Theory (Kimaro and Sahay, 2007); Normalization process, Diffusion of Technology/ Innovations (Haenssger and Ariana, 2017; Tomlinson, Mark et al., 2018); Structuration Theory (Nyella and Mndeme, 2010), and Organisational Change (Asangansi, 2016).

Studies in the second group largely focus on exploring or describing the role of human and non-human actors and their interactions with social and organisational factors in the

adoption and implementation of DHIs. They appear more frequently in studies reported from SSA, because DHIs are implemented largely to improve health information systems for informed decisions making and building the culture of information use (Aqil et al., 2009; Asangansi et al., 2013; Hotchkiss et al., 2010; Kimaro and Sahay, 2007; Safie et al., 2017). The organisational change perspective provides important insights about organisational change process attributed to the implementation of DHIs such as eIDSR in a complex health system environment (Avgerou, 2000; Avgerou, 2001; Kling and Lamb, 2000; Poole and Van de Ven, 2004). Thus, the following sub-section provides a brief discussion of organisational change theory from which the conceptual framework was drawn.

3.1.2. The organisational change theories

Organisational change is described as the whole aspect of an organisation to move from a current/equilibrium state to a desired state which can be a transformational or transition state (Cunliffe, 2008; Flamholtz and Randle, 2008a). A desired state or change can be a difference in form, quality, quantity, performance, or outcomes measure over time (Poole and Van de Ven, 2004). Changes involve aspects such as organisation vision, mission, structure, culture, performance-incentive systems, members, leaders, or processes (Armenakis and Bedeian, 1999; Bejinariu et al., 2017; Cunliffe, 2008; Flamholtz and Randle, 2008b; Weick and Quinn, 1999). Thus, organisational change concept deals with three ideas: the difference introduced by the change, at different temporal moments, between a state of an organisational unit or system (Poole and Van de Ven, 2004). In the current research, the organisational change initiative is the eIDSR intervention implemented by the DSS in Tanzania.

Theoretical frameworks applied in studying organisational change are collectively referred to as Organisational Change Theories (OCTs) (Poole and Van de Ven, 2004). In applying OCTs, it is important to put organisational changes into perspective since they fall under different categories. The categorisation is fundamental in theorising, understanding or planning, guiding and managing organisational change initiatives (Flamholtz and Randle, 2008b; Weick and Quinn, 1999). The categories can be characterised by theories of change, types, emergence, patterns, magnitude, and level of analysis of the organisational change under scrutiny.

Theoretically, organisational changes are viewed relative to the role of human agency in the change process which differentiate between “theories of change” and “theories of changing” (Poole, 2004). The former seeks to understand and conceptualise organisational change and factors influencing change while the latter labours to suggest

a set of prescriptions on how change processes should take place and be managed (Poole and Van de Ven, 2004).

Similarly, the role of human agency provides a fundamental dimension of change in describing the source of change: a contrast between planned and unplanned/emergent change (Poole, 2004). Planned change is a rationally proactive, consciously conceived and implemented by knowledgeable actors introducing a change in an organisation as part of its strategic development plan (Avgerou, 2001; Flamholtz and Randle, 2008b; Poole, 2004). Alternatively, emergent change is not purposively conceived and may or may not be driven by human choice, but can happen in response to something in the organisational environment (Avgerou, 2001; Bubshait et al., 1998; Flamholtz and Randle, 2008b). Planned change is better explained by theories of changing while unplanned change is understood by the application of theories of change (Poole, 2004).

Organisation change can further be characterised based on the pattern of work or activity, which can be either episodic or continuous change (Poole, 2004; Weick and Quinn, 1999). The episodic change consists of organisational changes that tend to be infrequent, discontinuous, and intentional; occurring when organisations try to address the misalignment from equilibrium positions attributed to external changes such as technology or internal such as leadership or personnel (Weick and Quinn, 1999). Conversely, continuous change comprises the types of changes tend to be ongoing, evolving, and cumulative as organisations continue to update work processes or adopt new patterns of organising without clear priori intentions (Weick and Quinn, 1999).

The magnitude of change concerns the scale of change and how it is being implemented: either as transformational/ revolutionary (radical) change or incremental/ evolutionary (gradual) change. The former involves a bold attempt to quickly find new ways of being effective by tactically focusing on achieving a specific operational target; and the latter assumes a gradual and narrowly focused approach to change, hence achieving a wider organisational goal (Jones, G.R., 2013; Lewin et al., 2004; Poole, 2004).

Level of analysis concerns the levels of organisation aggregation namely micro, meso, or macro perspectives (Jacobs, G. et al., 2013). The *micro* perspective analyses the position and influence of human actor behaviours toward an organisational change. It deals with issues such as attitudes, perception, sense of uncertainty, and acceptance or rejection of organisational change. The *meso* perspective concerns issues relating to the organisational change context and how the change affects and is affected by organisational identification and institutionalisation processes (Jacobs, G. et al., 2013). Lastly, the *macro* perspective deals with the organisational population ecology linking the organisation as a whole to its environment (Lewin et al., 2004).

Application of OCTs for technological organisational changes

OCTs are variably applied in studying organisational changes based on three main aspects. Firstly, the nature of research enquiries which might seek either to understand *why* organisational change initiatives fail or succeed; or *how* organisational change processes can be successfully implemented (Avgerou, 2001; Heeks, 2002; Heeks et al., 1999; Jacobs, G. et al., 2013). The theory of change is more relevant in addressing the former question and the theories of changing for the later.

Secondly, are the organisational change variables or main analytical themes common for consideration in studying organisational changes (Armenakis and Bedeian, 1999; Self et al., 2007) as briefly described below:

- Change content- it identifies what the change is all about. Focuses on factors comprising the targets of change efforts and how they relate to or result into organisational effectiveness.
- Change context: it focuses on forces or circumstances existing external and internal to the organisational environment triggering change and explain “why” the change is necessary and supported. They create an implementation climate with direct effect on implementation effectiveness.
- Change process: it is the “how” factor of the change embodying specific methods used to implement it. It focuses on phases and actions taking place at the individual, group and organizational level and its external environment during change implementation.
- Change outcome: concerns the nature of criterion variables which reflect the effect of change initiatives (Armenakis and Bedeian, 1999; Cunliffe, 2008).

Thirdly, the approaches used to study technological changes. Methodologically, organisational change studies are differentiated by application of either variance or process approaches (Markus and Robey, 1988; Poole, 2004). Variance approaches explain organisational changes in terms of the relationship between the perceived independent and dependent variables in seeking to establish conditions necessary and sufficient to influence change outcomes (Poole, 2004). Research in this group employ experimental and survey designs in attempting, using quantitative data and general linear models, to make a causality generalisation (Klein et al., 2001; Poole, 2004). Alternatively, process theories make it possible to uncover a series of events, unfolding during change implementation, leading to observed outcomes. They have lower aspiration about explained variance as opposed to providing richer explanations about the process and nature of change outcomes; answering the how, why and when questions about the change (Markus and Robey, 1988). In explaining organisational

change, process theories may incorporate different types of factors such as critical events and turning points, contextual influence, formative patterns, and causal factors that influence a sequence of events; thus employing different methods (Poole, 2004).

When applied independently, both variance and process approaches pose limitations that render them insufficient to study an ongoing or completed technological change initiatives. Variance approaches are limited to assessing the influence of change on organisational performance using process data, but they are insufficient to study activities, phases or process in which change unfolds (Poole, 2004). Conversely, process approaches are labour-intensive; require collecting a large amount of data; complex in developing process explanation and discerning patterns in the process-data; and limit the number of cases to be studied (Avgerou, 2001; Poole, 2004). The latter may limit the confidence in the generalisability of the conclusion reached (Poole, 2004). Accordingly, employing both approaches in studying organisational change may provide credible and strong evidence about the change initiatives and its outcomes.

Fragmented nature of frameworks of OCTs

When organisational changes are attributed to technology, the latter may be the source, content or enabler of the desired change (Avgerou, 2000; Prastacos et al., 2002). Based on the role of the technology, studying or guiding a change implementation can be a complicated undertaking, thus requiring a sociotechnical perspective of organisational change (Asangansi, 2016; Avgerou, 2001; Jacobs, G. et al., 2013). The latter regard technological innovations as social systems of which design, adoption, and implementation are ongoing sociotechnical processes (Avgerou, 2000; Fanta et al., 2016; Kling and Lamb, 2000). Besides being technological and technical in nature, technological solutions are adopted within, interact with and influenced by, complex social and organisational forces in their application domains (Berg and Toussaint, 2003; Nyella and Mndeme, 2010; Sheikh and Nyella, 2017). In the healthcare domain where eIDSR falls, such forces include technologies, workflows, culture, structures, users/beneficiaries, and social interactions (Asangansi, 2016; Fanta et al., 2016). The sociotechnical perspective posits organisational change initiatives may only be understood by systematically analysing all constitutive elements and the way they interact (Jacobs, G. et al., 2013).

OCTs are highly fragmented, attributed to diverse academic disciplines from which analytical frameworks are drawn and the need for considering contextual particularities in diagnosing or guiding implementation of organisational changes (Avgerou, 2001; Jacobs, G. et al., 2013; Jansson, 2013). Consequently, several models of integrated frameworks of OCTs are suggested which labour to provide theoretical tools for studying

and diagnosing fragmented components of organisational change (Bubshait et al., 1998; Flamholtz and Randle, 2008b; Jacobs, G. et al., 2013; Prastacos, 2002). They span the continuum of change initiatives from when decisions to adopt changes are made to when such changes become part of organisational routines, terminated or fail (Jacobs, G. et al., 2013).

3.1.3. Application of integrated framework of OCTs

The current research was guided by an integrated conceptual framework of OCTs, particularly, by adapting the structure of a unified framework of OCT developed by Jacobs et al (2013) in studying technological change. The framework was adapted because it provides a plausible theoretical lens to comprehensively analyse the entirety of a technological change under implementation such as the eIDSR. The framework is organised into an *input-throughput-output* process model (Figure 51 in the appendices).

Using macro and micro levels of organisational analysis, the model by Jacobs et al (2013) provides an analytical toolbox to understand contextual barriers and enablers of the organisational change process. *Input* component deals with the preconditions for change and the internal and external challenges which trigger the need for change (the period before the change). The change is established by the organisational misfit: the misalignment of organisation's internal features with that of its external environment, which weakens performance. The *throughput* component concerns with the process of change taking place within the organisation aiming to ameliorate identified weaknesses and reinforce existing strengths. It deals with how the change is introduced, prioritised, supported and managed. Also, to manage the unfolding resistance to change and translate it into more adequate change implementation approach. The *output* component concerns with the consequences of change to the organisational performance, which can be negative, neutral or positive.

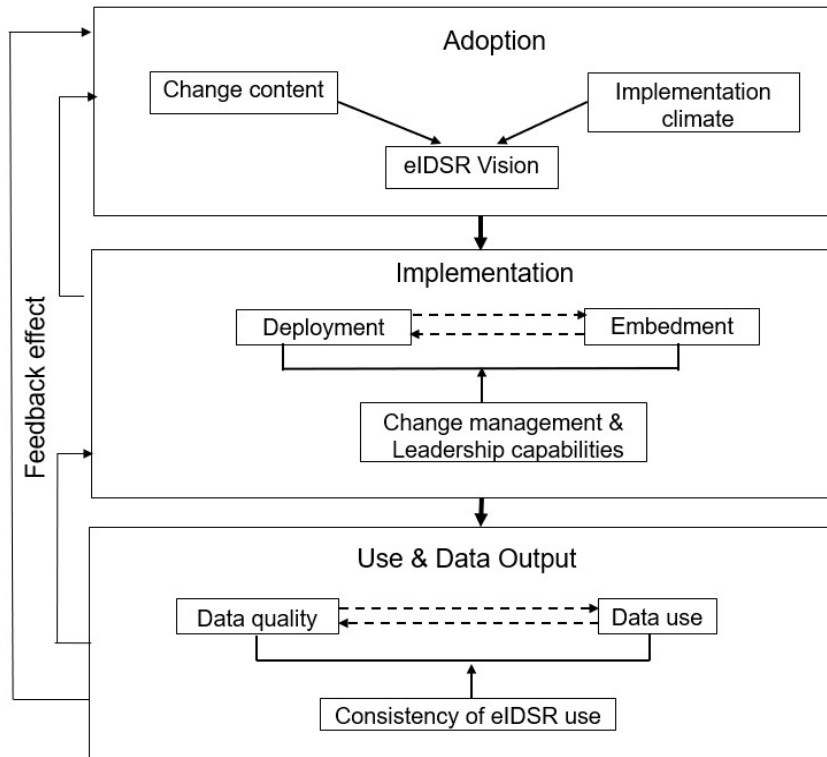
Moreover, the three components are mediated by the organisation's internal identity and external legitimacy (Jacobs, G. et al., 2013). The former is defined as the shared beliefs structure or organisational culture of which the organisation identifies itself, set its expectations and consistently defines its behaviours and actions. The external legitimacy is defined by how the expectations of organisation's stakeholders in its external audience are met. If a change is not carefully executed, it is likely to lead into internal identity conflict and external legitimacy erosion, both affecting organisational performance. Similarly, changes that are consistent with the internal identity are easier to implement and bear less opportunity costs.

3.1.4. The conceptual framework for the current research

Figure 9 summarises a conceptual framework visualising a continuum of the eIDSR change effort from the inception stage divided into three components: adoption, implementation, and eIDSR use and data output. Detailed descriptions of each construct, variables, and relationships are explained underneath in Table 5.

Three assumptions were made about the relationship of the components. Firstly, the implementation effectiveness, determined by eIDSR use and subsequent effect on data quality and use, would affect the eIDSR change vision (the outside feedback arrow). This would be by changing or improving the intervention content, plans, phases and implementation climate. Otherwise, ineffective implementation would render the eIDSR change vision irrelevant to its users. Secondly, effective implementation would affect the implementation approach and process either positively by improving deployment methods, priorities, coverage; or negatively by slowing down the process, changing priorities or terminating the implementation (the second inner arrow). Thirdly, the implementation approach and process would affect the change vision by changing the plans, phases, content or implementation climate (the first inner arrow).

Figure 9: A conceptual framework for assessing eIDSR implementation effectiveness based on organisation change perspective



Structure adapted from Jacobs et al (2013) p.777

Table 5: Description of the main constructs and variables of the conceptual framework for assessing eIDSR implementation effectiveness

| Constructs | Variables | Description |
|--|----------------------------------|--|
| <i>eIDSR adoption - Sought to explore how the eIDSR intervention was adopted, existing implementation climate, and what constitute eIDSR change vision</i> | Content | Change vision, type of change, the eIDSR application, actors/users, and anticipated outcomes |
| | Implementation climate | Determinant factors influencing implementation effectiveness |
| <i>eIDSR implementation - sought to understand how eIDSR was put into use and integrated into eIDSR use to DSS routines.</i> | Deployment | Approach, plans, phases, process, events, and activities |
| | Leadership and change management | Leadership capabilities, structure, technical support, mitigating resistance to change |
| | Embedment | <ul style="list-style-type: none"> integrate eIDSR into HMIS, surveillance and response functions reinforcement relationship between deployment approach and embodiments |
| <i>eIDSR use and data output - sought to understand whether and how eIDSR adds value to the disease surveillance and response system</i> | consistency of eIDSR use | <ul style="list-style-type: none"> Where, for what, by who, and how? Trends of use Factors influencing eIDSR use |
| | Data quality | Influence of eIDSR use on data availability and quality |
| | Data use | <ul style="list-style-type: none"> Analysis and use of eIDSR-generated data for routine surveillance and response functions reinforcement relationship between reporting and data quality and data use |

Theoretically, the framework applied a theory of change to retrospectively diagnose and understand the adoption and implementation of the eIDSR intervention. Methodologically, a variance and process approaches were used (Poole, 2004): the former to assess a causality relationship between eIDSR use and improvement of data quality, and the latter to get an in-depth understanding of the implementation climate, approach and process, and the quality of eIDSR use.

3.2. Research approach and philosophical stance

This thesis intended to obtain what Scott (2016) calls “the whole picture” of the eIDSR intervention implementation in its first 4 years. Thus, it explored the organisational, technical and technological deterministic aspects of the intervention and the socially constructed realities amongst its key stakeholders through the following work packages:

- unravelling the adoption and implementation process of eIDSR through oral narratives of key individuals involved and analysis of documentary data.

- assessing the value and accuracy of clinical records at HFs level before being reported through eIDSR.
- statistically and descriptively establishing data submission trends through eIDSR; factors likely to influence the observed pattern of eIDSR use; and the quality of data submitted through eIDSR relative to source clinical records in HFs. Also, an observation was made on how eIDSR was being used.
- assessing through oral narratives and documentary data whether and how eIDSR influenced data quality, analysis, and use.

To attend the above work packages, a mix of qualitative and quantitative approaches were used because the research sought to address questions requiring different ontological and epistemological views, which in turn determine different application of systematic methods to establish the truth (Creswell, 2014a; Killam, 2013; Morgan, 2013b).

Ontology is a philosophical concept concerns the nature of being or reality of social phenomena while epistemology concept concerns with how knowledge is developed or constructed (Ravitch and Carl, 2015). An ontological consideration questions whether reality can and should be considered as an objective entity independent of social actors (postpositivism/ objectivism) or as a social construction built from perceptions and actions of social actors (constructivism) (Bryman, 2012d). The quantitative research approach views truth as unchanged and discovered through objective measurements seeking to establish generalisable cause-and-effect relationship between objects of study (Killam, 2013; Morgan, 2013a). Alternatively, the qualitative approach views truth as having multiple versions; evolves and changes subject to time and experiences, and shaped by the context and meanings attached to it (Creswell, 2014b; Killam, 2013; Morgan, 2013a). It posits that the truth about social phenomena cannot be generalised but can be transferred to a similar context because meanings are continually being accomplished by social actors (Bryman, 2012c).

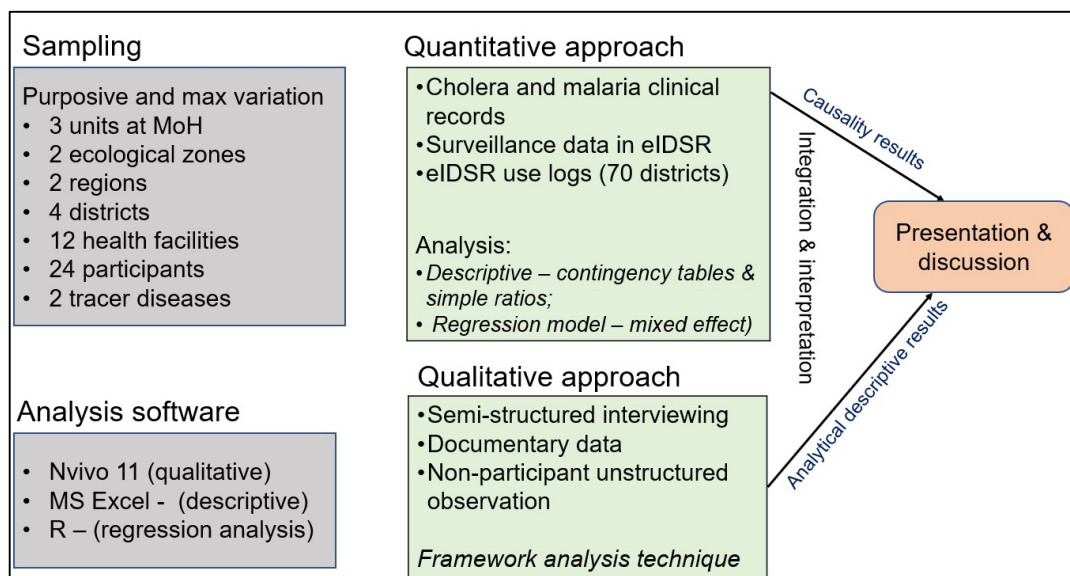
The implementation effectiveness of eIDSR examined in this thesis, is objectively represented by statistical data indicating the patterns of eIDSR solution use for data submission. Furthermore, the effect of the eIDSR use on information output can be objectively measured by comparing data variables before and after being submitted through eIDSR. Therefore, in view of epistemological position, these aspects (pattern of use and effect on data quality) could be established by a surface look independent of what I believe to be true about the intervention (Bryman, 2012d; Killam, 2013; Morgan, 2013a). Data collection and analysis were separate research undertakings requiring pre-determined designs (Greenhalgh and Taylor, 1997) to make reproducible and

generalisable results subject to the sampling representability of analysed data (Killam, 2013; Marshall, M.N., 1996).

Conversely, factors determining eIDSR implementation effectiveness, were considered as being subjectively defined and determined by sociotechnical factors specific to the context of eIDSR implementation and use. Such reality is shaped and determined by unpacking the eIDSR implementation context and experiences of individuals involved. It was constructed by getting an in-depth understanding of complex human phenomena, meanings and interpretations discovered through a direct interaction between the researcher and people in the natural setting where eIDSR is being implemented and used (Killam, 2013; Morgan, 2013a).

The ontological and epistemological views determine research designs and methods for data collection and analysis (Morgan, 2013c). Since the current research required both quantitative and qualitative approaches, a mixed-methods research design was applied as summarised in Figure 10.

Figure 10: A summary of the mixed-method design applied in the current research



The detailed description of the design and how it was executed is provided in the subsequent sections.

3.3. Research design and sampling strategy

A mixed-methods design is defined as a “the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or languages into a single study” (Johnson and Onwuegbuzie, 2004, p. 17). It permits addressing research questions that are more complicated and collection of a richer and strong array of evidence, compared to what could be achieved by any single method in isolation (Scott, 2016; Yin, 2013).

Nevertheless, the choice of a mixed-methods design is complicated by the question of how and when to use qualitative and quantitative methods in the design process. To address this dilemma, principles of prioritisation and sequencing are proposed (Bryman, 2012a; Morgan, 2013a). With prioritisation, a decision has to be made as to whether both methods play equal roles, or one method takes a role as a core-method, and the other a supplementary method to add to the strength of the former. The current research did not prioritise one methods over the other, so it adopted the concurrent mixed-methods design which is common when both methods are given equal priority (Creswell, 2014a). The design allows qualitative and quantitative data collection and analysis to be conducted simultaneously and independently and results being integrated during interpretation and conclusion (Fetters et al., 2013; Yin, 2013).

By the time of conducting fieldwork, the eIDSR intervention had already been implemented in 10 regions which together had 70 districts and nearly 3,000 HFs. The implementation of the eIDSR intervention involves all four levels of the healthcare system in Tanzania: HFs, council, region and national levels. Thus, all four levels were included in the current research. The sampling strategy for the units of observation and study participants is described in the next sub-section.

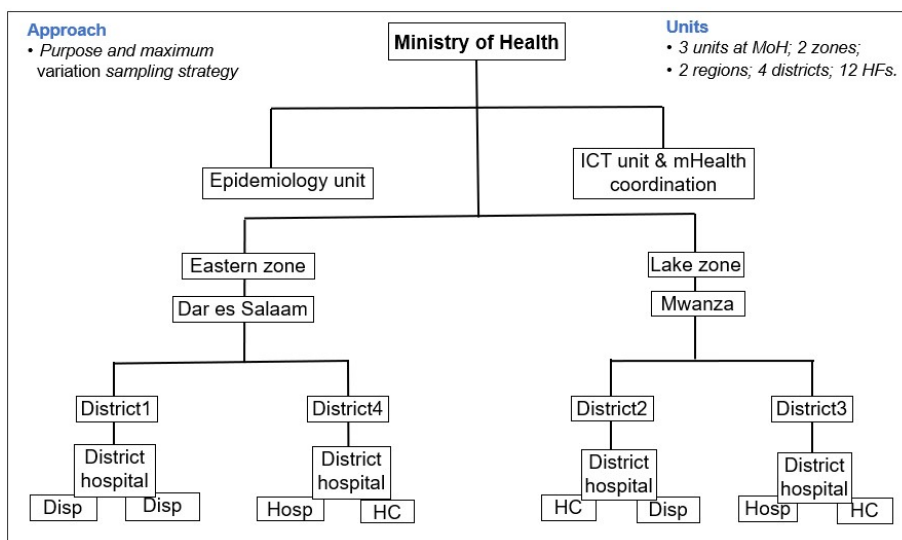
3.3.1. Sampling strategy

A nonprobability sampling approach was used to select units of observation and study participants by employing a purposive and maximum variation sampling strategies. Purposive sampling focused on selecting the most relevant units of observation to answer the research question, hence it was used because the research was confined within cases or units in which eIDSR is being implemented and involved individuals (Marshall, 1996). Additionally, maximum-variation-strategy was used to add to the rigour of the purposive sampling, taking advantage of studying a broad range of units to obtain broad insights and solicit shared patterns that cut across cases and derive their significance from having emerged out of heterogeneity (Kim et al., 2017; Marshall, M.N., 1996; Palinkas et al., 2015).

At the MoH, 3 departments comprising the national team were purposefully selected: epidemiology unit (lead implementer and eIDSR owner); national mHealth coordination; and ICT unit (technical support). In lower levels, pragmatic maximum variation sampling strategy was used to include a wide range of contextual factors likely to influence eIDSR implementation process and patterns of use. Two ecological zones were selected from the four in which eIDSR had already been deployed to allow comparisons between contexts and implementation environments. From each zone, one region was selected. Sampling criteria used to select districts in each region were level of development (rural-

urban variations); stages of eIDSR implementation (piloting vs scaling up); and duration of eIDSR use. HF's were selected based on ownership (public or private), type/size (primary or secondary), and distance from district capitals. Figure 11 summarises the sampled units of observation.

Figure 11: Sampled organisational units to inform the study



Key: Disp – dispensary; HC – health-centre; Hosp - hospital

Zones and regions

Eastern and Lake zones were selected. The former is along the Indian Ocean and the latter around the Lake Victoria. Ecological zones, though not exclusive, are differentiated by ecological features such as the weather, biodiversity characteristics, and prevalence of communicable diseases. For example, malaria prevalence varies between 1% to 33% across zones (Ifakara Health Insititute, 2014). Dar es Salaam and Mwanza regions, located about 1,100kms apart, were selected from Eastern and Lake zone respectively because some districts in these regions were among the first to be deployed with eIDSR and others were covered during the scaling up stage. Also, the two regions provide a heterogeneous epidemiological, ecological, social and economic environments potential to affect eIDSR implementation and use.

Dar es Salaam is the commercial and largest city with a population of more than 4.3M (NBS, 2014). It has the largest international airport and port, making it the major point of entry to the country. Up to March 2016, when the fieldwork for the current research started, Dare es Salaam was divided into 3 administrative districts of Kinondoni, Temeke and Ilala as plotted in Figure 48 in Appendix G, all urban (municipal councils) but have some areas with rural setting (Dar es Salaam, 2004; NBS, 2014). Ilala separates the other two and forms the central business district of Dar es Salaam city. According to Tanzania 2012 census (NBS, 2014), Kinondoni and Temeke municipal councils had a

population of about 1.8M and 1.4M people respectively. In mid-2016, two additional district councils were formed: Kigamboni from Temeke and Ubungu from Kinondoni.

Mwanza region has a population of about 2.7M (NBS, 2014) and 7 administrative districts, as shown in Figure 49 in Appendix G, two of which form the Mwanza city (Tanzanian second-largest city) and the rest have rural settings (Ministry of Agriculture, 2012). Mwanza borders two countries, Kenya and Uganda. It is the second major point of entry to the country through Lake Victoria and Mwanza International Airport.

District level and HFs

Two districts were sampled from Dar es Salaam before the division (named District1 and District4) and 2 from Mwanza regions (named District2 and District3). The eIDSR intervention was implemented in District1 and District2 during the piloting stage and District3 and District4 during scaling up stage. Table 6 summarises the diversity of features used to sample the districts from the four regions.

Table 6: Criteria used to guide the selection of districts

| Criteria | District1 | District2 | District3 | District4 |
|----------------------------|---------------|-----------|-----------|---------------|
| Location /region | Dar es Salaam | Mwanza | Mwanza | Dar es Salaam |
| Settings | largely Urban | Rural | Rural | Largely Urban |
| Number of HFs | 127 | 43 | 44 | 144 |
| eIDSR deployment | Nov 2013 | Jan 2014 | May 2014 | Aug 2014 |
| Distance from support team | 9km | 1,090km | 1,040km | 4km |
| eIDSR usage by Dec 2016 | 38 months | 36 months | 18 months | 16 months |

Three HFs, one being a district hospital, were selected from each district after consulting respective IDSR_DCo. District hospitals are the first level of hospital referral services, located within district capitals. The latter have semi-urban or urban setting, hence likely to have relatively good mobile phone network coverage, reliable electricity and internet connection. District hospitals are located in the same compound with or close to CHMT offices, hence receiving a close administrative support. They have more capacity in terms of health personnel, medical equipment and lab facilities. They receive more patients through direct visits or as referrals from PHFs, hence likely to record more cases of diseases under surveillance. Thus, district hospitals were included to assess the extent to which eIDSR is used different from PHFs. The rest of the sampled HFs were selected based on the following criteria:

- deployed and using eIDSR.
- located not more than 30km away from the district capital.
- a mix of HFs size was (hospitals, health centres, or dispensaries).
- a mix of HF ownership (private or public), subject to availability.

Rural districts have fewer hospitals and private HFs compared to urban districts. For example, by the time of conducting fieldwork, District2 did not have a private HF and had only one hospital. District3 had a district hospital and another privately owned. Each of District1 and District4 had more than 10 privately owned HFs and more than 5 hospitals. Table 7 summarises the characteristics of sampled HFs in each district.

Table 7: Sampled HFs and characteristics variations.

| District | HF | Type | Setting | Ownership | eIDSR use (months) |
|-----------|-----------|-------------------|---------|-------------|--------------------|
| District1 | HFS1Dist1 | District hospital | Urban | Public | 38 |
| | HFS2Dist1 | Dispensary | Rural | Public | 38 |
| | HFS3Dist1 | Dispensary | Urban | Private | 38 |
| District2 | HFS1Dist2 | District hospital | Rural | Public | 36 |
| | HFS2Dist2 | Health-centre | Rural | Public | 36 |
| | HFS3Dist2 | Dispensary | Rural | Public | 36 |
| District3 | HFS1Dist3 | District hospital | Rural | Public | 18 |
| | HFS2Dist3 | Hospital | Rural | Private/FBO | 18 |
| | HFS3Dist3 | Health-centre | Rural | Public | 18 |
| District4 | HFS1Dist4 | District hospital | Urban | Public | 16 |
| | HFS2Dist4 | Hospital | Urban | Public | 16 |
| | HFS3Dist4 | Health-centre | Urban | Private | 16 |

Study participants

A total of 24 participants were sampled. Table 8 gives the list of participants from each unit and their roles in the eIDSR intervention. All participants were consulted at their places of work for interviews (explained later), except one who was engaged through skype because he was abroad. Two other participants, one at the national level and another at HFS1Dist2, were sampled but could not be reached.

Table 8: Study participants from each observation unit

| S/n | Units | Roles in the eIDSR intervention | Participants |
|-----|----------------------|--|--------------|
| 1 | National level | National coordination, implementers, and technical support | 4 |
| 2 | Dar es Salaam region | Regional coordination | 1 |
| 3 | Mwanza region | Regional coordination | 1 |
| 4 | District1 | District coordination | 2 |
| 4 | HFs in District1 | HF users | 3 |
| 6 | District2 | District coordination | 1 |
| 7 | HFs in District2 | HF users | 2 |
| 8 | District3 | District coordination | 2 |
| 9 | HFs in District3 | HF users | 3 |
| 10 | District4 | District coordination | 1 |
| 11 | HFs in District4 | HF users | 3 |
| | | Total number of participants | 24 |

Tracer diseases

A total of 23 diseases and conditions are reported through eIDSR, grouped into two categories: epidemic-prone diseases which are immediately captured as identifiable case-based reports; other diseases captured weekly in aggregated format. Cholera and malaria were chosen because the current research aimed to assess eIDSR use for both categories of diseases. A preliminary study of weekly epidemiological reports, posted on the MoH website (MoH-Tanzania, 2016a), was done to guide the choice of tracer diseases. Cholera was sampled because data indicated there had been frequent outbreaks in different parts of the country. Also, the current research was designed when the country had one of the major cholera outbreaks in record, hence took advantage of the situation to assess effectiveness of eIDSR use. Malaria is an endemic diseases of public health importance, hence it was selected to represent weekly reported diseases because Dar es Salaam and Mwanza were marked as being malaria hotspots.

3.4. Data collection and analysis

The current research was conducted retrospectively, covering the first 4 years of the eIDSR intervention from January 2013 to December 2016. From January to October 2013, the investigation focused on the eIDSR adoption process and initial implementation activities leading to piloting stage. From November 2013 to December 2016 the research covered the implementation processes and eIDSR use.

Quantitative and qualitative data were collected in parallel. The main fieldwork for data collection in Tanzania was conducted between March and July 2016, in which I visited all units of observation and interviewed all participants. Also, I was granted access to the DHIS2 database to assess eIDSR and HMIS data. However, some of the datasets, particularly clinical records, could not be collected and following up after returning to the UK proved to be unfruitful. Therefore, a second fieldwork visit was conducted for three weeks between March and April 2017.

During the research design stage, there was no information in the public domain about the implementation of eIDSR intervention. Accordingly, designing the data collection approach, relevant to the organisation and operations of the intervention, was technically challenging. Therefore, before starting data collection, the study design was discussed with some of the key participants at the national level. It was set to collect data starting with the national level and narrowing down to the lowest (HFs) level consistent with how the intervention was being implemented. This approach would provide an opportunity to understand the project and nature of data reported prior to engaging users at lower levels. Nevertheless, it was proved to be impractical because permissions to collect data in some units at the higher levels and appointments were significantly delayed different

from those in lower levels. Thus, the plan was periodically revised to allow starting with units where permissions were granted, or appointments honoured.

In Table 9 is the list of quantitative and qualitative data collected. They are described in detailed in the next sub-sections.

Table 9: Types of quantitative and qualitative data collected

| Quantitative data | Qualitative data |
|---|--|
| • Case-based clinical records at HFs | • Semi-structured interviewing of eIDSR implementers and users |
| • Disease surveillance records reported through eIDSR | • Written documents related to eIDSR implementation and use |
| • eIDSR system usage logs | • Observational data on eIDSR setup and use |

3.4.1. Quantitative methods

The quantitative component on the current research was informed by four types of data.

- a) Patient identifiable cholera and malaria clinical records from which surveillance data are captured at HF level. These data were captured at HF level and were used to assess the value and accuracy of the source disease surveillance data before being submitted through eIDSR (assessing the relevance of the target of change).
- b) Cholera and malaria data submitted through eIDSR and asHMIS monthly reports, both in the DHIS2 database. They were used to assess the effect of eIDSR use on reporting accurate and data completeness (measuring the quality of eIDSR use).
- c) System logs extracted from the DHIS2 database indicating eIDSR use for reports submission from HFs. They were used to assess reporting quality through eIDSR for individual FHs and districts (measuring the pattern and consistency of eIDSR use).
- d) Dummy data collected from fieldwork and DHIS2 database of eIDSR implementation-related features. They were used to assess factors potential to influence eIDSR use over time (measuring factors affecting implementation effectiveness).

(1) Data quality parameters and analysis

Data quality is the value that makes data fit for use by data consumers. In the healthcare context, the value can be observed when data are used for function such as screening patients, making diagnoses, making clinical decisions, and monitoring of disease outbreaks (Marjanovic et al., 2017; Weinstein et al., 1980). Thus, the effect of using a digital information system (IS) such as eIDSR on data availability and quality, is an important indicator of its value to the implementing stakeholders (Aqil et al., 2009; DeLone and McLean, 2003). Also, it can demonstrate the frequency and quality of system use.

Data quality is measured by a set of quality attributes representing a single construct of data called data quality dimensions (Petter et al., 2013; Wang, R.Y. and Strong, 1996). Among the common dimensions discussed in the IS studies are completeness, timeliness, currency, accuracy, reliability, availability, precision, currency and relevancy (DeLone and McLean, 2003; Pipino et al., 2002; Strong et al., 1997; Wang, R.Y. and Strong, 1996)

Generally, digital solutions are implemented, inter alia, to improve a wide range of data quality dimensions subject to what implementers intended to change. The current research employed an empirical approach by pragmatically identifying data quality dimensions regarded by eIDSR implementers as more important to inform disease surveillance and response functions (MoH-Tanzania, 2011; Wang, R.Y. and Strong, 1996; WHO/AFRO, 2001; WHO/AFRO, 2010a). Of which, data accuracy, completeness and timeliness are repeatedly identified, in IDSR-related studies from SSA, as being poor, hence weakening the effectiveness of surveillance and response systems (Gueye et al., 2005; Mboera and Rumisha, 2005; Mghamba et al., 2004; Mwanyika et al., 2013; WHO/AFRO, 2001). Similarly, the value dimension is largely used to assess the usefulness of clinical records in HFs (Pipino et al., 2002; Weinstein et al., 1980). The current research considered the dimensions defined in Table 10 to assess the implementation effectiveness of the eIDSR intervention.

Table 10: Dimensions of data quality examined in this study

| S/n | Dimensions | Operational definitions |
|-----|--------------|--|
| 1 | Value | The extent to which data are beneficial and provide advantages from its use (Pipino et al., 2002). The value dimension was used to assess the how clinical record are used to inform treatment decisions. |
| 2 | Completeness | The extent to which data are not missing and have the necessary parts, elements, or steps (Michnik and Lo, 2009; Pipino et al., 2002). • It was used to measure the extent to which eIDSR facilitates frequent submission of disease surveillance reports from HFs. |
| 3 | Timeliness | The extent to which data is sufficiently up-to-date for the task at hand (Pipino et al., 2002). • It was used to examine how eIDSR facilitates timely submission of reports from HFs |
| 4 | Accuracy | Free from mistake or errors; the degree of conformity of a measure to a standard or a true value (Michnik and Lo, 2009). • It was used to investigate whether surveillance data represent the same reality as the corresponding clinical records in HFs. |

(2)Value of source clinical records

Clinical records include diseases or condition specific diagnosis, medical history, treatments decisions and outcomes (Markert et al., 2004; Weinstein et al., 1980; Williams and Peet, 1994). Their value is described as their usefulness to inform treatment decisions, demonstrated by examining the difference in treatment outcome rates,

contingent upon using records as opposed to outcome rates without the use (Markert et al., 2004; Weinstein et al., 1980). Outcomes may be situations such as patient death, life shortened or prolonged, disability, cure or experiencing more, less, or no pains. These variables are attached to arbitrary numerical values (number of patients) that can be categorically analysed in terms of frequency counts and relationships between variables (Bowers et al., 2013; Field, 2018). The same applies to other variables, such as the number of lab test requests, test results or number of patients treated.

(a) Data collection

Clinical records of cholera outbreak captured from August 2015 to June 2016 were collected from 2 districts, District1 and District4. They were collected from IDSR_DCo who kept them as line lists in Microsoft (MS) Excel spreadsheets. Malaria clinical records for the same period were collected from HF1Dist4, a district hospital. They were collected from paper based OPD, IPD and laboratory HMIS register books.

The HMIS books capture records of all diseases attended at the HF. Thus, with the help of a research assistance, targeted records were scanned to identify and tally malaria records. Test requests were tallied from OPD and IPD books and test results were counted from laboratory books. Similarly, some test results were recorded against the corresponding test requests in OPD and IPD books. Records were tallied manually then written on paper-based tables before being transferred into MS Excel spreadsheet.

(b) Data analysis

Contingency tables were used as data analysis tools. The records were categorised into test requests, test results, confirmatory tests, treatment decisions (medication) and treatment outcomes (cures or deaths). Frequency distribution were calculated, and categorical analysis was carried out to assess how the records are used to inform clinical decisions and the subsequent effect on treatment outcomes. Using MS excel, relative frequency distribution tables and categorical contingency tables were built as follows:

Assume X = “tests performed” and Y = “test results”, are categories with values X ($X_1 = \text{tested}$, $X_2 = \text{not tested}$) and Y ($Y_1 = \text{positive}$, $Y_2 = \text{negative}$), respectively. A “2 X 2” contingency table is given as shown in Table 11 where a, b, c and d represent frequencies counts for each variable.

Table 11: Formula for a “2 X 2” frequency county contingency table

| X/Y | X_1 | X_2 | Total |
|-------|-------------|-------------|-------------|
| Y_1 | a | b | (a+b) N_1 |
| Y_2 | c | d | (c+d) N_2 |
| Total | (a+c) N_3 | (b+d) N_4 | (a+b+c+d) N |

Table 12 and Table 13 give the corresponding relative frequency distribution and conditional probabilities respectively.

Table 12: A “2 X 2” relative frequency distribution table

| | | | |
|----------------|-------------------|-------------------|-------------------|
| X/Y | X ₁ | X ₂ | Total |
| Y ₁ | a/N | b/N | N ₁ /N |
| Y ₂ | c/N | d/N | N ₂ /N |
| Total | N ₃ /N | N ₄ /N | (a+b+c+d)/N |

Table 13: Condition probability from contingency frequency tables

| Condition | Conditional probability | Condition | Conditional probability |
|-------------------|---------------------------------------|------------------|------------------------------------|
| N ₁ /N | P(Y ₁) | a/N ₁ | P(X ₁ /Y ₁) |
| N ₂ /N | P(Y ₂) | b/N ₁ | P(X ₂ /Y ₁) |
| N ₃ /N | P(X ₁) | c/N ₂ | P(X ₁ Y ₂) |
| N ₄ /N | P(X ₂) | d/N ₂ | P(X ₂ /Y ₂) |
| a/N | P(Y ₁ and X ₁) | a/N ₃ | P(Y ₁ /X ₁) |
| b/N | P(Y ₁ and X ₂) | b/N ₄ | P(Y ₁ /X ₂) |
| c/N | P(Y ₂ and X ₁) | c/N ₃ | P(Y ₁ /X ₁) |
| d/N | P(Y ₂ and X ₂) | d/N ₄ | P(Y ₂ /X ₂) |

As an example, the conditional probabilities given in Table 13 are interpreted as follows;

- P(X₁) = probability of being tested and P(Y₁) = probability of testing positive.
- P(X₁/Y₁) is the probability for being tested given a patient is positive and P(Y₁/X₁) is the probability of being positive given a patient is tested.
- P(Y₁ and X₁) is the probability of being positive and tested and P(Y₁ and X₂) is the probability of being positive but not tested .

The conditional probabilities explain how clinical data were used to inform clinical treatment decisions.

The contingency tables were expanded to more than 2 variables such as adding a “Z” treatment variable with “Z₁ = treated”, and “Z₂ – not treated”; or dimensions of variables such as adding “Z₃ = no treatment record”.

(3) Completeness, timeliness and accuracy

Completeness and timeliness dimensions were used to assess the pattern of eIDSR use for reporting submission, hence measuring “reporting completeness” (RC) and “reporting timeliness” (RT). In the current research, term “reporting quality” is used in reference to both RC and RT.

(a) Data collections

There are two types of reports submitted through eIDSR. First is a report of epidemic-prone diseases of which suspected cases or deaths are submitted individually as a patient identifiable report within 24 hours of identification. Second is a weekly aggregated

report in which records of 9 diseases are submitted together as one report. This report has to be submitted on Mondays by 3.00pm whether cases are identified or otherwise. For epidemic-prone diseases, a report is submitted only when a case or death is suspected.

A weekly HF RC assumes a dichotomous value: 1 when a report is submitted, 0 otherwise. Similarly, for RT in which 1 is when a report is submitted on time, 0 otherwise. For epidemic-prone diseases, RC and RT are recorded only when such cases are being identified in HFs. Whenever a report is submitted, besides data values, the DHIS2 database keeps submission logs. Thus, the logs for each of the 12 sampled HFs and the 4 districts were extracted, exported into tables, and downloaded as MS Excel files.

(b) Analysis of reporting quality

For a given time interval, RC and RT rates for a given HF for both patient identifiable and weekly reports are computed as,

- RC rate = $\frac{n}{N} \times 100$, and RT rate = $\frac{t}{N} \times 100$, where N = total number of expected reports from a HF; n = number of reports submitted, and t = number of timely submitted reports.
- The district RC and RT rates are cumulative performances of its HFs, thus assume a continuous value between 0 and 1. Hence, for district with C number of HFs,
 - RC rate = $\frac{n_1+n_2+..+n_c}{N_1+N_2+..+N_c} \times 100$, and RT rate = $\frac{t_1+t_2+..+t_c}{N_1+N_2+..+N_c} \times 100$

Data completeness (DC) is the proportion of data elements in each report submitted through eIDSR that are completely captured/ filled. It was computed as,

- DC rate = $\frac{x}{Z} \times 100$, where Z = total number of data elements in a report; and x = number of data elements captured in a report = x

Two aspects of data accuracy dimensions were validated. Firstly, the accuracy of total number of individual reports submitted through eIDSR against the corresponding number of source reports at a HF.

- DA rate = $\frac{q}{P} \times 100$, where P = number of aggregated records in HFs; and q = number of aggregated records submitted through eIDSR.

Secondly, the accuracy given by number of data elements correctly captured in a submitted individual report against the corresponding source report in a HF.

- $DA = \frac{y}{Z} \times 100$, where Z = total number of elements in a single report; and y = number of data elements correctly captured.

Table 14 contains a list of data elements to be captured for each individual cholera case or death report submitted through eIDSR.

Table 14: Data elements in individual cholera record submitted through eIDSR

| S/n | Data elements | | |
|-----|----------------------------|----|-----------------------------------|
| 1 | Submission date | 11 | Case ID (submission confirmation) |
| 2 | HF code | 12 | Is the patient alive? |
| 3 | HF name | 13 | Days since death occurred |
| 4 | Age | 14 | Days since symptoms |
| 4 | Age Type (years or months) | 14 | Patient status (admitted or OPD) |
| 6 | Contact Tracing | 16 | Was Lab specimen taken? |
| 7 | Investigation | 17 | Was patient Vaccinated? |
| 8 | Quarantine | 18 | Where was specimen sent? |
| 9 | Referred | 19 | Approve Case |
| 10 | Case Definition | 20 | Sex |

Moreover, since HMIS monthly reports entered into the DHIS2 at the district level and they duplicate numerical diseases surveillance data, they were also used to enhance the quality validation of eIDSR data.

(4) Factors influencing reporting quality

The current research sought to quantitatively establish potential factors likely to influence eIDSR use, using an estimation of the causal effect concept. Causal effect is the effect on an outcome of a given action or treatment, as measured in an ideal randomised controlled experiment (Stock and Watson, 2012). The assumption was made that RC and RT rates are outcome variables affected by multiple treatment conditions (predictor variables) within and between HFs and districts. The considered predictor variables and the assumptions made were:

- Time in weeks: the research considered a timeframe of 164 weeks from the first week in the pilot HFs (Nov 2013 to Dec 2016). So, for each HF or district, number of weeks ranged from when it was deployed eIDSR up to week number 164.
- Type/size of HF- a dummy variable: 1 for hospital, 0 primary HF (PHFs). Presumably, circumstances influencing eIDSR use in hospitals are different from those in PHFs.
- HF location/setting- a dummy variable: 1 for rural, 0 for urban. Rural HFs and districts face organisational and infrastructural challenges different from those in urban areas.
- FH ownership- a dummy variable: 1 public, 0 private. HFs management, modus operandi, resources availability and practices are different between the two.

- Districts and HFs- categorical value based on sample size: districts and HF within the same districts have different contextual circumstances such as resources availability, leadership and infrastructure, which are likely to influence eIDSR use.
- Deployment- dummy variable: pilot 1, scaling up 0. Pattern and quality of eIDSR use in pilot HFs or districts differ from those deployed during scaling up stage.

(a) Data collection

Data for computing weekly RC and RT rates were extracted from the DHIS2 database. Only the 12 sampled HFs were included for analysis on HFs. Data about HF location were collected manually during fieldwork visits; deployment captured from eIDSR project documents; and ownership and type from DHIS2 metadata. Different from HFs, data about all predictor variables for the districts could be extracted from the DHIS2. Therefore, the analysis for the latter included all 70 districts wherein eIDSR had already been implemented by January 2016 (164 weeks for the pilot district and 52 weeks for the 70th). Covering the whole population of districts, provided a stronger evidence for causality argument.

(b) Data analysis

Using a causal effect conception, multiple regression models were stepwise built the using panel data, regressing RC and RT against the explanatory variables. The analysis and graphical visualisation was done using R, a free software environment for statistical computing and graphics (The R Foundation, 2019).

3.4.2. Qualitative methods

The qualitative component of the study focused on obtaining narrative providing whole picture of the eIDSR intervention, from the adoption stage. Thus, qualitative data aimed to provide an in-depth understanding of the context in which the intervention was envisioned; adoption process and pre-implementation considerations made; technologies, functional design and acquisition eIDSR application; the implementation approach, plans, phases, process, events and activities. Also, to give explanations about data quality, eIDSR use for reports submission, and data analysis and use practices.

Three sources of data were selected: (i) experience narratives and views of eIDSR implementers and users obtained through semi-structured interviews; (ii) analysis of documents related to eIDSR project (activities, progress reports, meeting notices, and data analysis reports); (iii) non-participant observation of how eIDSR is being used.

(1) Semi-structured interviewing

Three main types of interviewing methods are widely employed in social research: survey or structured interviewing for quantitative studies, and unstructured/open-ended and semi-structured interviewing for qualitative studies (Bryman, 2012b; Ravitch and Carl, 2015). The current research employed semi-structured interviewing because it aimed to collect rich information about the eIDSR intervention from different groups of participants with related roles but located in different units of observation using specific, tailored and follow-up questions within and across interviews (Bryman, 2012b; Ravitch and Carl, 2015). Participants groups were eIDSR users in HFs, district and regional managers, and national managers. Since the groups have different roles in the eIDSR intervention, 3 versions of participant information sheets (PIS) and interview guides were deployed. The PIS for participants in HFs and its Swahili version is appended in Appendix F (pg 220-223). The other two had slight differences to address some specific issues to participants based on their positions in the DSS. The interview guides were designed as follows

- The first version (Appendix F, pg 226) focused on understating the goal of eIDSR interventions; adoption process; the eIDSR application and its technologies; implementation approach, plans process, and activities; eIDSR use; and the value eIDSR is adding to diseases surveillance and response functions. Participants in this group came from the national team which coordinates the implementation and provides support to lower levels.
- The second interview guide (Appendix F, pg 228) sought the intervention information from district and regional managers, roles they play, nature of change introduced, and how they process and use data submitted through eIDSR.
- The third interview guide (Appendix F, pg 232) was specific for eIDSR users in HFs where surveillance data are captured. Specific topics covered included data capturing process, eIDSR use, their overall participation in eIDSR intervention.

(a) Interviewing process

Once permission to collect data in a given unit was granted, appointments were set with potential participants physically or through phone calls. Some were sceptical about their participation, hence requested to be given PIS in advance. Otherwise, on the interview appointments, participants were firstly provided with printed copies of PIS read before consenting by signing consent forms. They were given option to choose between English and Swahili versions. Several participants preferred oral explanation over reading the PIS. Others required further clarifications about the research purpose, nature of information they were expected to provide, and the need to sign a consent form. Majority

were more comfortable to sign consent forms at the end of interviews. They were given copies of signed consent forms to keep for their reference.

Regarding language use for interviews, 21 participants chose Kiswahili and 3 English. Notwithstanding the latter, interviews conducted in Kiswahili had a significant level of code-mixing and code-switching between the two languages. This practice is a common communication practise among the working class, and more evident among health professionals. The interview duration varied subject to participant's participation or level of knowledge about the intervention, time slot offered or information saturation. The shortest interview took 14 minutes, the longest 78 minutes. All interviews were conducted at participants' place of work, except three. For the later, one interview was conducted over Skype because the participant was abroad. The other two, one participant had time only over the weekend and the other could only be available late in the evening after working hours. Thus, they were interviewed in an office I was given at ColCT campus.

Interviews were tape-recorded except for two participants of whom one accepted a short interview without being recorded because he was occupied attending patients. The second had very little to say about the eIDSR intervention because, despite being registered as a HF user, he had never submitted data. For both, notes were taken.

(b) Interviews transcription and translation

Whenever possible, I started transcribing the interviewing records soon after interview sessions, but most of the work was done after coming back to the UK. The Express Scribe Transcription Software v14.2 was used to facilitate the transcription which was done using verbatim approach. Selectivity approach was also used for recordings in which participants diverted from guided questions by giving voluminous information irrelevant for the present research. In this case, only relevant phenomena and themes were selectively extracted during transcription. Interviews conducted in Kiswahili were simultaneously transcribed and translated into English, to preserve the actual wordings and meanings.

Before starting the transcription and translation process, each record was played at least twice for clarity purpose. After producing the first draft for each transcript, it was read word to word twice, to ensure the information was clearly captured without loss of ideas or meanings. When necessary, the corresponding recording was replayed. Transcripts were given a unique anonymous ID specifying participants and location; password-protected and stored in my personal folder (Drive M) in the University of Leeds computer network. I did the transcription myself because doing that drew me closer to the data and preserved the meanings and ideas attached, which could otherwise be distorted if I had

used a translator. Also, I could not afford paying for translation services with the resources I had.

(2) A non-participant unstructured observation

Non-participant unstructured observation was employed with the aim of developing a narrative account of participants' behaviour or practices related to eIDSR use (Bryman, 2012e). It was intended to provide an understanding of the arrangements, practices and processes of data capture and reporting by HF users; how district managers engage with eIDSR users in HFs, analyse and use submitted data. Unstructured field notes were recorded in a notebook, organised and transferred into a word document. Very little data was collected using this approach because, as it will be presented in results chapter 5 and 8, the eIDSR was rarely used. During the fieldwork, only one of the 12 sampled HF users was observed using eIDSR for data submission. Also, none of the district managers was observed using eIDSR or data.

(3) Documents review

Documents are important sources of evidence to inform scientific studies by providing the context in which the research happens and history of the topic under investigation (Ravitch and Carl, 2015; Yin, 2013). In the present research, eIDSR related documents were important to provide historical narratives of eIDSR intervention; its implementation approach, plans, process, activities, challenges and lessons. Also, they were expected to indicate how eIDSR is being used and an account of data analysis and use practices. Documentary data were corroborated with information from other forms of data (Ravitch and Carl, 2015); to verify the correctness of information collected through interviews, or supplement missing data (Yin, 2013).

Thus, at the end of every interviewing session, participants were asked to share any documents they had related to eIDSR implementation or data use. A total of 22 documents were collected, some in electronic format and some printed. They contain information about initial activities on requirements gathering; software acquisition and development plans; training materials; user manuals; software design; system release; training reports; data collection tools; meeting notices; supportive supervision visits, and implementation progress reports. All documents were collected from members of the national team except two which were collected from one district. Most of these documents were drafts (incomplete), short and kept in personal computers. Largely, the eIDSR implementation approach, plans, process and activities were poorly documented. Also, there was neither an original project proposal document nor any other document reporting about data analysis or use practices.

(4) Analysis of qualitative data

Qualitative data analysis was done using framework analysis: the method or technique belongs to a family of thematic analysis methods in qualitative research, such as content analysis (Gale et al., 2013; Srivastava and Thomson, 2009). Unique to this method is the analysis approach, in which commonalities and differences in qualitative data are identified, relationships between different parts of the data are established and, as a result, making it possible to draw descriptive and/or explanatory conclusions clustered in themes (Gale et al., 2013). Different from other types of thematic analysis, framework-analysis better suits a type of research with specific questions, a limited time frame, a pre-designed sample and prior issues that need to be addressed (Srivastava and Thomson, 2009).

The aforementioned characteristics of framework analysis are consistent with the focus and methodological approach of the current study. It focused on a specific organisational issue (implantation effectiveness of eIDSR intervention); responding to specific research objectives; was conducted within a limited timeframe; and the sample was predesigned. Likewise, the study was guided by a predefined conceptual framework drawn from an organisational change perspective. The data analysis employed a mix of deductive and inductive approaches. Theoretical concepts, derived from the conceptual framework, were used to provide a guiding framework for developing coding schemes. This approach was carried out flexibly, to allow emerging ideas, from the data, to develop into concepts and sub-themes.

The analysis was carried out systematically to respond to each research objective in turn, based on thematic constructs. While most of the documents such as interview transcripts and implementation reports were relevant to inform different objectives, some documents were relevant to specific topics. For example, documents related to eIDSR development and technical manuals were used specifically to examine the acquisition process of the eIDSR application, applied technologies and its functional design.

(a) Data analysis process

The framework analysis proposes seven chronological stages to be followed in the analysis process: data familiarisation, identification of a thematic framework, indexing/coding process, charting data into the framework, mapping, and interpreting the data (Gale et al., 2013; Smith and Firth, 2011). Following these stages in the current research, the framework guided a systematic process in organising data, developing and categorising codes, and developing codes into concepts. Prior to coding, familiarisation with data was done by rereading all documents include in the analysis, then naming and

grouping them based on their contents. Thereafter, documents were uploaded into Nvivo version 11, a Computer Assisted Qualitative Data Analysis Software (CAQDAS).

Using the conceptual framework as a guiding theory for analysis, the main concepts/themes were drawn to construct a thematic framework. Interesting ideas and concepts were developed into sub-themes and concepts, forming coding references and categories. This process was iterative, as more ideas and concepts were emerging from data. After exhausting relevant concepts, developed codes and coding categories were reviewed. Reference was made to the source documents whenever clarity was needed. In the review process, some codes and codes categories were renamed, recategorised, merged or deleted. Some codes had useful information, but it was not clear where they fall among codes categories. Thus, they were saved in a separate folder and referred to when seemed to add value in building specific concepts.

Next to the coding and categorising process, each document was made into a case, to represent units of observation. Using a framework matrix feature in Nvivo, cases were cross tabulated against codes categories. Separate matrices were developed for each main theme as a means of managing the volume of data and number of codes categories. Thereafter, the matrices were exported to Excel files as tables followed by further analysis to develop concepts and sub themes from extracted contents. Excel tables made it possible to identify differences and commonalities between ideas and units of observation; establish relationships from immersing concepts; develop explanations and interpretations. Summary tables were created for each theme and subsequent sub themes, in which descriptive and interpretative analysis was carried out. The analysis was further informed by specific quotes from the cases (sources of data). Finally, the analytical outputs were developed into chapter sections and full chapters.

3.4.3. Presentation of results chapters

Chapters 4, 5, and 8 are informed by qualitative results only while quantitative results were used to supplement and corroborate quantitative results in chapter 6 and 7. The table below provides a summary of types of data used to inform the result chapters.

Table 15: Type of data used to produce results of each of the results chapters

| Chapters | Type of data used for analysis |
|---|---|
| 4 Qualitative results | <ul style="list-style-type: none"> • Documentary • Interviews • non-participant observation |
| 5 Qualitative results | <ul style="list-style-type: none"> • Non-participant observation • Interviews • eIDSR implementation documents |
| 6 Quantitative and qualitative results | <ul style="list-style-type: none"> • Cholera clinical records from two districts (quantitative). • Aggregated malaria records from one hospital (quantitative) • Non-participant observation and interviews (qualitative). |
| 7 Quantitative and qualitative results | <ul style="list-style-type: none"> • Cholera and malaria records used in chapter 6 (quantitative). • Cholera and malaria records submitted through eIDSR (quantitative). • Cholera and malaria aggregated HMIS data in DHIS2 (quantitative) • Weekly reports submission eIDSR system logs (quantitative). • Dummy data on context-based eIDSR implementation factors (quantitative). • Interview and documentary (qualitative). |
| 8 Qualitative results | <ul style="list-style-type: none"> • Interviews • eIDSR implementation documents |

3.5. Ethical considerations

(1) Research ethical approvals

Prior to applications for ethical approvals, this research was approved by the University of Leeds Postgraduate Research and Operations as seen in appendix A. Also, I secured a written consent for conducting the research from the MoH in Tanzania (appendix B), and a supporting letter from UDSM, a local institution to which the researcher affiliates (appendix D).

The research was approved by the University of Leeds (School of Medicine Ethics Committee) on 16/02/2016 and granted an ethical clearance certificate with reference number MREC14-037 (appendix C). Also, it was approved and registered by the National Institute of Medical Research (NIMR) in Tanzania on 27/04/2016 with reference number NIMR/HQ/R.8a/Vil.IX/2182 (appendix E).

Ethical issues, considered in this study, included information handling and confidentiality; cultural values; the anonymity and privacy of participants, and permission to collect data from participants. After the ethical approval, the permission to collect data was sought from the permanent secretary for the MoH Tanzania. At the regional and district levels, permission was requested from the RMOs and DMOs, respectively. I managed to meet 3 of the 4 DMOs in person and clarified to them more about the research and its benefit to them. I used the meeting opportunities to seek DMOs understating of the eIDSR intervention and how they, as CHMT leaders, were participating in the implementation process. I did not manage to meet the 4th DMO and the RMOs since they delegated the

process to the respective IDSR coordinators. Permission to access to data and participants in HFs was sought orally from HF leaders after authorisation by the DMOs. Once permissions were granted, appointments with were set with potential participants face to face meeting or phone calls.

(2) Information privacy

This study consulted FHWs in HFs, who were eIDSR users, and IDSR coordinators managers at the district, regional, and national levels. All data collection activities took place in the participants' offices. The research design did not require interaction with patients. However, I had access to patients' identifiable records and aggregated data, hence a concern about privacy and confidentiality of data. The later was addressed by observing the specified study protocols agreed and any specific instructions given by participants. I had the necessary research ethics skills learnt at the University of Leeds, as part of my PhD training programme. Also, my working experience as a HIS consultant to the MoH was useful in adhering to ethical concerns specific to the research setting.

Access to the records in the DHIS2 national database was granted by the MoH. Credentials were limited to accessing system components and data relevant to my research. Records, extracted from the database, were exported to Microsoft Excel files, password protected and uploaded in the secured M-drive personal folder within the University of Leeds computer network. The confidentiality of interview participants was observed to the highest level possible. All interviews were conducted in private rooms to avoid interruptions.

(3) Confidentiality and anonymity

Data collected were stored as per the "University of Leeds policy for Safeguarding Data Storage, Backup and Encryption". Audio records were uploaded to the encrypted M-drive at the University of Leeds computer network, soon after interview sessions. Interview transcripts were given code numbers and were password protected. All printed documents were converted into electronic format, password-protected and uploaded to my secured M-drive storage. Signed consent forms and other documents collected from participants were stored in a locked cabin, within the Leeds Institute of Health Science (LIHS), Worsley Building room 10.38. During fieldwork in Tanzania, printed documents were kept in a locked room at the College of ICT (CoICT) campus of the UDSM, where I was given an office to use. As part of the ethical clearance approval, a data transfer agreement was signed between by NIMR (the provider) and I (the principal investigator), granting me permission to carry collected data to the UK.

(4) Culture and language

I am Tanzanian and a native Swahili speaker. Therefore, I did not face a cultural barrier, nor needed a translator, for conducting the fieldwork. Swahili is working and first official language in Tanzania, uniting more than 120 ethnic groups (Batibo, 1992). It is used for provision of social services in public and private institutions. English is the second official language used largely in written communications among the working class. For example, most of the documents, collected for this study, are written in English. My previous working experiences in the HIS strengthening initiative was useful in understanding the health system organisational setting and practices and interaction with the participants.

3.6. Reflexivity

(1) My relationship with the study, objectivity and potential biases

In conducting this research, I did all what was possible to ensure objectivity and validity of the research process. The latter was overstressed by my familiarity with the health system setting in Tanzania which gave me first-hand knowledge about health information-related challenges. Also, prior to this conducting the present research, I had interacted with some of the participants in other assignments as described later in this section. These experiences might have predetermined my thinking and worldview about some aspects of the study, hence the possibility of influencing my perception during data collection or results interpretation. Thus, despite my efforts to remain objective and adhering to the study protocol, the interpretation of results and conclusions made might contain some sort of unintentional biasness influenced by my insider-outsider perspective and positionality.

My desire to investigate the implementation of eIDSR was motivated by two factors. Firstly, from 2009 to 2014, I was part of University of Dar es Salaam (UDSM) team that provided technical support to the MoH Tanzania on its initiative to strengthen the mainstream routine HMIS (MoH-Tanzania, 2009b). In this initiative, essential data elements and health programmes indicators were reviewed; data capturing and reporting tools were redesigned; opportunities were explored to integrate data from vertical health programmes into the HMIS (Mahundi, 2010; MoH-Tanzania, 2009b; Nyella and Kimaro, 2015). In the team, I played both technical and coordination roles in the implementation of DHIS2 and the Human Resource for Health Information System (HRHIS) which are two major DHIs implemented to scaled from 2008 to 2014 (Ishijima et al., 2015; Kiwanuka et al., 2015; Nyella and Kimaro, 2015; Nyella and Mndeme, 2010). Likewise, my MSc research project, in which I co-authored an article (Nyella and Mndeme, 2010) examined challenges and opportunities surrounding the implementation and sustainability of DHIS2 in Tanzania as an integrated HMIS database (Mndeme, 2011; Nyella and Mndeme, 2010). Secondly, when eIDSR intervention was introduced, I was

involved for a few days at the initial stage when the MoH was exploring technological and design feasibility for an mHealth solution for surveillance purpose.

The technical and research experience gained in the above initiatives, gave me important insights about the sociotechnical complexities surrounding the implementation of DHIs in resource-limited settings. Consequently, I developed an interest on the question of evidence-based implementations of DHIs in resource-limited settings; hence my venture into undertaking the current research.

(2) Challenges faced in the data collection process

Data collection design and practices

Initially, the research design envisioned collecting data using a top-down approach consistent with how the eIDSR intervention was designed and is being implemented. This approach would provide an opportunity for understanding the project and nature of data reported through eIDSR prior to engaging participants in lower levels. Nevertheless, this approach proved to be impractical because permissions to collect data in some units were delayed; several participants missed, cancelled or postponed appointments; and some participants, in HFs and districts, accepted appointments before those at the regional and national levels. Some units had to be visited several times before securing appointments or being granted permission to collect data. Therefore, data collection plan was revised, starting where permissions were granted, or appointments honoured.

Poor documentation of eIDSR intervention

During data collection, only a few documents with limited information about the eIDSR project were made available as explained earlier. The documentation problem made it difficult to get a clear understanding of the eIDSR adoption and implementation process, particularly for validating participants' narratives of events and processes. To address this challenge, participants were prompted to provide as much information as possible during the interviews. Likewise, whatever piece of documentation written or kept by participants was required to inform the analysis.

Contradicting responses during interviews

Majority of health-related programmes and interventions in Tanzania are supported by donors (Martinez-Álvarez, 2014). Thus, those involved in donor-funded initiatives, seemingly, giving positive remarks is important to substantiate the usefulness of the support. This situation was observed in the current study. During interviews, unsubstantiated views were given about the eIDSR effectiveness, contradicting the data in eIDSR or documented information prepared by the same participants. As a mitigation strategy, more clarification was given about the purpose of the study and the role of the researcher. Also, follow-up questions were raised in search of the truth without showing

participants their narratives were questionable. Doing that, participants were correcting or contradicting themselves as the interviews progressed.

Participants discomfort during interviews

Even though participants were not exposed to any physical or biological risk, some seemed to be uncomfortable when I asked to read PIS or sign consent forms and knowing the interviews were tape-recorded. Some avoided to respond to some of the questions, claiming they were not spokespersons. To address this challenge, more clarification about the purpose of the study was given. Participants were made to understand the importance of the research procedure requiring them to sign consent forms. Likewise, they were ensured that audio records would be anonymous and destroyed after transcription.

Clinical records

Collecting clinical records was a challenge in all HFs for different reasons. Some participants claimed medical records books were not kept after being closed. Others did not want to share clinical records because they were sceptical about the intention of the study, thinking I was sent by authorities to investigate services delivery in HFs. When access to clinical records was given, several pages or records could be missing, pages could be blank, records could be incompletely documented, and other books could not be located. Specifically, for cholera records, I was told HFs were not keeping them because all suspected patients were immediately referred to specific cholera treatment-centres (CTCs), before being treated. Thus, by the end of the first fieldwork, I could not collect the clinical data as planned in the study design. After coming back to the UK, I engaged further with several participants and managed to secure a comprehensive line list of cholera records, captured in two districts. Also, I conducted a followed-up fieldwork in which malaria clinical records were captured from one hospital. Moreover, further clarification regarding the data I had collected was done through emails, WhatsApp text messages, or phone calls.

3.7. Study strength and limitations

Research on organisational change efforts recommends the use of mixed-methods designs, as applied in the current research, because they can potentially produce good quality evidence (Poole, 2004). However, this design proved to be laborious in several ways. First, it was difficult to decide the number of cases (units of observation) to be included and type or volume of data to be collected. Second, data analysis was a tedious process because the study covered several topics. Third, given the volume of data I collected, I faced a difficult time to decide how to prioritise the use of data to inform the thesis. Fourth, making a coherent presentation of the finding was challenging because

there were many interesting findings and some of which were beyond the scope of this thesis. The research process demanded more resources and efforts than planned.

3.8. Chapter summary

This chapter has served three main purposes. Firstly, it has developed a conceptual framework guided the current research using an organisational change perspective. Secondly, it has presented the philosophical position from which the research design and methods were drawn. Thirdly, it has described the mixed method designed of used to carry out the present research and methods used for data collection and analysis. Lastly, the procedure used to secure a research ethical approval was presented and a reflection on issues arose in the research process.

The next 4 chapters present key findings from analysis the analysis of quantitative and qualitative data. Chapter four sets the scene by providing the context in which eIDSR intervention was being implemented. It discusses the implementation climate; the interventions vision and contents; acquisition of the eIDSR application and its functional design and features.

CHAPTER 4

The adoption of eIDSR: the vision, context and design

4.0. Introduction

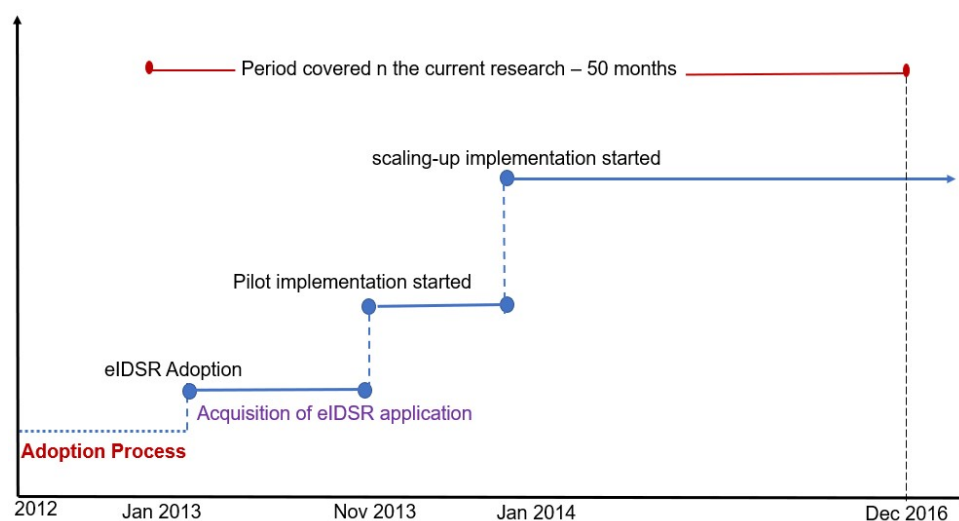
This chapter responds to one aspect of the first objective of the current research which sought to understand the adoption, design and implementation of the eIDSR intervention. It focuses on the eIDSR adoption stage by presenting descriptive results about the change vision; circumstances leading to adoption; development and functional design of the technological application; and factors characterising the implementation climate. The results situate the eIDSR intervention in the context of the disease surveillance system (DSS) and provide an understanding of the context factors influencing the approach and process in which the intervention is being implemented and put into use [as discussed in the subsequent results chapters]. Table 16 summaries key findings presented in this chapter.

Table 16: The summary of key findings presented in this chapter

| Main themes | Specific findings |
|--|---|
| The eIDSR change vision and implementation setting | <ul style="list-style-type: none"> • The implementation goal is unclearly defined. • Targeted to improve the conventional paper-based disease surveillance information system (DSIS) at all levels of the DSS. <ul style="list-style-type: none"> ▪ DSIS has a coordinated structure from HFs to the national level; it supports routine management of the DSS, epidemic notifications and response activities. ▪ Captures identifiable and numerical diseases surveillance data. |
| Forces rationalised or influenced eIDSR adoption. | <ul style="list-style-type: none"> • Information challenges posed by the DSIS; • spread of surveillance data in different systems; • threat of epidemics importation from neighbouring countries; • implementers' presumptive benefits of digital health solutions; • a relatively positive eIDSR implementation climate; |
| The eIDSR application | <ul style="list-style-type: none"> • It is wrongly perceived by implementers as an mHealth solution; • It is an integrated digital health application comprised of: <ul style="list-style-type: none"> ▪ a paper-based system for capturing surveillance data from HMIS records at HFs, ▪ USSD mHealth application for data submission, ▪ emails and SMS messages for delivering notifications and alerts, ▪ the DHIS2 web-based database for data storage and analytics, • It was designed and developed centrally without the participation of key users at District and HF levels. |
| Change implementation approach and plans | <ul style="list-style-type: none"> • Technocentric perspective – intervention not viewed as an organisational change initiative. <ul style="list-style-type: none"> ▪ No application of change management strategy, validated nor unvalidated implementation framework or approach. ▪ Undocumented and unclear implementation plans and phases. |

Figure 12 indicates the timeline of the intervention phases examined in this thesis. This chapter covers the adoption process and activities took place up to November 2013 when the pilot implementation started.

Figure 12: The timeline of eIDSR implementation stages examined this thesis



This chapter together with chapter 5 and 8 are informed by the analysis of qualitative data only while chapter 6 and 7 are informed by the mix of quantitative and qualitative data. The qualitative analysis was informed by a mix of qualitative data extracted from different sources as listed in Table 17.

Table 17: List of documents provided data used for qualitative analysis

| S/n | Type of documents | Description of the type of data | Number of documents |
|-----|---|---|---------------------|
| 1 | Interview transcripts | Members of the national eIDSR implementation team | 4 |
| | | IDSR regional coordinators | 2 |
| | | Members of district councils' rapid response teams | 6 |
| | | HF IDSR focal persons | 10 |
| 2 | Implementation progress reports documents | Supportive supervision report in the pilot district done 16 months from the piloting stage | 1 |
| | | Supportive supervision report conducted 19 months since the start of scaling up stage | 1 |
| | | eIDSR implementation and usage progress report after scaling up to 9 regions (about 60 districts) | 1 |
| | | Report on eIDSR follow-up training for HFs users | 1 |
| 3 | Meeting Notices | Meeting notices about challenges faced the use of eIDSR and way forward. | 2 |
| 4 | Software development reports | Monthly technical and progress reports about development of eIDSR application to piloting stage | 11 |
| 4 | Technical documentation | eIDSR software development plan, technical architecture, system requirements, system release, infrastructure setup, and administrative guides | 12 |
| 6 | Training guides and user manuals | Training guides and user manuals | 6 |

4.1. The eIDSR intervention change vision

The eIDSR intervention was introduced by the MoH in Tanzania under its DSS to strengthen disease surveillance and response functions. The main goal of the eIDSR intervention implementation is described differently in eIDSR project documents.

Predominantly, it is described with an emphasis on the technological capabilities of the eIDSR application rather than the anticipated implementation outcomes. For example, three documents described eIDSR as:

“eIDSR is a mobile application developed to enable quick and instant reporting of outbreaks and diseases of epidemiological importance by facility health workers for the Ministry of Health” (ProjectDoc1).

“a system of collecting information on diseases of priority and reporting through mobile phones direct from health facilities to a national server” (Report1).

“a tool for data reporting and analysis developed to strengthen and improve integrated disease surveillance and response in Tanzania” (ProjectDoc2).

This perspective was also observed among eIDSR implementers at the national level when they were asked to describe what they intended to achieve. One of them said:

“The vision was to see that we have a system which we get information on time so that we can promptly respond. The whole idea of IDSR is a response (...) to be rich in information which is collected in a proper way and everybody can access it (...) to simplify the means of data collection and storage because data would be digitalized (...) The system collects data, aggregates, and makes it easy to analyse.” (MoHP2).

Despite lack of clarity in specifying the intervention goal, analysis of documentary and interview data suggested it had six objectives as listed in Table 18.

Table 18: eIDSR intervention’s objectives and corresponding outcome measurements

| S/n | Objective and approach facilitated by eIDSR | Measurements criteria |
|-----|---|--|
| 1 | Reporting of diseases, conditions, and events under surveillance and facilitating timely identification and notification of outbreaks (USSD mHealth app). | At least 80% of all HFs submit reports on time as per the surveillance guidelines. |
| 2 | Facilitating data use for outbreaks response; controls and monitoring disease trends; surveillance plans and other activities (SMS, emails & DHIS2). | Informed rapid response actions to outbreaks; evidence of improved data analysis and use practices. |
| 3 | Providing health workers in HFs with updates on standard case definitions for preliminary cases identification (SMS). | Improved detection, confirmation, and recording of priority diseases, conditions and events under surveillance in HFs. |
| 4 | Providing data validation features for improving quality (mHealth app & DHIS2). | Improved quality of data submitted through eIDSR (error-free, complete, and timely). |
| 5 | Digitising data submission, storage, and analysis; reports generation; and feedback mechanism (DHIS2). | Having all surveillance data submitted through eIDSR, then stored and processed in the DHIS2 system. |

Technologically, the eIDSR application was solely considered as a mobile phone-based mHealth application. However, the outlined objectives indicate eIDSR is an integrated DH solution in which an mHealth application is used only as a communication approach for data capturing and submission at HF level. Similarly, they suggest the eIDSR intervention was a planned technological change envisioned to improve information system aspects within the operational framework of the DSIS. Thus, the next section

discusses results about the DSIS structure, roles, and the challenges it presented to the DSS.

4.2. The implementation context: the conventional information system

As introduced in chapter one, the DSS is a vertical programme with a coordination mechanism at the community, HFs, district, regional and national levels. Nevertheless, there is no a formal structure at the community level because there are no specific healthcare workers responsible for surveillance activities. Alternatively, identification and reporting of suspected cases and deaths of diseases under surveillance are done by individuals providing basic services at the community level such as religious, traditional and political leaders; traditional birth attendants; community healthcare workers, and schoolteachers.

Rumours or suspected cases of epidemic diseases are reported to a nearby HF or government leaders. Means of reporting from this level are contingent on what is manageable for a reporting individual. Verbal communication and mobile phone calls are common approaches. By the time of conducting the current research, eIDSR implementation had not included the community level. Therefore, results present in this section focus on the DSIS structure from HF level since it was operational parallel to the eIDSR intervention up to when the current research was conducted.

4.2.1. The components of the DSIS

In the literature, information system are commonly described using there components: actors, technology, data, and process(Bourgeois, 2014; Stair and Reynolds, 2018). Drawn from these components the DSIS can be described as follows:

(1) Actors

Each HF has a disease surveillance officer, known as an IDSR focal person (IDSR-HFP), who are responsible for, inter alia, managing surveillance data and reporting to the district level. Oftentimes, IDSR and HMIS roles are discharged by FHWs as additional responsibilities. In PHFs the roles are discharged by the same person who is likely to be a HF leader. This was the case in 4 of the 6 PHFs sampled in the current research. In hospitals, IDSR and HMIS roles are discharged by different individuals and the IDSR-FPs are likely to be trained public health officers. This was observed in 5 of the 6 sampled hospitals. In the other, a nurse was excluded from clinical duties and designated IDSR and HMIS roles as core responsibilities.

At the district level, surveillance activities are coordinated by the district health officer/epidemiologist, commonly known as the IDSR coordinator (IDSR-DCo). S/he oversees DSS functions such as managing data reported from HFs, submitting data to

the regional level, investigating suspected epidemic cases reported from HFs or community level and facilitating laboratory confirmation. The IDSR-DCo reports to the regional IDSR coordinator (IDSR-RCo) who reports to the national IDSR coordinator (IDSR-NCo) at the MoH. The latter reports to the WHO country office.

These are rapid response teams (RRTS) at the district, regional and national levels. They are multidisciplinary technical teams organised for quick mobilisation and deployment in response to public health emergencies such as epidemic outbreaks. At the district and regional level, the RRT are comprised of all CHMT and RHMT members respectively. Based on the need, the RRTs may involve technical staff from outside health management teams such as animal health and water department. At the national level, the RRT is formed under the preventive directorate and may also involve members from any government department. At all levels the RRTs are ordinarily led by the respective surveillance coordinators and their main activities include:

- periodically reviewing surveillance data to identify trends of diseases of public health concerns.
- planning response activities in collaboration with authorities at affected areas.
- securing and mobilising financial and material resources.
- strengthening case-management practices, identifying training needs, updating health staff skills, and educating the vulnerable communities.
- reporting outbreak response activities along the management hierarchy and giving notification of confirmed and suspected epidemic cases.
- developing outbreak prevention strategies and actions after outbreaks.

(2) Diseases surveillance data

These are suspected and confirmed cases or deaths attributed to priority diseases under surveillance. HFs are the main source of surveillance data, extracted from the paper-based HMIS clinical records. Two types of reports are prepared and submitted to the district level: patient-based reports of cases or deaths of epidemic-prone diseases, and numerical reports of other diseases and conditions under surveillance. As summarised in Table 19, report 1, 2 and 3 originated from HFs while report 4 originates from disease-specific health programmes. Table 20 indicates frequencies of reports submission at different management levels.

Table 19: Types of surveillance reports

| Type of reports | List of diseases |
|--|---|
| Report 1: • Immediately notifiable diseases: • Case-based reports | 13 diseases: Cholera; Bloody diarrhoea; Plague; Measles; Yellow fever; Cerebral Spinal Meningitis; Anthrax; Rabies/ animal bite; Viral haemorrhagic fevers; Human influenza caused by new subtypes; Smallpox; Epidemic viral keratoconjunctivitis; and Acute Flaccid paralysis / Polio. |
| Report 2: • Weekly reported diseases • Numerical reports | 15 diseases: All diseases in group one + Malnutrition; and Neonatal tetanus. |
| Report 3: • Monthly reported diseases: • Numerical reports. | 23 diseases: All disease in group two + Diarrhoea in children <5 yrs; Pneumonia in children < 5 yrs; Malaria; Typhoid; Trypanosomiasis; Tick-borne relapsing fever; Trachoma; Onchocerciasis. |
| Report 4: • Quarterly reported diseases • Numerical reports from disease-specific programmes | 12 diseases: Diabetes mellitus; High blood pressure; Cataract; Road traffic accidents; Cancers; Leprosy; Lymphatic Filariasis; Schistosomiasis; Soil-transmitted helminths (STH); Tuberculosis (MDR/ XDR); HIV/AIDS (New cases); and STIs. |

Source: IDSR technical guidelines (MoH-Tanzania, 2011).

Table 20: Frequency and hierarchy of reporting surveillance data

| Reports | HFs to district | Districts to region | Region to MoH | MoH to WHO country office |
|------------|--|---------------------|-------------------|---------------------------|
| Case-based | Within 24 hours | Immediately | Immediately | Immediately |
| Weekly | Wednesday by 3.30 pm | Thursday by 3.30 pm | Friday by 3.30 pm | By 3.30pm on Mondays |
| Monthly | By 7th | By 14 th | By 28th | On 30th |
| Quarterly | From disease-specific programme to MoH | | | |

Source: IDSR technical guidelines (MoH-Tanzania, 2011)

Table 65, 65 and 66 in Appendix J, are templates of cholera death report, weekly summary report of epidemic-prone diseases, and weekly aggregated report respectively. Figure 50 summarises data flow in the DSS hierarchal structure.

Procedural, numerical reports are to be routinely submitted even in the absence of cases (zero reporting). This rule is set to differentiate between non-reporting and absence of cases in a reporting period. As seen in paper-based district monthly reports in Table 21 and Table 68 in appendix J, there were no reported cases for most of the diseases.

(3) Technology

The DSIS infrastructure is paper-based from HFs to the national level. HF reports are manually submitted to the district where they are manually aggregated and reported to the regional level, then to the MoH. This is different from paper-based HMIS reports from HFs which are entered into the DHIS2 at the district level, hence electronically accessed. With the increasing use of mobile phones and internet penetration, electronic means such as emails, phone calls, and SMS text and WhatsApp messages are informally and conveniently used parallel to the manual reporting system. Such means are preferred during outbreak when data are urgently needed or when manual submission to the district is not possible.

Table 21: A district monthly manual report of surveillance data

FORM 2(B) - FORM FOR DISTRICT AND HEALTH FACILITY MONTHLY DATA FOR INPATIENT AND OUTPATIENT TO SENT TO DISTRICT AND REGION LEVELS

District: [REDACTED] Month: JUNE 2015

No. of Health Facilities: [REDACTED] No. of Health Facilities reported: 108 No. of Health Facilities reported Timely: 103

| S/N | DISEASES | < 5 CASES | | | | | | | | > 5 CASES | | | | TOTAL | |
|-----|----------------------------|-----------|------|---|---|---|---|---|---|-----------|------|---|---|-------|----|
| | | C | | | | D | | | | C | | | | D | |
| | | M | F | M | F | M | F | M | F | M | F | M | F | C | D |
| 1 | AFP | 0 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 0 |
| 2 | Anthrax | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | Blood Diarrhea | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 49 | 37 | 0 | 0 | 0 | 0 |
| 4 | Cholera | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | CSM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | Diarrhoea < 5 years | 1225 | 966 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2191 | 2 |
| 7 | Human Influenza | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | Keratoconjunctivitis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | Malaria | 2670 | 2805 | 3 | 4 | 0 | 0 | 0 | 0 | 3319 | 2668 | 0 | 0 | 11762 | 15 |
| 10 | Measles | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | NNT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | Onchocerciasis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | Plague | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | Pneumonia < 5 years | 1207 | 806 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2013 | 4 |
| 15 | Rabies/Animal Bites | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | Small Pox | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | Tick borne relapsing fever | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | Trachoma | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | Trypanosomiasis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | Typhoid | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | VHF | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | Yellow Fever | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Date: 02/07/2015

At the management levels where computers and internet may be accessible, manual reports may be compiled in customised excel spreadsheets (Table 69 in the appendices) and shared to next levels as email attachments. However, the use of informal approaches focuses on selected datasets only. One of the HF participants explained the selective reporting by saying,

“I just send those diseases I have encountered [through SMS]. For example, when he [IDSR-DCo] requests (..) I respond, ‘pneumonia under 5 male 6, female 5 or pneumonia 0, 0 [no cases]. Diarrhoea under 5 female 2, male 3’” (HF3Dist2).

Table 22 is a section of a monthly aggregated report organised in an Excel spreadsheet by one of the IDSR-DCo in which only 3 diseases were aggregated.

Table 22: Customised district monthly reports in an Excel sheet – 2015, District4

| Month | DISEASES | < 5 CASES | | | | > 5 CASES | | | | TOTAL | | | |
|----------|----------|-----------|------|---|---|-----------|------|---|---|-------|------|---|---|
| | | C | | D | | C | | D | | C | | D | |
| | | M | F | M | F | M | F | M | F | M | F | M | F |
| October | BloodD | 2 | 1 | 0 | 0 | 4 | 1 | 0 | 0 | 6 | 2 | 0 | 0 |
| | Cholera | 1 | 1 | 0 | 0 | 16 | 19 | 0 | 0 | 17 | 20 | 0 | 0 |
| | Malaria | 782 | 821 | 0 | 0 | 2125 | 5838 | 0 | 0 | 2907 | 6659 | 0 | 0 |
| November | BloodD | 4 | 1 | 0 | 0 | 3 | 6 | 0 | 0 | 7 | 7 | 0 | 0 |
| | Cholera | 1 | 1 | 0 | 0 | 3 | 12 | 0 | 0 | 4 | 13 | 0 | 0 |
| | Malaria | 986 | 721 | 0 | 0 | 5263 | 6048 | 0 | 0 | 6249 | 6769 | 0 | 0 |
| December | BloodD | 1 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 2 | 3 | 0 | 0 |
| | Cholera | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Malaria | 861 | 1975 | 0 | 0 | 2560 | 3403 | 0 | 0 | 3421 | 5378 | 0 | 0 |

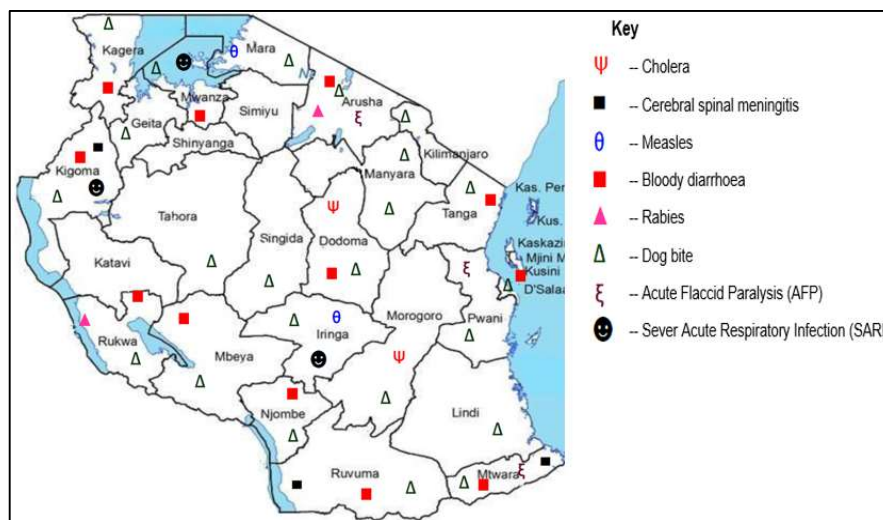
(4) Process

Data processing aims to make data useful by giving them meaning (producing information). It requires the priori awareness and knowledge of a set of information useful to support specific tasks or inform decision making mechanism (Stair and Reynolds, 2018; Whitman and Mattord, 2017). Processing of disease surveillance data focuses at generating quality and timely information necessary to inform public health actions of controlling, preventing and eliminating diseases. Processing is guided by indicators

outlined in the IDSR guidelines, which are grouped into general or core surveillance and response indicators and disease-specific indicators. Most indicators inform the district level where surveillance and response functions are concentrated.

Basically, disease surveillance data are manually processed. But the observation done during fieldwork, identified 3 IDSR-DCo, 1 IDSR-RCo and 1 IDSR-NCo using computers to organise and process manually submitted data from HFs. The use of computers facilitates to produce information in different formats such as tables, charts, and maps.

Figure 13: Tanzania national weekly epidemiological report (43rd week in 2016)



Source: Ministry of Health Tanzania (2016a)

For example, Figure 13 is a weekly geospatial report produced at the national level indicating cases of epidemic-prone diseases reported from different parts of the country.

4.2.2. The role of the DSIS in the disease surveillance system

(1) Supporting the routine M&E of the DSS at all levels

Monitoring encompasses the routine and continuous tracking of planned surveillance activities such as data collection and analysis; flow of data; adherence to surveillance guidelines; and detecting issues to be addressed. Evaluation refers to periodically assessing whether surveillance and response objectives are being achieved. M&E activities are expected to provide feedback to where data originate to motivate data capturing and reporting compliance; improve data quality; providing support and correct mistakes; reinforce participation in surveillance activities; and strengthening communication and the teamwork spirit. Likewise, feedback is expected to inform and create awareness about disease situations in the community. However, results established that such practices were very poor, at all levels as expressed by participants:

“I was not receiving any feedback from the district unless I call to ask for it. So, I get used that there is no feedback based on what I report” (HF2Dist3).

“I don’t get feedback from above: ministry of health nor regional level” (Dist2P1)

“We don’t get feedback (...) we just submit” (HF2Dist4).

(2) Delivering of outbreak notifications

Outbreak definitions are disease-specific determined by an action threshold which is defined as “a situation, denoting the critical point beyond which action must be taken (...) expressed in terms of numbers of cases or proportions” (MoH-Tanzania, 2011, p.26). There are two types of action thresholds. First is an alert-threshold that gives a critical point for epidemic-prone diseases, reached when at least one case or death is confirmed. Second is an epidemic threshold signifying a critical point for diseases of public health importance reported in numerical format. It is reached when the current disease situation indicates an unexplained increase of new cases or unusual pattern seen over time in weekly or monthly reports, *ceteris paribus*.

Once a case of epidemic-prone disease is suspected at a HF during clinical consultation, the IDSR-HFP has to be immediately notified. In turn, the IDSR-HFP will immediately report the case to the district with preliminary information to trigger response action. Thereafter, a written case-specific report (case investigation form) providing detailed information about the cases, actions already taken by the time of reporting, and the nature of assistance needed from the district. Table 66 in appendix J, is the format of a case investigation form for cholera.

(3) Response to outbreaks

Response to health emergencies or outbreaks are actions taken to deal with the outbreak or other public health emergencies. Once a district RRT receives a notification, case investigation starts followed by other actions depending on a reported disease. If the situation escalates, the regional and national RRTs are engaged. In appendix I, Table 64 provides steps to be taken in responding to cholera and malaria outbreaks and Figure 50 depicts the information flow during epidemics outbreaks.

4.3. The eIDSR adoption process

The current research did not get written narratives on activities and the process followed before the decision to use eIDSR was reached. The intervention-related documents collected during fieldwork reveal that the project documentation started after the implementation decision was made in January 2013. Even so, it was done prospectively based on project activities as listed in Table 17. Thus, the process leading to eIDSR adoption could not be established, apart from the narratives of factors rationalised or facilitated the adoption. The latter, categorised into internal and external organisational forces to the DSS organisational environment, are presented in the next subsections.

4.3.1. Internal organisational forces which triggered eIDSR adoption

These are circumstances which necessitated and rationalised the need for technological change to improve the effectiveness of the DSS.

(1) Information challenges posed by the DSIS

The DSIS presented several challenges to the DSS as expressed by one of the managers at the national level:

“What is needed [by implementing eIDSR] is notifications to reach the response team promptly (...) to summarise a report on paper and find transport to the district to submit data makes it difficult to report on time (...) will save money spent for transport to the district and time” (MoHP3).

Also, there was a lack of simplified and innovative solutions to facilitate data management practices. These challenges were attributed to poor quality of diseases surveillance data.

(2) Discrepancy of diseases surveillance data

There was the discrepancy of diseases surveillance data attributed to lack of integration across entities dealing surveillance related functions. Besides the DSIS, surveillance data are desperate distributed in the HMIS, disease-specific programmes and the health laboratory network.

Firstly, the HMIS medical records briefed in section 1.5.7, are the main source of all routine health data. Thus, HMIS operations and practices, particularly production data at HFs level, determines capturing of disease surveillance data through DSIS and other disease-specific health programmes. Also, routine HMIS data reported from HFs duplicates surveillance data. For example, Figure 14 is a section of a monthly HMIS report in DHIS2 with several diseases reported through the DSIS.

Secondly, disease-specific control programmes focusing on minimising the effects of diseases through preventive measures; limiting the spread; and case treatment, management and isolation. Among them is the NMCP; National AIDS Control Programme (NACP); and the National Tuberculosis and Leprosy Control Programme (NTLP). Likewise, there are specific coordination for Non-Communicable Diseases (NCD) and Neglected Tropical Diseases (NTD). Among other things, these programmes have their own coordination mechanism and information systems. Besides, diseases under these programmes are also prioritised for surveillance, hence they reported to the DSS as discussed in section 4.2.1. The eIDSR was expected to address anomalies of data as explained in one of the eIDSR project documents:

“to capture all data from the source so as to avoid having discrepancies of the same data from the same source in various levels of health services delivery” (Report1).

Figure 14: A section of OPD report in the DHIS2 showing diseases under surveillance

| Taarifa ya Mwezi ya Wagonjwa wa Nje (OPD) | | | | | | | | | | | | | | | | |
|---|-------------------------------------|-----------------------|----|-------|---|----|-------|---|----|-------|----------------------------|----|-------|------------------------------|----|-------|
| Na. | Maelezo | Umri chini ya mwezi 1 | | | Umri mwezi 1 hadi umri chini ya mwaka 1 | | | Umri mwaka 1 hadi umri chini ya miaka 5 | | | Umri Miaka 5 hadi miaka 60 | | | Umri Wa Miaka 60 na Kendelea | | |
| | | ME | KE | JUMLA | ME | KE | JUMLA | ME | KE | JUMLA | ME | KE | JUMLA | ME | KE | JUMLA |
| | Diagnosea Za OPD | | | | | | | | | | | | | | | |
| 4 | Acute Flaccid Paralysis | | | | | | 0 | | | 0 | 1 | | 1 | | | 0 |
| 5 | Cholera | | | | | | 0 | | | 0 | | | 0 | | | 0 |
| 6 | Dysentery | | | | | | 0 | 3 | 1 | 4 | 21 | 20 | 41 | | 1 | 1 |
| 7 | Measles | | | | | | 0 | | | 0 | | | 0 | | | 0 |
| 8 | Meningitis | | | 0 | | | 0 | | | 0 | | | 0 | | | 0 |
| 9 | Neonatal Tetanus | | | 0 | | | | | | | | | | | | |
| 10 | Plague | | | | | | 0 | | | 0 | | | 0 | | | 0 |
| 11 | Relapsing Fever(Louse borne Typhus) | | | | | | 0 | | | 0 | | | 0 | | | 0 |
| 12 | Yellow Fever | | | | | | 0 | | | 0 | | | 0 | | | 0 |
| 13 | Influenza | | | | | | 0 | 2 | 2 | 4 | 6 | 14 | 20 | 1 | 1 | 2 |
| 14 | Typhoid | | | | | | 0 | | 1 | 1 | 31 | 25 | 56 | 2 | 2 | 4 |
| 15 | Rabies | | | | | | 0 | | | 0 | | | 0 | | | 0 |
| 16 | Onchocerciasis | | | | | | 0 | | | 0 | | | 0 | | | 0 |

Key: Column names are in Swahili indicating age-groups, gender and totals.
 Source: National HMIS database (MoH-Tanzania, 2018c).

Thirdly, health laboratories, which are coordinated by the National Reference and Public Health Laboratory (NRPHL), are important sources of surveillance data but with a loose integration to the DSIS. Primarily, cases of diseases under surveillance are detected using diseases-specific standard case definitions. Moreover, guidelines require laboratory testing procedures to be involved in disease investigation and confirmation.

“Rapid identification of the causative agents by the assistance of the laboratory is essential for effective control of communicable diseases (...) to identify the likely source or mode of transmission of the disease” (MoH-Tanzania, 2011, p. 27)

Thus, health laboratories, serve both clinical and public health needs. Not all HFs have the necessary laboratory facilities or equipment for testing and confirming diseases under surveillance. Thus, majority of cases detected in PHFs are performed in district, regional, zonal and national hospitals or the national laboratories. Some epidemic-prone diseases such as cholera can be confirmed only at the national laboratory.

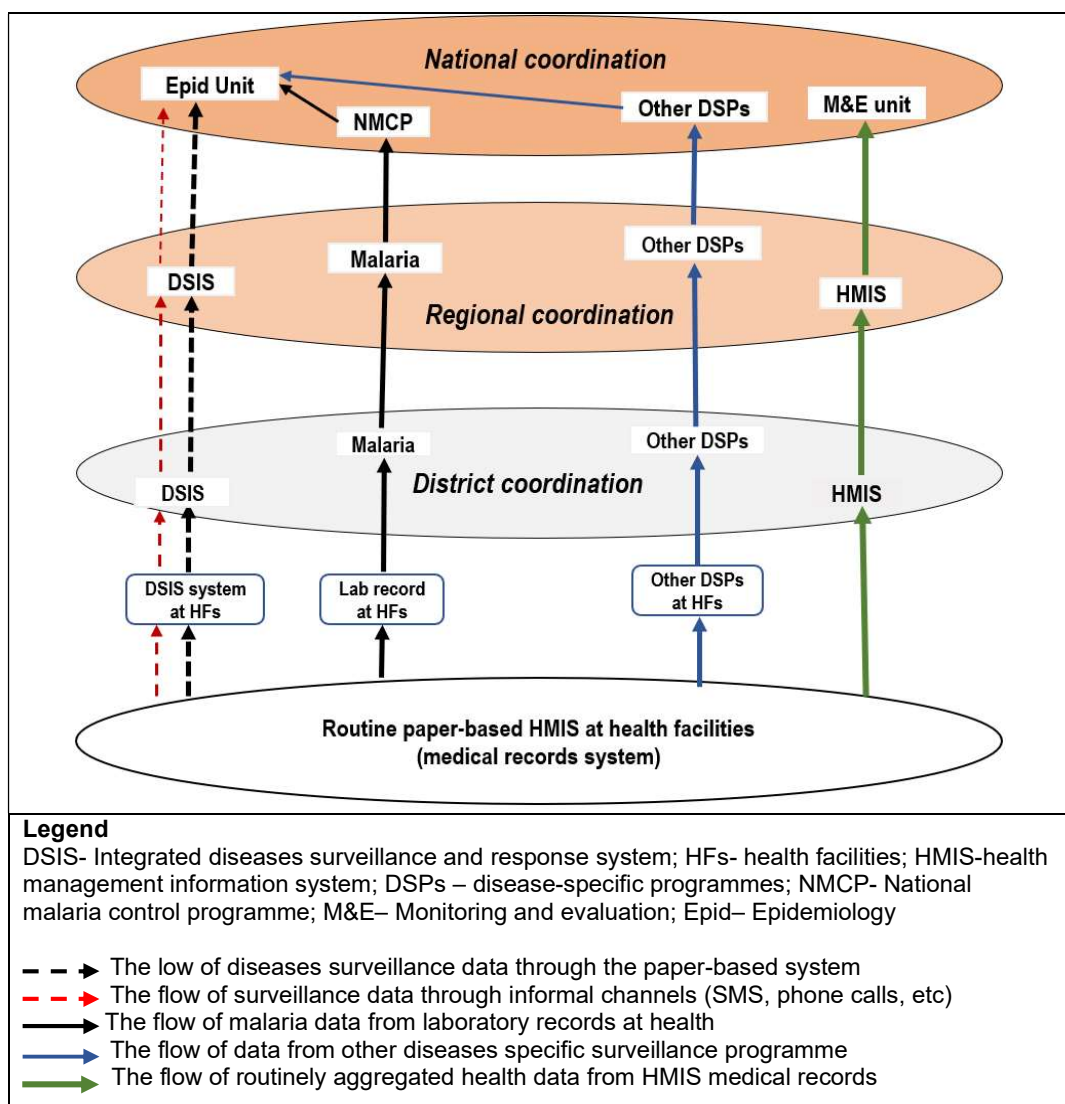
Currently, each level of laboratory service is required to report specified test records to the respective IDSR coordinator on monthly basis. For example, district laboratories are obliged to report malaria test records to district coordinators. Regional and referral hospitals report cholera, shigella, plague, malaria and typhoid to the regional and national coordinators. The national laboratory reports cases of all epidemic-prone diseases to the WHO country office. Therefore, the desire to harmonise data from laboratories with those from HFs, rationalise the need to implement eIDSR.

The data discrepancies explained above revealed five channels through which surveillance data were captured as explained in Figure 15 from left to right.

- The paper-based DSIS (dotted black) accompanied by informal electronic means of reporting (dotted red).
- Paper-based malaria reporting system (solid black) under national malaria control programme (NMCP) capturing numerical records.
- Other disease-specific control programme (blue) such as HIV/AIDS, leprosy, STIs, and lymphatic filariasis (paper-based).
- The HMIS (green) which is paper-based at HFs level and electronic from the district level as the DHSI2 database.

All the reporting channels above were not integrated and there were variations in reporting formats. For example, the DSIS captures case-based records for epidemic-prone diseases while the HMIS captures them as numerical values, except for death reports. Also, datasets categories, such as age groups and sex, and reports submission frequencies varied across programmes. While HMIS and NMCP reports are submitted monthly, DSIS reports are submitted either daily, weekly, monthly or quarterly.

Figure 15: Diseases under surveillance data channelled through different systems



(3) The quest for “going digital”

Health managers at the national level attributed most of the DSIS challenges to it being a paper-based system. Thus, implementing a digital solution was expected to a panacea:

“to simplify the means of data collection and storage because data are digitalised (...) Also, to make it easy to access and get information out at levels” (MoHP2).

The informal use of electronic communication was used to solidify the argument.

“mobile phones were already being used. People felt like taking a form [report] from health facility to the district level took time and was costly (...) using mobile phones for reporting had already been practised in a different way” (MoHP4).

Additionally, implementing a DH solution was perceived as being a success on its own.

“when you go back like 5 years it was hard to have a digitalised health information system. So, eIDSR is a move in which we want to attain information stored and used in a digital format” (MoHP2).

“the main changes the system will make (...) automated data collection, automated collation of data, automated validation of reports, automated feedback to users, and automated documentation of a person submitting reports” (ProjectDoc2).

4.3.2. Organisational forces external to the DSS

These were forces external to the DSS which influenced or facilitated the decision to implement eIDSR. They are summarised in Table 23 and expanded underneath.

Table 23: External forces influenced the adoption of the eIDSR intervention

| S/n | External organisational forces | |
|-----|--|--|
| 1 | The influence of ICT ecosystem | The national health policy framework on digital health solutions |
| | | Existence of supportive technologies and network infrastructure. |
| | | Widespread use of mobile phone applications for financial transactions |
| | | Locally available expertise for developing and supporting digital health solutions |
| 2 | Peer-pressure from related initiatives | The narratives on mHealth implementation experiences from other countries |
| 3 | Burden of diseases | The burden of diseases and epidemics importation from neighbouring countries. |
| 4 | Access to resources | Access to implementation resources from donors |

(1) The influence of the national ICT ecosystem

The national ICT ecosystem is conceptualised as “encompasses the people, policies, strategies, processes, information, and other ICTs that together make up a social-technical environment surrounding an ICT embedded within a country” (Nguyen, S.P. and Mahundi, 2019, p.1). It is built on the notion that ICT is not an isolated technical

system, but rather a part of a wider ecosystem of organisational and social dynamics that transcends technical and technological factors (Diga and May, 2016; Nguyen, S.P. and Mahundi, 2019). This ecosystem exhibits a direct influence on the adoption of eIDSR

Firstly, as presented in section 1.5.8, implementation of DHIs in Tanzania is a strategic objective in the national health policy operationalised through the national eHealth strategy. The latter promotes the use of digital solutions to strengthen diseases prevention, surveillance, and control by facilitating early detection of epidemics, prompt notifications, and rapid response as expressed by one of the managers at the MoH:

“eHealth solutions section [within the ICT unit] oversees the implementation of eHealth strategy (...) responsible with eHealth solutions, eIDSR being one of them” (MoHP4).

Secondly is the supportive technical and technological infrastructure. As discussed in section 1.4, the increasing growth of mobile phone penetration and subscribers created a supportive environment to implement eIDSR.

“we envisioned the trend of growth of mobile phone network penetration. At that time [2012] the penetration was about 20% and we forecasted it would increase significantly in the next 3 to 4 years” (MoHP4).

Thirdly, implementation of innovative mobile phone solutions, supported by all mobile phone services providers, had already shown success in the financial sector. Thus, it was expected that the same technology would be applied for surveillance functions.

“even very old people know how to send and receive money through their mobile phones (...) we introduced eIDSR using similar technology to mobile money technology” (MoHP5).

Fourthly, the DHIS2 which was being scaled up as a national HIS database, provided desirable features useful to improve the DSIS.

“we thought it would be better to use the DHIS2 platform to integrate the IDSR system (...) to receive reports from health facilities into the DHIS2” (MoHP1).

Fifthly, there was enough evidence of locally available expertise necessary to develop and support the eIDSR application.

“We thought of capitalizing the use of DHIS2 owned by the MoH under the technical support of the University of Dar es Salaam” (MoHP1).

As presented 4.4.1, previous attempts to implement mHealth solutions for disease surveillance had failed; attributed to, *enter alia*, the dependence on foreign expertise and technical support.

(2) Peer pressure from related initiatives in other countries

Health managers at the national level explained that they had learnt from other countries that mHealth solutions can be useful to improve disease surveillance functions.

“We came out with an idea of using an electronic system because the system had already been implemented in other countries. When you go to conferences you see what other countries are doing and learn how best you can try to replicate” (MoHP1).

(3)Threats of epidemic importation

The use of a digital solution was expected to facilitate timely identification of epidemic-prone diseases attributed to the interaction of Tanzania with 8 neighbouring countries.

“We are bordering many countries and there are a lot of outbreaks importation due to high interaction of people in our region” (MoHP1).

Also, a digital solution would facilitate the compliance with the WHO regulations requiring countries to promptly report epidemics of international concerns.

“we have to report to the WHO within 24 hours for immediate notifiable cases since it is the requirement for the international health regulations” (MoHP1).

(4)Reassurance of financial support

There are several local and international organisations, commonly known as development partners or donors, supporting different aspects of the healthcare system in Tanzania. They provide human, material and financial resources to support efforts focusing on improving healthcare services delivery, and prevention or controlling of diseases such as malaria, HIV/AIDS, tuberculosis and leprosy (Martínez Álvarez, 2014; USAID, 2018). Thus, the reassurance of getting financial support from donors strongly influenced and rationalised the decision to implement the eIDSR intervention.

“as the ministry, we started to introduce the eIDSR by engaging other partners (...) who helped us a lot” (MoHP1).

“partners funded software developments, purchased a server, and training” (MoHP3)

4.4. The technology and design of the eIDSR application

4.4.1. System acquisition process

The eIDSR application was built using an internal custom development process through the technical support of local experts from the University of Dar es Salaam (UDSM). Main development activities included requirements gathering and analysis, identification of system design, software development process, testing and integration.

Requirements elicitation and choice of relevant technologies

The IDSR technical guidelines document was used as the main source of system requirements. However, it was insufficient for developing an mHealth solution particularly in deciding aspects of the paper-based DSIS to be digitised. Thus, interviewing

surveillance managers at the MoH, document analysis, and review of mHealth literature were used as requirements collection methods to complement the IDSR guidelines.

According to managers at the national level, the process of collecting requirements and identifying relevant technologies for implementing eIDSR, was mainly informed by previous failed attempts to implement mHealth solutions. Prior to eIDSR adoption, the MoH had piloted three mHealth solutions, two being specific for diseases surveillance, but they all failed at piloting stage. The failures were attributed to:

- the mismatch between the worldview guided the design of the deployed applications on the one hand and the context of use on the other. HF users did not have the required competency to use the applications and the existing mobile phone infrastructure could not sufficiently support the deployed technologies.
- insufficient and untimely technical support to users because the solutions were designed, developed, hosted, and remotely supported from outside the country.
- the deployed technologies were unaffordable to the MoH because they required large financial resources for investment, maintenance, and support.

Therefore, drawn from the above experiences, the managers explained that the development of eIDSR had to:

- consider the nature of mobile phone technologies available in the country.
- consider the coverage and signal strength of mobile phone network infrastructure.
- depend on local experts for development, maintenance and support.
- minimise implementation cost by leveraging on users' mobile phones ownership.
- consider technologies compatible with mobile phones of different specifications.
- avoid the need for specific application to be installed in users' mobile phones.
- be menu-driven to minimise risks of making data entry mistakes.
- avoid internet requirement because of low penetration and associated cost
- optimize user-friendly design to simplify learning and use by low skilled HF users.

Additionally, eIDSR had to be linked to the DHIS2 to take advantage of DHIS2 features supporting the integration of surveillance data with routine health data; data quality validation, analysis and presentation; and data aggregation as expressed by one of the eIDSR implementers:

“DHIS2 was meeting our need for data analysis. Therefore, we thought of how to send information from a mobile phone system to DHIS2 database in order to centralise data storage, analysis, and comparison” (MoHP1).

The mHealth component of the eIDSR application was developed using the USSD technology: a communication protocol for data transfer from mobile phones, using a

special code registered with a mobile service provider. USSD uses Global System for Mobile (GSM) communication network the same way as short message service (SMS) but, while SMS needs a store-and-forward oriented message transaction, USSD provides session-based connections (Dabas and Dabas, 2009). The USSD technology provided three key features desirable for implementing eIDSR:

- interactive real-time text messages are sent between mobile phones and the eIDSR application server by allocating specific sessions for each interaction. The turnaround response time for the interaction application is shorter compared to SMS.
- USSD transactions occur only when users mobile phone and the eIDSR application are all active and within a range. This feature gives instant confirmation as whether a report is being submitted to the server or otherwise. It is different from SMS technology, in which, a text message can be sent to another mobile phone even when it is inactive and out of range; stored for a specified number of days, then delivered when the receiving end is active and within the range.
- the USSD service is independent of users' cell phones, since it does not require distinct specifications nor a pre-installation. Thus, the technology fits most of eIDSR users in rural areas, who are unlikely to own mobile phones with high specifications. It supports reporting procedure from HFs, addressed identified limitations, and presented additional communication benefits as stated by one of the participants:

“USSD was the best technology because it uses a pre-menu whereby users select and enter preferences step by step (...) the good thing with USSD is the fact that it is easier to use. Mobile money in Tanzania is one of the most used mobile phone applications. Almost everyone, even very old people, knows how to send and receive money through mobile phones” (MoHP5).

System development process and technologies

Documentary data do not stipulate a validated software development approach used to build the eIDSR application. Nonetheless, they reveal that the application was built using an iterative process through which software developers and customers were collaborating in defining and refining requirements. Starting with a prototype produced from initial requirements, software deliverables were incrementally produced and presented to the national disease surveillance technical working group for feedback. Through this process, more requirements were gathered, clarifications were sought, and the functional design was confirmed. However, this process did not include prospective eIDSR users in regional, district or HFs level as expressed by a participant from a district where eIDSR was piloted:

“When it started IDSR focal persons we were called to the training by the MoH (...) for my level, I was not involved in any other way (Dist1P1)”.

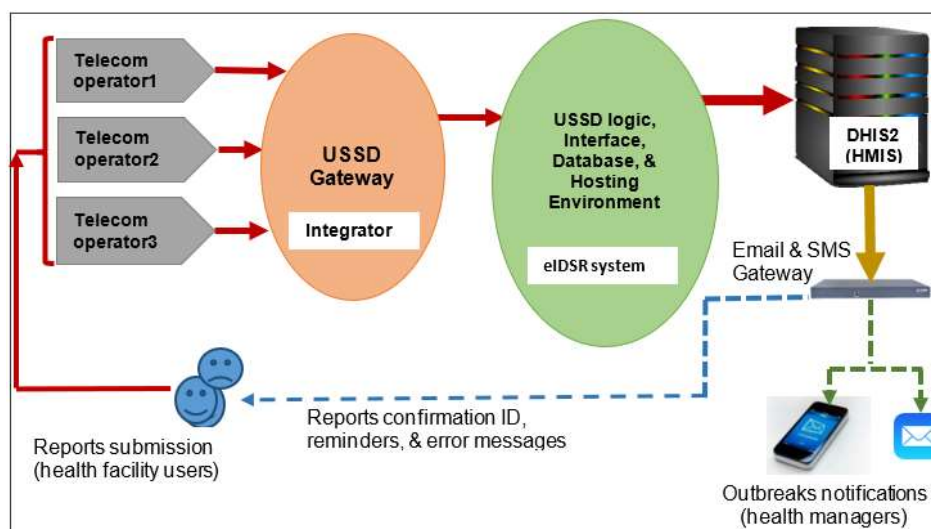
As it will be discussed in the next chapter, the participation of users in lower levels was only by being invited to attend an operational training for pilot implementation.

Technologies and technical infrastructure

In considering the need for using locally available, supported, affordable technologies, free and open-source software were used for software development. PHP is used as a scripting language, and MySQL and PostgreSQL as database management systems (DBMS). MySQL implements a temporal eIDSR database for receiving and temporarily storing data sent from users before sending them into the DHIS2 (built on PostgreSQL) for permanent storage. Both eIDSR mHealth application and DHIS2 are housed in servers installed with freely distributed Linux operating system. Figure 16 is the technical infrastructure of the eIDSR application which incorporates:

- Mobile phone operators through which eIDSR users are subscribed. Initially, eIDSR was operating through only one provider. Later, a flexible design was put in place to allow data submission from multiple operators.
- An integrator: this flexible design above is made possible through an intermediary service provider, a USSD gateway integrator, who provides a shared communication channel for users subscribed to different service providers.
- The DHIS2 server: the eIDSR application server is linked to the DHIS2 server for permanent data storage.
- Email and SMS gateway: this is used to deliver systems generated messages to users as notifications or alerts.
- Users mobile phones for data submission and to which notifications or alerts are delivered as SMS text messages.

Figure 16: The eIDSR technical infrastructure and functional design



There is no physical installation of the eIDSR application in users' mobile phones. Thus, as sketched in Figure 17, the application is imbedded as a logical layer of the HF information system setup, on top of the paper-based medical records system and DSIS.

Users connect to the eIDSR login interface by dialling a special code number from pre-registered mobile phone numbers. A successful login provides users with 3 option: enter data a case-based report of epidemic-prone diseases , enter data for weekly numerical report, or submitting a pending weekly report that had already been entered (Figure 18).

Figure 17: The setup of eIDSR at the health facility level

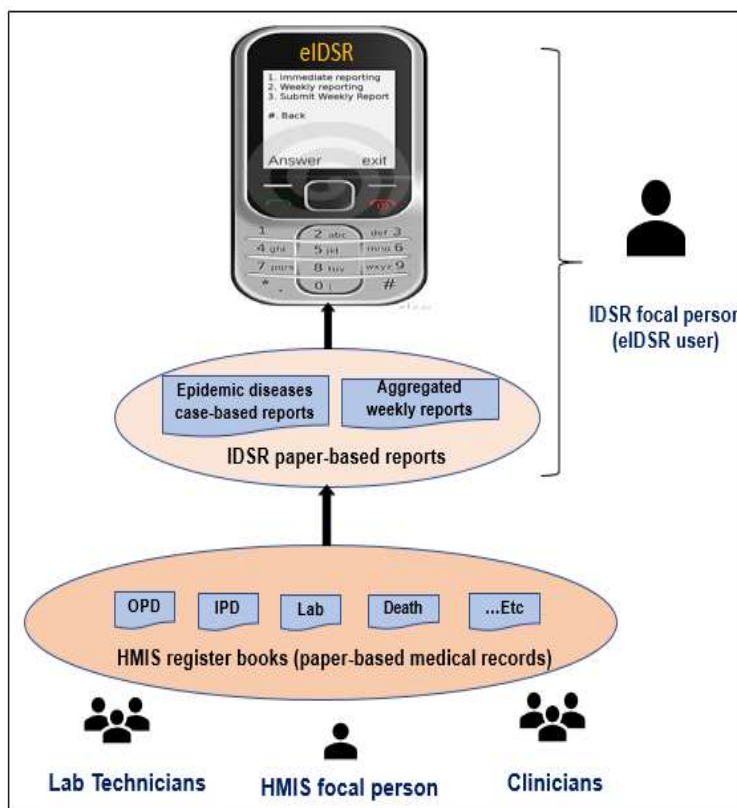


Figure 18: Access to the eIDSR mHealth application by health facility user

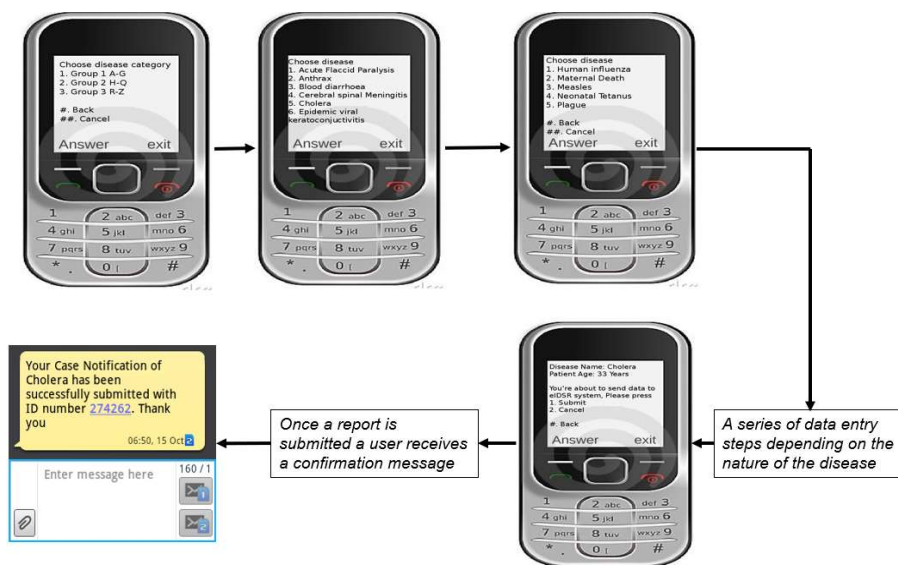


4.4.2. The eIDSR functionalities

(1) Reporting epidemic-prone diseases

As seen on Figure 19, when a user chooses an immediate reporting a list of diseases falling in this category is provided. Then, a series of steps follows, guiding a user to enter data elements in each field without skipping steps. Once all data elements are entered and a report submitted, a user receives an instant SMS notification with a reference ID, confirming a successful submission. Otherwise, an error message is delivered.

Figure 19: Reporting epidemic-prone diseases



(2) Submission of weekly aggregated reports

The weekly paper-based report has 23 diseases as seen in Figure 20, but only 10 are entered through eIDSR (15 to 23, and malaria) because the first 14 are epidemic-prone reported on case-based. Also, malaria records are recorded separately (Figure 21) because they are captured in different data element categories to meet the NMCP information needs but they are reported weekly instead of monthly as it was before the introduction of eIDSR (Table 68 in appendix J)

Figure 20: Health facility paper-based weekly report capture into eIDSR

FORM 3 B: WEEKLY REPORTED CASES / DEATHS AT HEALTH FACILITY LEVELS
 Week: beginning (date): 28, 09, 2015 Week Ending (date): 04, 10, 2015 Week Number 40
 DD/MM / YYYY DD/MM / YYYY

| S/N | DISEASES | Under Five years | | | | Five years and above | | | | TOTAL | | | | Cumulative Totals (From 1st January) | | | | |
|--|----------------------------------|------------------|----|--------|---|----------------------|---|--------|---|-------|----|--------|---|--------------------------------------|---|--------|---|--|
| | | CASES | | DEATHS | | CASES | | DEATHS | | CASES | | DEATHS | | CASES | | DEATHS | | |
| | | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | |
| Weekly summary of immediate reportable diseases | | | | | | | | | | | | | | | | | | |
| 1 | Acute Flaccid Paralysis (AFP) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 2 | Anthrax | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | Blood Diarrhoea | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 4 | Cholera | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 5 | Cerebral Spinal Meningitis (CSM) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 6 | Human Influenza/SARI | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 7 | Keratoconjunctivitis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 8 | Measles | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 9 | Neonatal Tetanus (NNT) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 10 | Plague | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 11 | Rabies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 12 | Small Pox | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 13 | Viral Haemorrhagic Fevers (VHF) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 14 | Yellow Fever | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Weekly reportable diseases | | | | | | | | | | | | | | | | | | |
| 15 | Malnutrition | 16 | 18 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 16 | 2 | 0 | | | | | |
| 16 | Diarrhoea < 5 years | 21 | 15 | 1 | 0 | | | | | 21 | 15 | 1 | 0 | | | | | |
| 17 | Pneumonia < 5 years | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 2 | 1 | 0 | 0 | | | | | |
| 18 | Animal Bites | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| 19 | Tick borne relapsing fever | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| 20 | Trachoma | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| 21 | Onchocerciasis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | |
| 22 | Trypanosomiasis | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 2 | 1 | 0 | 0 | | | | | |
| 23 | Typhoid | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 2 | 1 | 0 | 0 | | | | | |

Figure 21: A separate section of a weekly report with malaria records

Week: beginning (date): 14, 12, 2015 Week Ending (date): 20, 12, 2015 Week Number 50
 DD/MM / YYYY DD/MM / YYYY

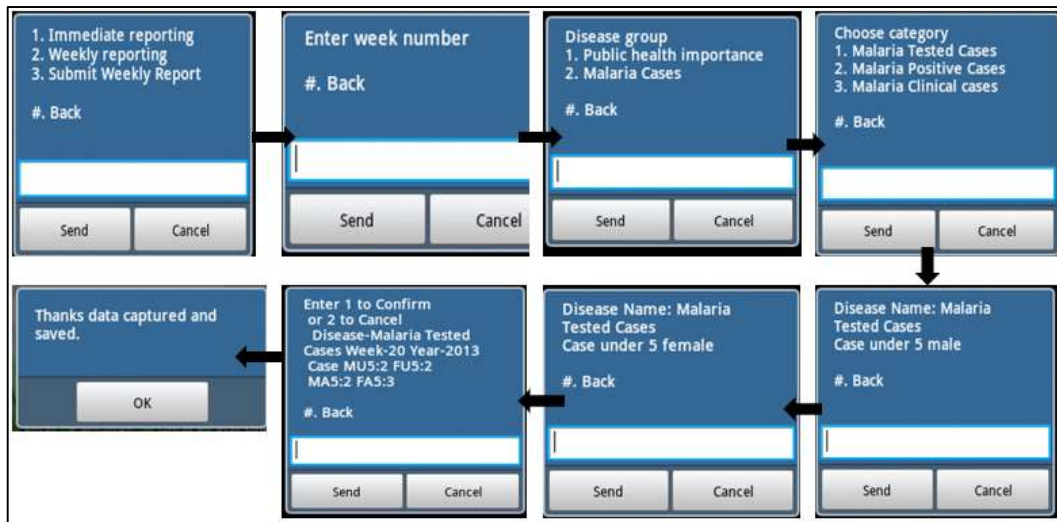
WEEKLY MALARIA SURVEILLANCE

| Days | Number tested with mRDT/ Microscope | | Number tested positive | | Number of clinical malaria Cases | |
|-----------------|-------------------------------------|----------------------|------------------------|------------------------|----------------------------------|------------------------|
| | Under 5 yrs | 5 yrs and above | Under 5 yrs | 5 yrs and above | Under 5 yrs | 5 yrs and above |
| Monday | 2 | 5 | 1 | 5 | 0 | 0 |
| Tuesday | 1 | 1 | 1 | 0 | 0 | 0 |
| Wednesday | 1 | 4 | 1 | 3 | 0 | 0 |
| Thursday | 5 | 9 | 4 | 5 | 0 | 1 |
| Friday | 4 | 9 | 3 | 3 | 0 | 1 |
| Saturday/Sunday | 4 | 5 | 2 | 4 | 0 | 2 |
| Totals | 17 | 33 | 12 | 20 | 0 | 2 |
| | Under 5 yrs Tested | 5 yrs & above Tested | Under 5 yrs Positive | 5 yrs & above Positive | Under 5 yrs Clinical | 5 yrs & above Clinical |

Report sent by: [Redacted] Confirmation ID Number [Redacted]
 Date report sent: [Redacted]

Thus, when a user selects submission of weekly report on the eIDSR (Figure 22), is guided to enter numerical values through the interactive interface. For each disease, values are entered for three data element categories: age group, gender, and case or death condition. The process requires a user to complete entering all 10 diseases before been allowed to submit the report. On the DHIS2, case-based reports are aggregated into respective weekly reports to reflect the format of the source paper-based report.

Figure 22: Steps for submitting a of weekly report through eIDSR



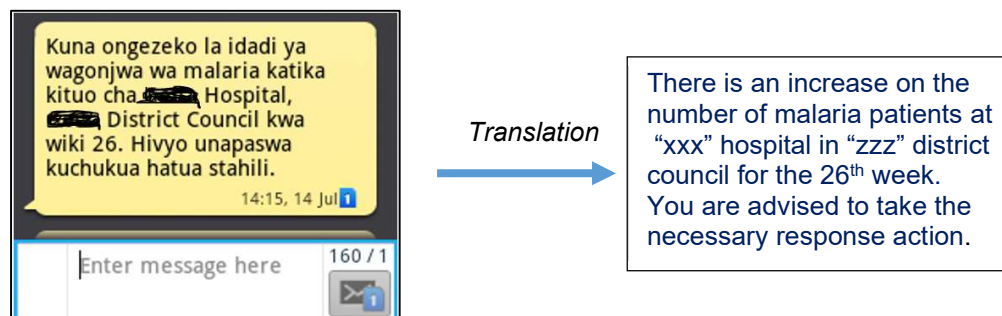
(3) Delivery of outbreak notifications

When action thresholds of diseases reported through eIDSR are reached (described in section 4.2.2), notifications are automatically generated and sent to members of the district, regional and national RRTs in form of SMS text messages and emails. Notifications contain basic information necessary to trigger response. Figure 23 shows examples of SMS and email notifications for epidemic-prone disease and Figure 24 is an SMS outbreak notification for a numerically reported disease (malaria).

Figure 23: Examples of SMS (left) and emails (right) eIDSR outbreak notifications



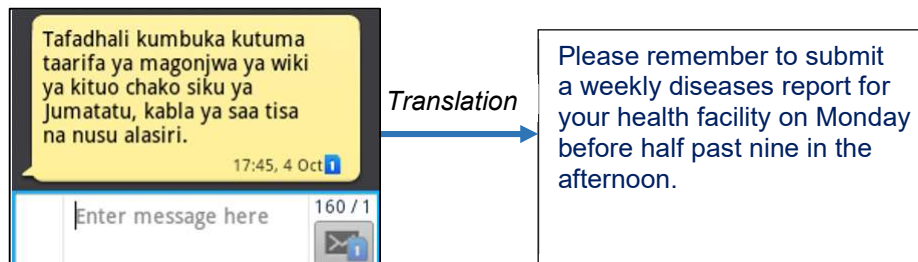
Figure 24: Example of malaria outbreak notification sent by eIDSR



(4) Alerts and reminders

Besides outbreak notifications, the eIDSR application generates other types of messages. These are report confirmation messages (Figure 19 above); rejection notifications attributed to report submission errors or network/system problems; and report submission reminders sent to users prior to the deadline as seen on Figure 25.

Figure 25: A reminder to a health facility user to submit a weekly report on time



The eIDSR requirement analysis document indicates that eIDSR was meant to facilitate two other functions. Firstly, to provide feedback to HFs leaders and managers based on submitted reports (e.g. a list of top ten diseases reported in a specific period). Secondly, to deliver important tip messages focusing on improving surveillance activities in HFs. Suggested tips include new disease diagnosis techniques; common surveillance mistakes to be avoided; and standard case definitions. However, none of the study participants reported to have ever received such messages. This suggests the module was either not developed, dysfunctional or contents were not developed.

(5) Data quality validation

This function was implemented in two approaches. Firstly, as users enter data, the application guides them through menu-based entries to avoid making entry mistakes or submitting incomplete reports. Secondly, once reports are submitted, they are temporarily stored in the database waiting for quality validation by IDSR-DCo through the DHIS2. Once quality queries are addressed (if any), reports are approved and committed to the server for permanent storage.

During fieldwork, I observed that this functionality has been disabled. Reports submitted by HF users were committed to the server without being validated. One of the eIDSR implementer explained that validation has to be bypassed because district managers were either not validating reports or doing so with significant delay. As a result, all reports from HFs were recorded as being either unreported or latently submitted.

eIDSR usage and users

The eIDSR functionalities described above, indicate the application is designed to serve two main types of users. First is the HF users authorised to capture and submit data. The second are managers at the district, regional and national levels who receive outbreak

notifications from HFs. Also, through the DHIS2 they can assess reports submission trends by HFs; download raw data; or analyse data and generate reports in formats such as tables, charts, or geospatial.

4.5. The eIDSR implementation climate and implementation approach

Drawing the results in preceding sections and conceptual framework of the current research in Figure 9, the eIDSR implementation climate at the adoption stage can be characterised as follows. Firstly, there was a sense of readiness by MoH to implement DHIs since it had other related interventions at advanced implementation stages, particularly the DHIS2 as the mainstream HIS database. The DSS managers were determined to use eIDSR to improve surveillance and response functions. Secondly, there were supportive IPPs through the national health policy, health strategic plans, and the national eHealth strategy. Thirdly, resources were ensured through donor support which were used to pay for building the eIDSR application and setting up the technical infrastructure. Also, there was a relatively supportive technical and technological infrastructure and locally available technical skills to support the implementation efforts. Fourthly, the intervention was introduced using a top-down approach, meaning DSS managers at the national level were supportive and ready to solicit resources to support implementation activities. However, users in lower levels were not involved in designing the eIDSR application nor planning the implementation approach. Fifthly, the health managers at the national level, NMCP, and donors played a key role as champions of the eIDSR intervention. Sixthly, the prospective value fit of using eIDSR application could not be established at the adoption stage since the participation of key users at lower levels was not considered.

Despite the relatively positive eIDSR implementation climate at the adoption stage, the analysis of documentary and interviewing data suggests a lack of clarity on eIDSR implementation plans or phases. For example, in one of the project reports, three phases are mentioned up to when the intervention had covered ten regions: piloting in one district for about two months; deployment in 7 regions with 40 districts for 20 months; further deployment in 24 districts for two months. But this information is inconsistent from the narrative of eIDSR implementers at the national level:

“I would say somehow the MoH does not have a plan on scaling up, but we depend on resource availability and funding priorities. A decision on where to start and where to go afterwards mostly depends on the availability of resources” (MoHP5).

“all of these have been gone step-by-step after doing assessments. As of now, we have covered ten regions as we planned since the beginning that we will be increasing regions incrementally and not engaging all at the same time. So right now, we have ten regions and we have stopped. We have to ensure all challenges experienced in these ten regions are been worked out. When the system performs well, then we will add five more regions and stop again” (MoHP1).

These narratives suggest the absence of a common understanding about eIDSR implementation phases even among implementers. Phases were impromptu planned and executed as opposed to being pre-determined as part of implementation plan.

“you will not get such a document. To be honest with you, we did not have a comprehensive documented implementation plan. We started the eIDSR development process immediately after the agreement between the MoH and one of the development partners who provided funds for the initial infrastructure and pilot deployment” (MoHP5).

Similarly, there was no a written validated or invalidated framework or approach to guide eIDSR implementation. Available project documents do not provide any information on change management approach to guide effective implementation of eIDSR.

4.6. Conclusion

This chapter has presented descriptive results about the adoption of the eIDSR intervention. It has explored the eIDSR change vision; structure and roles of the conventional paper-based DSIS as the main target of technological change; the acquisition of the eIDSR solution; and its technological, technical and functional design.

Generally, the eIDSR intervention was a planned change triggered by information system-related challenges. The weak conventional DSIS has failed to provide sufficient, timely, and good-quality data to inform surveillance and response functions, hence weakening the performance of the DSS. Additionally, the decision to implement eIDSR was strongly influenced by other organisational forces such as the national ICT ecosystem; threat of infection diseases from neighbouring countries; reassurance of financial support from donors; and the desire of having a digital information system. Despite eIDSR being regarded as an mHealth intervention, results revealed that the mHealth application was just one of the communication approach and technologies used to develop the eIDSR intervention.

The eIDSR application was aimed to improve timely identification and notification of disease outbreaks; simplifying reporting and information flow; and facilitated data management and use. The application design integrates different communication approaches (SMS text messages, the USSD application, and emails) and linked to the routine HIS database (DHIS2). It mimics and duplicates the design, contents and format of the paper-based DSIS report and continues to depend on HMIS medical records in HFs as the main source of data. However, these objectives, the eIDSR goal was not clearly and consistently articulated. As a result, the intervention was introduced without the application of any implementation approach; the dimension of change and implementation plans were not clearly stipulated; and specific and measurable outcomes were not set. Also, the intervention adoption was highly influenced by technocentric

views, focusing on the technological and technical aspects of the eIDSR intervention as opposed to a strategic technological organisational change effort.

Results in this chapter have set the scene for addressing the rest of the study objectives in subsequent chapters. It has addressed the first component of the conceptual framework of this thesis by providing rich insights on how the eIDSR intervention was conceived in view of technological organisational change prior to its implementation. The next chapter examines the approach, process and practices through which the change initiative was practically implemented relative to the change vision and pre-implementation considerations.

CHAPTER 5

The eIDSR implementation process

5.0. Introduction

This chapter responds to the second aspect of the second objective which sought to examine the implementation process, practices and activities of the eIDSR intervention. It presents qualitative results organised as follows: Section 5.1 analyses the eIDSR deployment at pilot and scaling up stages. Section 5.2 describes the environment of system use and use practices. The effect of leadership and technical capabilities on the implementation process are examined in section 5.3 and monitoring and evaluating are assessed in section 5.4. Section 5.5 discusses the embedding of eIDSR solution in the routine surveillance functions. Table 24 provides a summary of the key findings presented in this chapter.

Table 24: Key findings presented in this chapter

| Main themes | Specific findings |
|--|--|
| eIDSR piloting and scaling up deployment | <ul style="list-style-type: none"> • The intervention was piloted for about 2 months followed by rapid deployment without evaluating the outcome of the pilot. • In the first 2 years it covered nearly 50% of all HF's in the country. • Implementation guided by technocentric view as opposed to the organisational change process; no written implementation approach, work plan or change management strategy. • Rapid scaling up was not influenced by producing anticipated implementation outputs or improved outcomes. |
| Leadership capabilities | <ul style="list-style-type: none"> • Top-down leadership using the conventional DSIS structure with the national team making all implementation-related decisions. • Poor, indirect and reactive user participation • Irrelevant leadership and technical capabilities to support eIDSR implementation • Insufficient and unreliable technical and supervisory support. • Imbalance of financial resources allocated to the national team and managers at lower levels, hence failing to support HF users or enforce eIDSR use. |
| eIDSR use and environment in HF's | <ul style="list-style-type: none"> • Non-institutional implementation focusing on trained individuals; hence no activities took place at HF level. • eIDSR use dependent on data being produced through the HMIS medical records and paper-based DSIS. • Poor eIDSR use attributed to technical and organisational challenges and poor implementation approach and process. |
| Evidence and implementation results | <ul style="list-style-type: none"> • No evaluation studies and limited project monitoring • Generally, the eIDSR was being ineffectively implemented. |

5.1. The deployment process and activities

With reference to eIDSR intervention, the term “implementation” is used to denote the approach, process, activities and practices through which eIDSR was put into use and being used as anticipated. The term 'deployment' denotes the implementation activities to operationalise the eIDSR intervention in a geographical or administrative area. The subsequent sub-sections examine eIDSR deployment at the piloting and scaling up stages.

5.1.1. Piloting

The piloting of eIDSR intervention started in November 2013 after the first version of the eIDSR application was released. User manuals and training materials were developed, training arrangements and schedules were proposed, a pilot location was identified, and a national implementation team (implementers) was formed. The DSIS paper-based data-capturing tool was also redesigned to modify reporting frequency of some diseases and update data element categories. These activities were executed by eIDSR implementers at the national level [described later in this chapter].

Piloting criteria and location

The eIDSR intervention was piloted in District1 in Dar es Salaam region for three main reasons. First, District1 is a municipal council with some locations having a rural setting. At that time, it had 104 HFs, some of them 50kms from the district capital. The district provided a better environment for testing eIDSR by subjecting it to different conditions likely to affect its functioning and use, such as the availability of electricity, mobile phone network coverage and signal strength, users' exposure to the use of digital applications, the reach and accessibility of HFs for technical support, and different HF types/sizes and ownership (public/private). Second, eIDSR implementers regarded District1 as of epidemiological importance, due to being exposed to diseases introduced by the high number of migrants, thus providing a better setting for testing the efficacy of the mHealth application as regards the timely identification and notification of epidemics. Third, the national implementation team was housed at the MoH headquarters, 10kms from District1 capital, making it easy to reach for technical support and/or monitoring activities.

It was planned that piloting would take place in all HFs in District1, 6 of which were hospitals and 98 were PHFs. The rationale for including all HFs in the pilot could not be established due to the lack of a defined implementation design/approach and insufficient documentation of the implementation process, activities and practices, nor were stipulated piloting work plan, timeline, resources and qualification outcomes.

Process and activities

Deployment started when users were invited to attend a 5-day training course organised at the district capital. Key system users were IDSR-HFPs and district regional IDSR, HMIS, and NMCP coordinators. Letters were sent to HF leaders requiring them to appoint one person to attend the training on the condition that they were in charge of disease surveillance activities (IDSR-HFPs) and owned a mobile phone connected to Vodacom (a mobile phone service provider that provided technical and technological infrastructure for the eIDSR).

Among the 104 HFs, only 67 attended the training course during which the participants were engaged in instructor-led sessions, group discussions and hands-on practice. The training contained three elements:

- a) The IDSR technical guidelines: in the first 3 day, the participants were trained to use the updated IDSR technical guideline, as they had not been trained to use the second version of IDSR strategy released in 2011. Aspects covered included priority diseases, conditions and events under surveillance, standard case definitions, and the capture, analysis, and reporting of surveillance data through the DSIS paper-based tool.
- b) The eIDSR application: The next 2 days were used to introduce the eIDSR intervention and how to capture and report data through the mHealth component of the eIDSR.
- c) Introduction to DHIS2 database: The last part of the training focused on the roles of the district and regional managers in the eIDSR intervention. They were trained to use the DHIS2 to verify the data submitted by HF users, assess reporting trends, aggregate and analyse data, and generate reports through the DHIS2.

The deployment of eIDSR did not include physical installation in HFs. Thus, the course included a hands-on training on how to access the system remotely, and the system was configured to enable users to start submitting data immediately after the training.

“They sent us a letter calling us for the training (...) the following week we started using it” (HF3Dist1)

Project documents indicate that main activities after the training were the monitoring of eIDSR use and providing user support through phone calls. Also, users were visited in HFs for supportive supervision, which is described in the next section.

5.1.2. Scaling up stage

The expansion of eIDSR deployment started about 2 months, after it was first deployed in District1, in 3 districts in Mwanza, Mara, and Kagera regions, all located in the Lake Victoria zone. It is unclear whether this was the start of the scaling up efforts or an

extension of the pilot implementation. For example, in one project document, deployment in these districts is described as part of the pilot, while in another as scaling up implementation.

“eIDSR (...) was piloted in some districts in the lake zone regions” (Report2).

“launched a pilot eIDSR system in 67 health facilities in (District1), following the successes and lessons learned from this pilot, rollout began in January 2014 (...) a total of 141 health facilities were deployed in (the three) districts” (Report1).

The same inconsistency was noticed when implementers were prompted to describe the implementation plan.

“From there we moved to the next phase in which few districts in Lake Zone were selected (...) to test eIDSR in more remote areas” (MoHP5).

“We thought the best practices from (District1) would be easy to extrapolate to other regions” (MoHp1).

If the deployment of eIDSR in 3 districts in the lake zone was an extended piloting phase, this would raise four arguments. Firstly, the pilot involved only 64% of HFs in District1, and so further piloting would have taken place in the remaining HFs, instead of 141 located in 3 other districts more than 1,000 kms away in 3 different regions. Secondly, if the idea was to test eIDSR in different contexts as part of the piloting approach, as argued by one of the implementers, the decision would have been informed by the lessons learnt from District1, which was not the case. Thirdly, the number of HFs covered in 3 districts was far too many to manage and study, given the size and location of the implementation team. But if not enough, two months later (March 2014) eIDSR was deployed in 8 more districts with a total of 279 HFs. Fourthly, the efforts to test eIDSR on a wider scale and in different contexts would have resulted in addressing, inter alia, the technical challenges users faced in District1. As expressed by one of the health managers in District1, this was not the case.

“We are still challenged by issues that should have been addressed earlier during the piloting stage. When we started there was no concentration. Just after deploying and seeing people sending data, they were satisfied and decided to expand to other regions” (Dist1P2).

Moreover, eIDSR pilot implementation was not evaluated before scaling it up to a wider coverage. Only the technological aspects of the intervention were monitored to establish whether the application was functioning according to its design.

“After the pilot, we had some sort of supportive supervision visits to health facilities. We got feedback from users, and their perception of the system was positive, that it simplified their work. The feedback is what made us move forward to other regions (...) we relied on feedback about the use of the system” (MoHP3).

Therefore, the results strongly suggest that the immediate expansion of eIDSR to other districts before covering all HFs in District1 signified that scaling up had already started.

As explained by one eIDSR implementer, coverage was expanded before there was evidence of improved outcomes at the piloting stage.

“We are adhering to the plan we had, and we are moving smoothly (...) we are following that plan and there are no obstacles” (MoHP1).

Besides the claim above, no written implementation plan had been prepared before piloting in District1 and up to when this research was being conducted. There is difference an evidence showing that the deployment of eIDSR in other districts, before covering all HFs in District1, was influenced by the presence of high transmission rate of malaria in the lake zone. The donor supporting the NMCP was ready to fund eIDSR deployment hoping it would facilitate the prompt identification of malaria outbreaks.

“one of the areas they [donor] supported was the Lake zone where the spread of malaria was alarming” (MoHP5).

Main activities during scaling up

The main activities undertaken during scaling up of eIDSR were the same as those during the pilot, namely training and monitoring activities through mobile phone communication and visits made by eIDSR implementers to regions, districts and HFs deployed with eIDSR to provide supportive supervision. Since there was no written monitoring framework or work plan, it could not be established when supervision visits started after deployment in a given location and how they should have been conducted.

Supervision visits were impromptu, depending on, inter alia, resource availability. One or more members of the national implementation team would purposely sample one or more districts in a region, in which they would sample a few HFs to visit. In this way, either a small number of HFs or larger ones were visited, as quoted below from two reports:

“supervision was done in 58 health facilities which were not reporting at all” (Report3).

“In each region, two districts with the lowest reporting rate were selected for the supervision (...) in each district, about five to six health facilities were selected: two being those which are performing well and four which are not performing well” (Report2).

This indicates that supervision visits did not cover HFs. For example, 7 of 12 HFs sampled for this research had never been visited.

“I have never seen anyone coming for a supervision visit since deployment” (HF3Dist1)

“I expected to see them coming for supportive supervision or to assess how we use the system, but that has never happened” (HF2Dist3).

During the piloting stage, the visits focused on getting feedback from users on how the eIDSR application was functioning and identifying issues needing to be improved.

“We were doing supporting supervisions at least 3 months after the training to find out what technical challenge users face and try to address them. It helps us understand the usability of the system as well as building capacity at district level” (MoHP5)

Issues raised by users in these visits were documented in the supervision reports but there was no evidence on what they addressed. During interviews, users in the pilot district expressed similar concerns to districts covered during scaling up implementation.

During scaling up, supervision visits were less frequent, covered fewer HFs and were largely conducted in places with poorer performance. Normally, the visits would start by meeting RHMT and CHMT leaders to discuss the purpose of the visits and another meeting arranged at the end to provide feedback and recommendations on their findings. Activities in HFs focused on assessing the capturing of data, system usage, receiving feedback on eIDSR functionality, identifying technical challenges, and suggesting issues that could be addressed locally, such as training more users. The visitors could not address system-related technical challenges because the eIDSR application is centrally accessed and managed. Supervision reports document issues raised or found during the visits that require the attention of users or implementers, but no further information was provided on whether, how and when they were addressed.

Implementation schedule

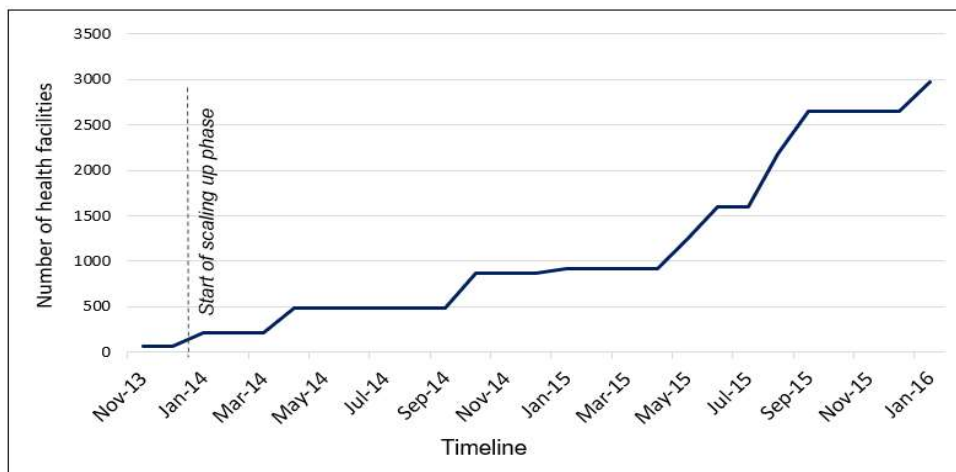
Table 25 summarises deployment from November 2013 to January 2016 when eIDSR had already covered 10 regions with 70 councils and nearly 50% of all HFs in the country.

Table 25: Deployment of eIDSR intervention from November 2013 to January 2016

| Deployment date | Locations/ coverage | Districts | HFs |
|---------------------|---|-----------|------|
| November 2013 | District1 in Dar es Salaam region (pilot) | 1 | 67 |
| January 2014 | 3 districts: District2 in Mwanza and 2 others in Mara and Kagera regions. | 3 | 141 |
| March 2014 | Remaining districts in Kagera region and 1 district in Geita region. | 8 | 279 |
| September 2014 | Kilimanjaro region | 7 | 387 |
| December 2014 | Remaining health facilities in District1. | 0 | 50 |
| April 2015 | District 5 and remaining districts in Mwanza | 7 | 316 |
| May 2015 | Remaining districts in Mara Region | 8 | 229 |
| | Remaining districts in Geita Region | 5 | 133 |
| July 2015 | District4 in Dar es Salaam Region | 1 | 172 |
| | Manyara region | 7 | 198 |
| | Singida region | 7 | 214 |
| August 2015 | District5 in Dar es Salaam region | 1 | 111 |
| | Dodoma Region | 8 | 350 |
| Dec 2015 - Jan 2016 | Arusha region | 7 | 324 |
| | Total | 70 | 2971 |

No implementation schedule with clear criteria on how deployment progressed after piloting was found. Figure 26 shows the deployment trend, indicating that eIDSR was rapidly and irregularly scaled up, the time between each deployment was very short, and number of districts and HFs covered each time varied significantly. For example, 857 HFs in 18 councils were deployed in 2014 as opposed to 1,731 HFs in 44 councils from May-August 2015.

Figure 26: Number of health facilities deployed with eIDSR in the first 2 years



The rapid scaling up of eIDSR was determined by the following factors:

(4) Financial support from donors and their priorities

Many donor organisations are supporting the healthcare system in Tanzania. Usually, the MoH allocates them to specific administrative areas (districts/regions/zones) where their support is greatly needed.

“We are trying to map all donors to areas they would like to go to, and the government puts money where nobody wants to go (...) if we would convince a donor to put money where we like, we normally take areas where there is huge population or good number of health facilities” (MoHP4).

Similar to eIDSR adoption, scaling up was also driven by the fact that different donor organisations were ready to support the scaling up of the eIDSR intervention. Donors not only supported eIDSR deployment but also influenced the rapid deployment approach and prioritisation of regions to be covered. For example, prioritisation of Lake zone regions served a donor’s interest in getting malaria data.

“instead of implementing eIDSR to report malaria data only, the partner supported the whole package of diseases under surveillance (...) they were getting malaria data and the MoH was getting data for all diseases under surveillance. In this way, eIDSR was automatically rolled out in all regions in the lake zone” (MoHP5).

When donors were prepared to fund eIDSR deployment in regions in which they operate, the MoH took advantage to expand the coverage.

“The decision to scale up to more regions was also influenced by funding partners. Every partner had their own interests depending on the project and the nature of the support they provided (...) the roll out was driven by priorities set by funding partners since they had the resources to conduct training” (MoHP5).

(5) Perceived benefits of eIDSR as a technological solution

The eIDSR implementers claimed eIDSR piloting was successful, thereby justifying their decision to expand deployment.

“We saw that it worked well, and so we said, let us include more users to see how it works” (MoHP3).

The notion that “it worked well” was not attributed to improved outcomes, but to implementation feasibility, and to some degree the fidelity of the eIDSR application, which was perceived to indicate effectiveness, rationalising wide-scale implementation.

“I don’t have to worry much because mobile phones can help to do a lot. Our introduction of mobile phone innovation for health has motivated other people to include mobile phones in other programmes (...) Right now the mobile phone systems are used for appointments in some hospitals, and we are going to implement mobile phone payment in hospitals. It is also used for behaviour change to remind pregnant women to attend clinics (...) and for blood banks to send reminders about donating blood” (MoHp4).

The overall socio-technical organisational change necessary for effective implementation of eIDSR has been left out of the implementation equation. For example, based on assumption that DHIs are emphatically beneficial, regions where eIDSR has been deployed are regarded as being protected from epidemics.

“The main drive for us to move to the regions is how risky they are to importing epidemic diseases (...) we are shielding the country from public-health threats or any outbreak that might be imported from neighbouring countries on crossing borders” (MoHp1).

Thus, regions regarded as being at risk of epidemics are among the ten where eIDSR has already been deployed, in that they have a large population and a high internal migration rate, border another country, or are an international transport hub (Dar es Salaam, Mwanza, Kilimanjaro, Kagera, Arusha and Dodoma). However, apart from implementers’ anecdotal narratives, there was no evidence that eIDSR is adding value in protecting the above regions from epidemics [discussed in chapter 8].

(6) The desire to achieve full-scale implementation

The eIDSR implementers planned to deploy eIDSR to scale at the adoption stage, notwithstanding the nature of the evidence it would produce. Thus, soliciting resources for deployment activities was prioritised over attaining anticipated outcomes.

“No evaluation has been done but this is part one. When we know that we have covered the whole country and that we are ready to be evaluated, we will do that (...)

we have not done that due to lack of funds. Any money we get now we use to deploy more regions rather than doing an evaluation” (MoHP4).

This approach may have been attributed to prior knowledge about the presumed benefits of DHIs, thereby assuming that eIDSR would be effective. Donors seem to have supported the implementers’ views, and so they continued to fund scaling up efforts without proof of improved outcomes.

“They saw how the system works and they showed interest in continuing their support, especially funding users’ training” (MoHP3).

“We were working with partners to facilitate the initiative through the funds we solicited. They demanded outputs and wanted to understand the procedure for complementing through soliciting funds and entering into contract with the service providers” (MoHP4).

However, as presented in chapters 7 and 8, the findings disputed implementers’ narratives about eIDSR’s effectiveness, and despite its rapid deployment the implementers were dissatisfied with the coverage achieved by the time of conducting the research. One main challenge mentioned to have constrained deployment momentum was that some rural areas had not yet been covered by mobile phone networks.

“Since we are using mobile phones, we focus on establishing the nature of network coverage first (...) we are going to areas where networks are available” (MoHP3).

In addition, rapid deployment resulted in unresolved technical challenges to users [described later in this chapter], hence the need to suspend deployment.

“We want to train Rukwa and Katavi regions, but we did not manage to because we want to make sure the system is functioning perfectly to give us confidence before moving to other regions. The system is not performing to its optimal level (...) we need to make sure the 10 regions are reporting as expected first, and the system is running properly” (MoHP2).

5.2. The environment of eIDSR use and factors affecting its use

The extent of innovation use is an integral part of the implementation process, determining implementation effectiveness (Klein and Knight, 2005). The use of eIDSR was examined regarding how well it supports to capture and submit disease surveillance data at HF level, and how well the data were analysed and used by district, regional and national health managers. This section presents the results of the former, and the latter is covered in chapter 8.

5.2.1. eIDSR usage environment at the health facility level

Use of eIDSR at the HF level is determined by the internal and external environment. The internal environment encompasses the IDSR-HFPs, the eIDSR users, as well as clinicians, laboratory technologists and HFHMIS-FP, the HMIS medical record system, and data collection tools, all influencing how eIDSR is being used. As sketched in Figure

17, for eIDSR to be used to submit data, the HMIS medical record system must be functional and HMIS clinical records be effectively captured. From the HMIS records, disease surveillance data are captured in the paper-based DSIS and thereafter captured in the eIDSR. As a result, eIDSR use at HF level is a function of and limited to the interaction of different components of the HMIS and DSIS.

The external environment consists of health managers at the district, regional and national level and the technological elements of the supporting infrastructure, discussed in 4.4.1 and summarised in Figure 16. Thus, besides the components of the internal environment, eIDSR is only able to function when mobile phone service providers provide a reliable network and strong signal, the integrator provides the required bandwidth shared by users connected to different service providers, the eIDSR application is supported and functions without technical glitches, the DHIS2 database is functional and stable, there is reliable internet connectivity to both the eIDSR and DHIS2 servers, and when managers provide the technical and administrative support and incentives needed by HF users.

5.2.2. Factors influencing eIDSR use

The use of eIDSR by HFs was poor in the sampled HFs and generally in all the others. For example, one supportive supervision report indicates that more than 50 HFs in District1 had never used the system for nearly 16 months since they were deployed. The findings reveal that eIDSR use was constrained by factors relating to organisational practices, system design and deployment approach, as discussed below.

(1) Non-institutional deployment approach

The implementation of eIDSR did not include any activity at the HF level. Thus, there was no defined strategy for institutionalising eIDSR use in HF working practices or for seeking the support of other HF workers involved in the production of data. Only those who had received training were involved with eIDSR use. As a result, eIDSR users seemed to be unaccountable to anyone within HFs.

“I don't have any reports I have generated from the data I collect (...) I do not present disease records at hospital meetings, maybe during outbreaks” (HF1Dist4).

Lack of the institutional approach in deploying eIDSR was not exclusive to HFs. Even at the council level, the involvement of the CHMTs was insufficient, although they are the immediate users of data reported from HFs to inform their role in surveilling diseases and responding to outbreaks.

“To be frank with you, the CHMT does not do anything or follow up on the use of eIDSR” (Dist2P1).

The researcher managed to informally engage with three DMOs while seeking permission to collect data at the district level. They indicated that they knew about eIDSR, but when asked about the status of use, they advised the researcher to engage with IDSR coordinators because they are the only ones responsible for its use. Thus, eIDSR implementation seemed to have centred on individual users instead of the DSS as an organisation.

(2) Data production process

The users of eIDSR need to cooperate with other FHWs who capture clinical records from which surveillance data are extracted, but the findings reveal poor or lack of such cooperation, mostly in hospital settings where clinical records are captured in several HMIS books, some of which are shared by two or more clinicians.

“They [doctors] know that I need to be notified so that I can report to the district. Some don’t do that and will just decide to remain silent. Also, there are those who never record anything in registers and so there is no way I can get those records” (HF2Dist4).

In PHFs, clinical data are captured in a relatively orderly manner because there are fewer FHWs, hence fewer HMIS books used by the same individuals. In addition, eIDSR users are likely to be HF leaders, but this does not seem to support eIDSR use. Clinical duties and leadership responsibilities do not give users time to submit data.

“I have many things to do and I don't have time to submit data through eIDSR. As you can see those people outside came before we open the facility and I have had to stop attending to them to see you” (HF3Dist1).

When users are HF leaders, they are not accountable to anyone for failing to use eIDSR because the buck stops with them.

Furthermore, the capturing of medical records in the HMIS books was generally poor, not standardized, and inconsistent. As discussed in chapters 6 and 7, disease surveillance records were either missing, incomplete, illegible or captured in different sources but without common identifiers.

“Patients’ registers are not filled as required. A doctor would fill in the patient’s name, where he comes from, age, and diagnosis. But you would find he has not documented anything about lab test requests and results. For diseases like malaria, we are supposed to report tests and positive test results. It becomes difficult to understand those records since we don’t know whether cases are positive or negative” (HF1Dist4).

Because HMIS records are the source of surveillance data, poor data capturing weakened the efforts to use eIDSR.

(3) Use of personal mobile phone

People using their mobile phones to access eIDSR was meant to create a sense of ownership and minimise implementation costs. Despite the practicability of the idea, it

posed some challenges for eIDSR use in HFs. Submission of data is only through pre-registered mobile phone numbers as explained quick guide to eIDSR users in Figure 52 in appendix M, hence when owners are not at work or their phone has become dysfunctional, it is suspended.

“When I am away, I have to call someone in my facility to send me the data through a phone call or SMS, since my phone is the only one which is registered to report. If this person is occupied, then there will be no report on that day” (HF3Dist2).

“In one facility the person trained and registered to submit data went to school. When the facility wanted to report, they had to send the data to him first through SMS and ask him to submit the data, which was difficult because he was preoccupied with his studies” (Dist3P1).

The challenges worsen when registered users permanently leave HFs, which is common due to the high attrition rate, mainly attributed to movements between public and privately owned HFs, transfer of post, change of career or retirement.

“Another challenge is the transfer of users from the health facilities in which they were registered to access the system. They move without informing us and that becomes the end of that facility to report (...) whenever they move out of facilities, then that becomes the end of the system” (Dist1P2).

(4) Inability to build capacity for the needed skills in health facilities

During the eIDSR training sessions, the participants were advised to train at least one more person in their Hs on how to use eIDSR to submit data. Among the HFs sampled for this research, only one user indicated having managed to do so. The findings suggest four factors challenged implementation of this plan.

The per diem culture and controlling mentality: attending workshops or training courses organised outside HFs is an opportunity highly sought after by FHWs, because they get extra income paid as per diems. This privilege is referred to as “the per diem culture”, which was reported to affect eIDSR use in HFs because those who receive training are not given the necessary cooperation of other FHWs involved in data production.

“People have sentiments in health facilities against those who attend training. They consider going to attend official training is an opportunity to get money in terms of allowances. Accordingly, when those who attended training want to train them, they decline the offer claiming they have nothing to benefit” (Dist2P1).

Moreover, most of the invitations sent to HFs concerning training stipulate specific individuals based on their responsibilities. However, it is common for HF leaders, which was also observed during eIDSR training course, to appoint individuals to be trained whose responsibilities are different from the intended tasks, as those not responsible for surveillance activities are appointed to attend eIDSR training but thereafter would not be involved in using eIDSR. For example, in a HF where eIDSR was piloted, eIDSR had never been used up to when this study was conducted. When asked about this the district coordinator said:

“They sent an irrelevant person for training thinking that it was all about allowances without knowing that it was training intended for work” (Dist1P1).

The attendant did not use eIDSR after the training because he is not involved in information management in the HF and so the IDSR-HFP decided not to use eIDSR.

This problem was more common in urban districts, which have large number of private HFs. It was reported by district managers that private HF owners or leaders tend to personally respond to training invitations, even when they are not directly involved as FHWs, after which they are not prepared to train someone else in eIDSR use.

“Some health facility leaders want to hold onto power, and so they don’t want to share responsibilities with others. Since they are the ones who were trained, they don’t see why they should train someone else to do the work” (Dist3P1).

Staff shortage and heavy workload: the training of new eIDSR users in HFs is constrained by the shortage of FHWs and the workload. Using eIDSR is an extra responsibility because users have other core responsibilities, mostly clinical.

“I have not trained someone else to help because we are short staffed” (HF2Dist1).

“the other thing is the workload. I have my core responsibilities which exhaust me. Data management activities add to that” (HF3Dist3).

“That is a big challenge because sometimes I have work to do in the community especially during outbreaks. As a result, I fail to report on time” (HF1Dist1).

(5) Technical challenges and insufficient user support

Concerns about eIDSR instability and technical challenges were raised during interviews, mostly with HFs and district participants, more frequently than any other topic. Similar issues are widely reported in all supportive supervision reports and notes taken during implementation progress review meetings.

“There is the question of users’ motivation to use the system. Some users are discouraged from continuing to use it when they fail to submit data due to technical problems. When they try more than once and fail, they give up” (Dist2P1).

The problems include unsuccessful login attempts, system unresponsiveness, expiration of login sessions while capturing data, delayed or failed feedback notification after data submission (confirmation ID), mobile phone network congestion, poor connectivity or weak signal in rural areas, insufficient bandwidth relative to the number of users accessing eIDSR simultaneously, and failure to deliver reported outbreak notifications. Most of these challenges were felt by users in both rural and urban areas.

“We had challenges with the mobile phone network. In some facilities, users had to climb a tree or stand on top of a hill to get a strong network signal (...) currently the network has improved, but users are facing another challenge. They don’t receive a confirmation number after data submission” (Dist3P1).

Technical challenges were intensified by the lack of immediate technical support. HF users were instructed to seek technical support from district coordinators as indicated eIDSR quick start guide,

“Contact district IDSR focal person for your password to be reset (...) You must contact district IDSR focal person for your old number to be removed and your new one to be registered” (eIDSR Quick Start Guide, Appendix L: eIDSR implementation Figure 52 in the appendices)

However, IDSR-DCo were unable to provide the needed support.

“If someone like me visits health facilities, I might come back without any solution to the current challenges. We need ICT experts to be part of supervision visits” (Dist1P2).

The severity of technical challenges discouraged users from using eIDSR to submit data, which stopped some of them using it soon after deployment.

(6) Limitations attributed to the eIDSR design

The eIDSR design has two main limitations to HF users. First, users find the mHealth application interface unfriendly because it takes them a long time to submit reports.

“On average they [users] spend 2 to 3 hours to complete a report” (Report3).

“There are times when reporting an immediate notifiable case could take me the whole day or I manage to submit it late at night. Just think of what it is like when you have five or more cases. It was boring and that is why I had to stop using it” (HF2Dist4).

Second is the failure of the system's design to foresee emergency situations, as it was expected that eIDSR would facilitate timely identification and notification of suspected cases and deaths attributed to epidemic-prone diseases, such as during the cholera outbreak in 2015/2016. However, eIDSR was unhelpful for two main reasons. The system only allows data to be submitted by users linked to registered HFs. During the cholera outbreak, HFs were directed to immediately refer all suspected patients to cholera treatment centres (CTCs) even before capturing their records.

“Cholera cases are not recorded in facilities because they were directed to report any suspect cases to the district, and the patients were transferred to a CTC. There was no arrangement for capturing patients' records through eIDSR in CTC” (Dist1P2).

At the same time, CTCs were not registered to submit data through eIDSR, and FHWs assigned to CTCs were not necessarily among those trained to use eIDSR and were overworked. As a result, all cholera cases attended to at CTCs were not submitted through eIDSR, which indicates a weakness in the design of eIDSR and lack of consideration of possible situations which could affect eIDSR use.

Third, when a user realises there was a mistake in a report s/he has submitted, the design requires a resubmission of the whole report, as explained in Figure 52 in the appendix M, hence discouraging users to correct data.

(7) Implementation plans

Up to when this research was conducted, both eIDSR and the paper-based DSIS were used to report surveillance data. No milestones were set to terminate using the DSIS in places where eIDSR was deployed. HF users found that using the two systems was an unbearable burden and illogical. Some users had stopped using eIDSR, perceiving it as unimportant.

“I think we should just do it through eIDSR. It doesn’t make sense for me to submit reports through eIDSR and receive confirmation ID that it has been received and yet I have to submit the same report manually” (HF3Dist3).

“Despite having the eIDSR system, they still demand that we send a paper-based report to the council” (HF3Dist1)

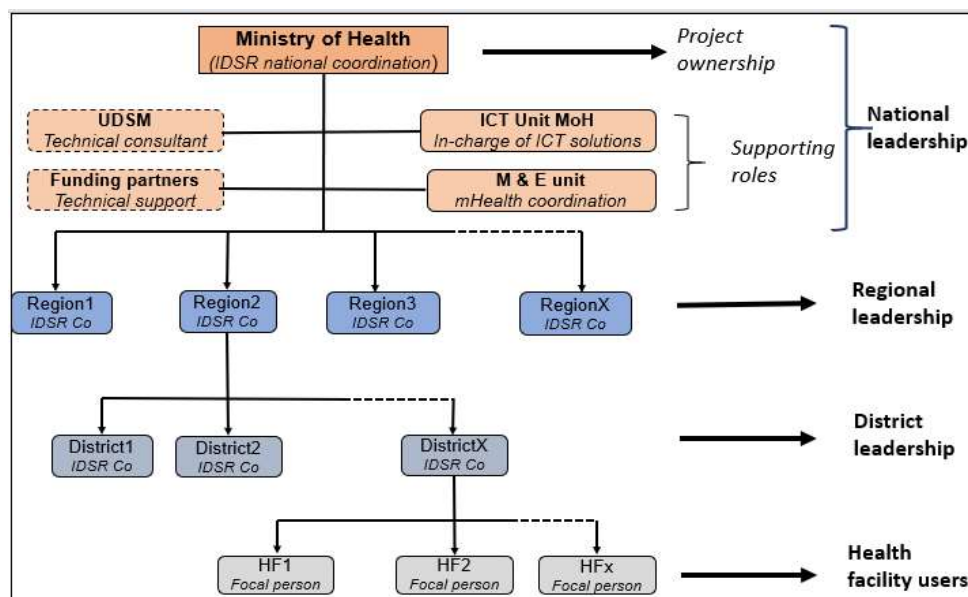
5.3. Leadership structure, roles and capabilities

The implementation of eIDSR intervention used the same conventional management structure as that of the DSS. No new managers were recruited to oversee its activities, and the leaders in place were not equipped with the skills needed to effectively implement eIDSR.

5.3.1. Structure and roles

The eIDSR is being implemented using the top-down leadership approach. As depicted in Figure 27, the leadership structure is composed of the national team and district and regional coordinators.

Figure 27: The leadership structure for implementing the eIDSR intervention



Led by the national IDSR coordinator, the national team comprises officials from the epidemiology unit, which owns the intervention, the M&E unit which, manages the mainstream HIS, and the ICT unit, which coordinates DHIs and provides policy-related implementation guidance on the technology, standards, infrastructure, connectivity and technical support (MoH-Tanzania, 2013a). There were at least 2 permanent members from each unit, but the team composition was flexible subject to the manpower needs of implementation activities.

The national implementation team included participants external to the MoH, who played a critical role in building the capacity of the national team. They were the eIDSR developers from the UDSM, who were also involved in deployment activities in the pilot district and several others covered in the first 2 years, as well as some donor organisations, whose experts provided technical support to the national team through, inter alia, user training and supportive supervision.

“When we started the implementation, the team was small. It had a few people from the ICT unit, epidemiology department, M&E unit, UDSM, and some partners (...) they were adding inputs to build different teams which were working in parallel in different districts for training and other rolling out activities” (MoHP5).

As scaling up rapidly progressed, the implementation team was expanded to provide the manpower needed to support this move. More members were recruited from other units within the MoH and among IDSR-DCos and HMIS-DCos in districts and regions which had already been equipped with eIDSR.

“There were different implementation phases and the team has been incrementally growing (...) as we continued to cover more regions, the number of people involved increased. We reached a point where we were doing parallel training sessions (...) we could have 3 or 4 teams in one region for training but in different districts. In this way, there were 30 to 40 people facilitating training concurrently” (MoHP5).

The second level of leadership is the DSS management structure at the regional and district level. IDSR-DCos comprise the management and technical team supporting HF users, while IDRS-RCos oversee eIDSR performance in districts. There were no new recruits and district and regional managers were not provided with the skills they needed, because it was assumed that the IDSR-HFP or regional/district IDSR manager could take charge of eIDSR implementation, subject to attending the five-day training course described earlier in this chapter. However, as argued in the previous section, district and regional coordinators could not provide the kind of support needed by HF users.

“We were reporting to the district coordinator to link us with the technical team at the MoH.” (HF2Dist4).

5.3.2. Leadership capabilities

The hierarchical and highly bureaucratic structure characterising the management of the healthcare system facilitated communication of the eIDSR change vision to users at lower levels. This chain of command was applied to introduce, deploy and enforce the use of eIDSR. In this regard, the findings showed no obvious resistance to accepting eIDSR or friction between leaders and system users, although this research reveals that those leaders did not have the relevant skills for supporting and overseeing effective implementation of eIDSR in the following areas.

The mismatch between the urgency and actionable implementation plans

Despite the top-down implementation approach, eIDSR implementers succeeded in effectively communicating the change vision and creating the sense of urgency necessary for technological change. Nearly all the participants consulted in this research acknowledged the need for technological change and were positive about the anticipated eIDSR benefits.

“People were positive about eIDSR, especially those in remote areas” (Dist1P1).

“I don’t have to go to the district to submit data because I can do it directly through a mobile phone” (HF3Dist1)

To HF users, eIDSR gave them hope that the information-related challenges they were facing would be resolved once and for all.

“We appreciated the system and felt good about using new technology to submit data. We saw that it was a good thing for us since it would simplify our work” (HF2Dist4).

“eIDSR makes me feel more responsible because it sends me reminders to report that makes me feel compelled to report” (HF2Dist1).

However, efforts to translate the eIDSR change vision into actionable plans and activities were insufficient. Once eIDSR was accepted by users and donors were ready to fund deployment, implementers were confident that eIDSR would be helpful, but they did not establish a change management strategy to ensure its success.

“The introduction of eIDSR was very critical because we have realised a lot of improvement in terms of receiving weekly reports and immediate notifications of epidemic-prone diseases (...) after the introduction of eIDSR we found that most of the facilities comply with reporting frequency and no facility is missing to report, whether an immediate or weekly report. The system is very supportive” (MoHP1).

However, their position was inconsistent, both in terms of the evidence they provided and the views of users at lower levels.

“I failed to submit records several times, and so I decided to stop using eIDSR” (HF3Dist2).

All implementation-related reports and notices provided for this study state categorically that eIDSR use was very poor and data submission rates were far below the 80%

minimum target. A progress report produced 22 months after the pilot indicated that none of the 8 regions using eIDSR by then had reached the minimum reporting target, as RC ranged between 32% and 77% and RT between 7% and 27%.

Lack of technical skills and unreliable technical support for users

Despite the novelty of the eIDSR intervention, its implementation is being led by traditional health system managers, who have been given additional responsibilities on top of the routine tasks that are already too demanding. The managers do not have the competence or experience to lead the implementation of DHIs, nor have they been equipped with the relevant skills.

“they have never capacitated me to provide support at the district level (...) I have been connecting health facility users directly to the ICT unit (...) that is the best I can do since I don’t have any other means to help them” (Dist4P1).

Thus, all regional, district and HF users depended on insufficient technical support. This study identified only two personnel in the ICT unit assigned to support all eIDSR users, while fulfilling their routine and non-routine obligations in the MoH.

Failure to produce short-term wins

“Short-term wins” are regarded as an indispensable prerequisite for the effective implementation of any organisational change (Kotter, 1995). They motivate those affected to embrace the change and maintain the momentum of the change process. The eIDSR change vision focused on improving the detection and notification of outbreaks, the submission of routine reports, data analysis, use and feedback. As a short-term win, eIDSR would change these functions. However, nothing was done to ensure that users would immediately benefit from using eIDSR.

“Nothing has changed. We are still doing what we were doing in terms of capturing records and reporting” (HF2Dist2).

“I have never received any notification from HFs regarding epidemic-prone diseases (...) eIDSR has not supported the reporting process as anticipated” (Dist2P2).

Similarly, users were unhappy with the lack of a plan for suspending the parallel use of eIDSR and the paper-based system, because it increased their workload.

“I don’t know the rationale for demanding both electronic and paper-based reporting (...) we are required to capture data in a paper-based report on Monday and submit it through eIDSR. We then send the paper-based report to the district on Tuesday morning” (HF2Dist1).

“we are not just working on information (...) we have many other things to do” (Dist1P2).

Despite these concerns, implementers wanted both reporting systems, as full-scale implementation had not yet been achieved.

Lack of a sense of ownership by system users

Most eIDSR users at lower levels seemed to struggle owning the intervention while appreciating its importance and relevance. They perceived using eIDSR as an obligation to implement management directives rather than as a change they own.

“Unfortunately, we have not heard from the ministry team. They have never bothered even to ask us about perceptions and feelings about the system” (HF2Dist4).

“they should communicate with us at lower levels” (Dist1P2).

During interviews, the participants would initially suggest they were positive about the system, but when prompted to provide evidence backing up their claims, the narratives would change into describing how dysfunctional the system was. For example, 67% of the consulted district and regional managers were not receiving notifications from HFs or accessing DHIS2 data. Some had never accessed this data since being trained, while others had forgotten their credentials because of an extended period of inactivity. However, they were still confidently describing the benefits of using eIDSR.

“I like the system so much and I usually login (...) eIDSR has increased the reporting rates because health facilities were reluctant to report” (Dist1P1).

One manager whose phone had never even been registered to receive notifications said:

“eIDSR has facilitated immediate reporting of epidemic-prone diseases (...) timely submission of reports has improved compared to the situation before” (Dist2P1).

This observation suggests that participants had reservations about the eIDSR initiative but were uncomfortable freely expressing their concern. Moreover, users at lower levels distanced themselves from the failure of eIDSR to function as expected, blaming the national implementation team.

“**They** should design the system in such a way that some information would be inserted automatically (emphasis mine)” (HF3Dist3).

“I think **those who implement the system** should make available resources to train more than one person (emphasis mine)” (HF3Dist3).

The intention to implement eIDSR and the reason for rapid deployment were also questioned.

“Maybe someone is doing his PhD research and introduced the system for the sake of research. The system has proved to be a failure, even for the pilot district” (Reg1P1).

Resource allocation

Financial resources provided by donors were directed only to activities discharged by the national team. IDSR-DCo and IDSR-RCo were concerned that the implementers had not provided the finance to facilitate their role as supervisors of HFs neither their immediate employers (CHMTs or RHMTs). For instance, they needed credit in their phones to

remind users to submit data and validate submitted reports, and computers and internet connectivity to access DHIS2, assess eIDSR use, analyse data, or generate reports.

“We use our own laptops and pay for internet connectivity. Since 2012 when I started using DHIS2, I have only received money twice from the district for internet” (Dist3P1).

“Health facility users report only when they are reminded to do so. Otherwise, they don’t report, or delay reporting (...) it costs me a lot since I use my own money to put credit in my phone while it is government work” (Dist2P1).

The narratives above suggest that implementers focused on achieving full-scale deployment without thoroughly considering the resources needed to facilitate system use.

5.3.3. Embedding eIDSR and users’ participation

Embedding eIDSR refers to the process of normalising and making it a fully operational and dependable information system in relation to the surveillance and response functions. The findings could not establish whether there was a strategy for embedding eIDSR, as activities that had taken place prior to and during this study focused only on expanding eIDSR coverage and ensuring the fidelity of the software application. The absence of an eIDSR embedding strategy indicates, inter alia, the poor participation of users in the implementation process.

As established earlier, eIDSR users did not participate in planning implementation, as they only found out about the intervention during training sessions. After eIDSR was deployed in a particular location, users interacted with the implementers mainly to report technical challenges or seek technical support, and for some during supervision visits. However, an indirect user participation approach was observed during the scaling up stage, when implementers faced challenges, they could not address without involving CHMT and RHMT leaders. For example, after observing declining eIDSR usage by HFs, implementers organised consultative meetings with RHMT and CHMT leaders, two of which had been held involving 3 regions before fieldwork for this study was conducted. In addition, when the implementers realised that many HFs were sending unsuitable participants to eIDSR training sessions, they wrote a letter to the leaders.

“we proposed that a letter be written and signed by the MoH permanent secretary directing RHMTs and CHMTs to make sure that those attending training sessions are those who would report (...) the plan to send a letter from the MoH (...) has made a difference in some areas” (MoHP4).

Furthermore, during supportive supervision visits, the implementers held meetings with RHMT and CHMT leaders to discuss the purpose of the visits, thereafter, providing feedback and recommendations subject to their findings in HFs. Thus, users’

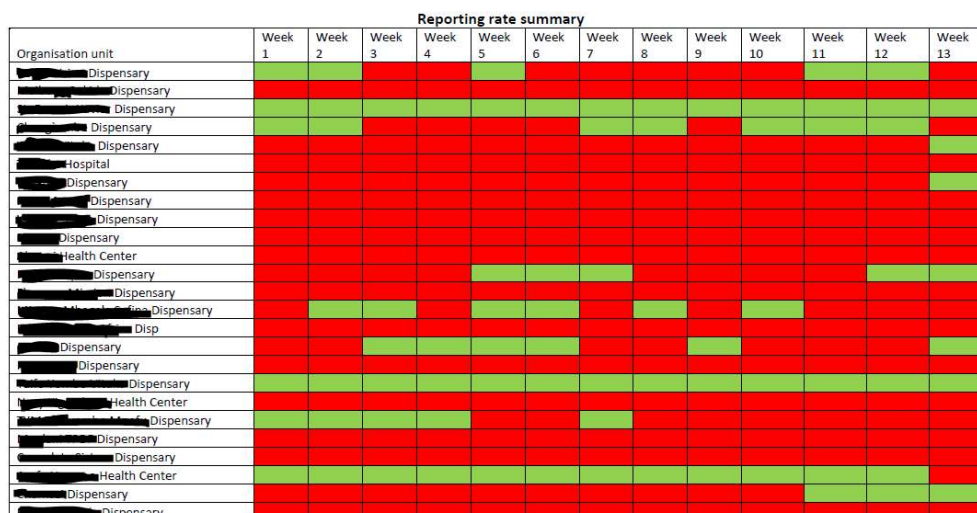
engagement was a reactive and administrative strategy rather than a participatory one, and involved only leaders, not HF users who captured the data and sent reports.

5.4. Monitoring and evaluation

In the context of implementing DHIs, monitoring is “the routine collection, review and analysis of data, either generated by digital systems or purposively collected, which measure implementation fidelity and progress towards achieving intervention objectives” (WHO, 2015, p.5). Evaluation is “the measures taken and analysis performed to assess the interaction of users or the health system with the digital health intervention strategy, or changes attributed to the digital health intervention” (WHO, 2016b, p.5). During the implementation of DHIs, monitoring and evaluation are expected to take place in parallel and complement each other. While monitoring focuses on ensuring the fidelity of the solution, evaluation focuses on wider and complex aspects of the intervention, to establish whether it produces the intended results (Agarwal et al., 2016a; WHO, 2016b).

The eIDSR intervention was being implemented without a written monitoring and evaluation framework, but the findings reveal three implementation activities focusing on ensuring intervention fidelity and attaining the intended outcomes. First were the supportive supervision visits explained above. Second was the assessment of eIDSR use through the DHIS2 by district, regional and national health managers by reports submitted by HFs, individually or collectively. Specifically, IDSR-DCo are supposed to frequently generate report about eIDSR use patterns as part of their role in supporting and supervising HFs. However, none of those consulted in this research produced such reports. At the national level, graphical reports were generated as part of the supportive supervision or progress reports as shown in Figure 28, a graph extracted from a report of a supportive supervision visit. It indicates the weekly reports submission status of 25 HFs in the pilot district for the first 13 weeks in 2015. Despite being more than a year since deployment, few of these HFs had submitted or frequently submitted reports.

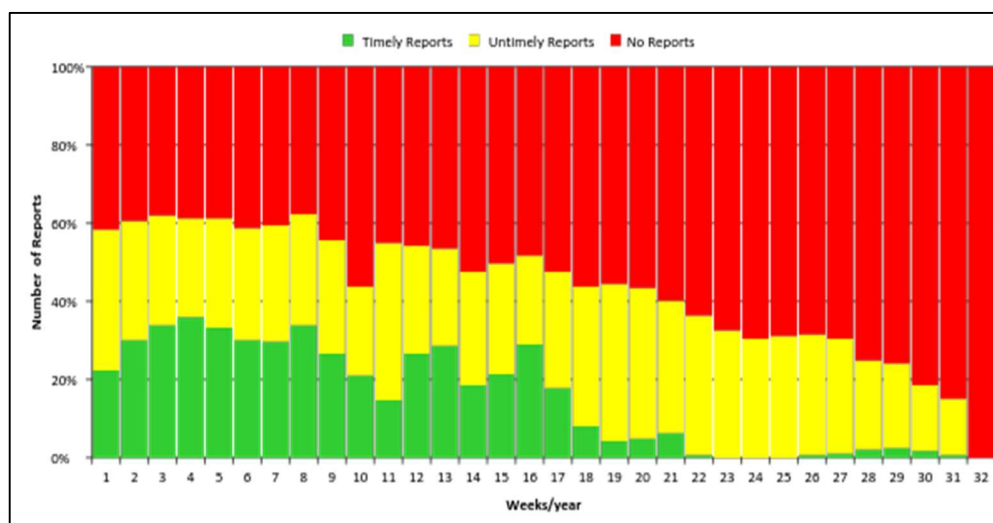
Figure 28: Reports submission status for 25 health facilities in the pilot district



Key: Green - submitted reports in the respective week: Red- not submitted reports

Similarly, Figure 29 shows eIDSR use from January to August 2015 by all HFs in Kagera region, one of the first regions to be equipped with eIDSR soon after piloting. By the time the report was prepared, eIDSR had been in use for nearly 17 months, but only few reports had been submitted and were late, and the reporting trend continued to decline.

Figure 29: Weekly reporting submission status in Kagera region, first 32 weeks in 2015



Third were the implementation progress review meetings that eIDSR implementers held with CHMT and RHMT leaders, discussed in the previous section. The meeting notices indicate that the concerns raised were the same as those documented in supportive supervision reports and raised by participants during interviews.

“We are still challenged by issues that should have been addressed much earlier” (Dist1P2).

This situation questioned the rationale for rapid deployment and whether the supportive supervision visits were useful, because similar concerns had been expressed by participants in the pilot district and those covered during scaling up.

The monitoring of eIDSR could have been relevant to the intervention context, as it might have provided needed information on implementation progress and fidelity of the technological solution. For example, it is a routine for health managers to pay lower levels supportive supervision visits when a new health-related intervention has been introduced. Users at lower levels regard these visits as meaningful, because they signify that their efforts are valued and the intervention is useful. They get feedback on their performance and get the opportunity to express concerns they may have. Likewise, for RHMT and CHMT leaders, progress meetings were useful for getting away from the busyness of their work. However, there was no evidence on whether the monitoring of eIDSR use was effective as leaders were faced with several limitations.

For example, the shortage of staff in HFs could not be immediately addressed by CHMT and RHMT leaders, because it is a continuing health system problem, which needs a sector-wide intervention to resolve it. In addition, the problem of poor eIDSR use was attributed to the leaders themselves because IDSR-Cos were not playing their role in supporting FHs and accessing the reports submitted. Similarly, proposed plans of action from supervision visits and progress review meetings were not accompanied by actionable plans and targets, or a timeframe for addressing them.

Evaluation of the implementation process

Regarding evaluation, up to when this study was conducted, eIDSR had not been systematically evaluated during its 3 years of use and the scaling up to ten regions. Thus, there was no evidence that eIDSR was producing the anticipated results despite anecdotal narratives given by implementers suggesting the opposite.

“We have evidence that the system is helping us to achieve the intended objectives (...) we have several evidence supporting the effectiveness of eIDSR compared to the paper-based reporting system” (MoHP1).

“We have not rolled out [eIDSR] to the whole country, but preliminary results show there is an improvement” (MoHP4).

However, when prompted to explain how such results were found or to provide documentary evidence about evaluation practices, contrasting answers were given.

“We are following up outcomes through our monitoring and evaluation mechanism. After every 3, 6 and 12 months we do an analysis based on the performance indicators we have (...) we assess how many facilities have submitted reports (...) the monitoring indicators help us to know that the system is working well” (MoHP1).

“No evaluation has been done, but this is part one. When we cover the whole country and feel that we are ready to be evaluated, then we will do that (...) we haven’t done

that because of lack of funds. Any money we get for now we decide to use for rolling out rather than doing evaluation” (MoHP4).

The inconsistent explanations by implementers, as to what evaluation entails and whether it had been done, raised questions about the shared understanding of key implementation aspects. It suggests the absence of an informed implementation approach and a definite, timely, actionable and measurable set of activities guiding the process.

The focus on the technological aspect of the eIDSR intervention, and the desire to achieve full-scale implementation meant that no attention was paid to how its effective implementation could be judged. Even the eIDSR application was not yet functioning as intended

“We are still challenged by issues that should have been addressed much earlier (...) had we concentrated on the pilot district for at least 6 months before moving to other regions, we could have answers for the questions we still have and addressed the technical challenges we are facing” (Dist1P2).

Therefore, the rapid deployment of eIDSR was technically unjustifiable, because it did not show evidence that the anticipated outcomes had been attained.

5.5. Chapter summary

This chapter has presented qualitative results on the approach, process and activities characterising the implementation of the eIDSR intervention at the piloting and scaling up stages in its first 3 years. Themes covered were eIDSR deployment during the piloting and scaling up stages, eIDSR use environment, implementation leadership structure, roles and capabilities and monitoring and evaluation.

The eIDSR intervention is being implemented using the top-down approach. It was introduced to users by senior health system officials through the existing institutional hierarchical structure, but its implementation was not guided by the evidence-based approach, and the participation of users was poor, reactionary and indirect. Users were largely regarded as recipients of a management directive rather than important stakeholders whose experience, roles and skills need be involved in determining the design and process of eIDSR implementation. Some of the implementation challenges faced could have been addressed had user participation been valued. Thus, users had little sense of ownership, and perceived eIDSR as an imposition that increases the workload of FHWs.

The intervention was piloted in 64% of 104 HFs in District1, but it could not be categorically determined when and how the piloting stage ended and scaling up started. Two months after the pilot, and even before covering the remaining HFs, eIDSR was extended to 3 other districts in 3 different regions. A few months later an irregular and

expeditious deployment process started, covering 70 councils with nearly 50% of all HFs within 2 years. The main implementation activities were training users, providing technical support, and some councils and HFs receiving supportive supervision visits. The rapid scaling up was largely influenced by donors' financial support, and the timing and location set by them, the presumed benefits of DHIs, the desire to achieve full-scale implementation, and the techno-centric perspective focusing on the technology as opposed to the organisational change process. There was no change management strategy, activities designed to institutionalise eIDSR use, or evaluation looking for evidence of its usefulness.

At HF level, the eIDSR is positioned as a logical information system on top of the HMIS paper-based medical records system and the DSIS. The functioning of these systems dictates the availability of surveillance data, hence the quality and consistency of eIDSR use. As an immediate management level, the district plays a key role in supporting and enforcing eIDSR use by HFs. However, the capacity of district managers was not built to facilitate implementation, nor were they provided with the necessary financial and material resources to support HF users. There was an imbalance of skills, knowledge, experience and resource allocation between implementers and leaders at lower levels.

The use of eIDSR was poor and so there was no correlation between scaling up efforts and the results produced. This was affected by the weak interaction between eIDSR and the other information system components in HFs, due to eIDSR use being seen as the role of individual users rather than of the organisation as a whole. As a result, eIDSR users have no sense of accountability, and the cooperation of other FHWs involved in producing data is lacking. In addition, eIDSR use was affected by the per diem culture, dependent on personal mobile phones, the controlling mentality of HF leaders, application design limitations, staff shortages, insufficient technical support, unresolved technical challenges, heavy workload, and poor implementation plans.

Therefore, the findings establish that, up to when this research was conducted, the eIDSR intervention has been ineffectively implemented. The quality and consistency of eIDSR use for submitting data at HF level was poor.

The next chapter expands the findings presented in this chapter by focusing on the data intended to be improved through the use of eIDSR. It presents analysis results of the value of clinical records at HF level from which disease surveillance data reported through eIDSR are extracted. It also examines the accuracy of these records prior to being submitted through eIDSR, and factors affecting it.

CHAPTER 6

The value of source disease surveillance data

6.0. Introduction

This chapter addresses the second objective which aimed to investigate the value and quality of clinical records at HF level. As presented in chapters 4 and 5, disease surveillance data are captured from the routine paper-based HMIS medical records in the DSIS, and thereafter in the eIDSR mHealth application. Thus, HMIS and DSIS practices determine the quality of the data submitted through eIDSR. This chapter examines the value of clinical records to:

- d) establish they are useful to the disease surveillance and outbreak response functions.
- e) provide a basis for assessing the effect of eIDSR use on the quality of surveillance data (chapter 7 and 8).

Section 6.1 quantitatively examines the value of cholera and malaria clinical records, regarding their usefulness in informing clinical decisions and determining treatment outcomes. Section 6.2 qualitatively investigates the factors affecting the quality of surveillance data in HFs.

Table 26: Key findings presented in this chapter

| Key message | Specific findings |
|---|--|
| The clinical value of disease surveillance data in HFs | <ul style="list-style-type: none"> • The usefulness of clinical records in determining treatment outcomes could not be established because there was no evidence that clinical records were used to inform clinical decisions. • Laboratory testing was rarely done to determine treatment, but confirmatory testing was not a standard procedure. |
| Factors affecting the quality of clinical records in HFs. | <ul style="list-style-type: none"> • Clinical records were inaccurately, inconsistently and incompletely captured or documented. • Heavy workload, shortage of data collection tools, poor storage of clinical registers, non-institutional data management practices. • Limitations and contradictions caused by surveillance guidelines for treating and testing. • Non-adherence to standard clinical practice. |

6.1. The value of cholera and malaria clinical records

The clinical records analysed in this chapter were collected from District1 and District4, during the cholera outbreak from August 2015 to June 2016. Malaria clinical records were collected from HF1 in District4 (HF1Dist4).

6.1.1. Cholera records

Cholera data were captured in different HFs at the onset of the outbreak, in cholera treatment centres (CTCs) established a few weeks after the outbreak, and in HFs after

the closure of CTCs. These records were collected from district RRTs instead of HFs because districts were coordinating the management of data. Before the CTCs were established, suspected cases were immediately reported to the IDSR-DCOs, who then collected more information on the confirmation, treatment and outcome of cases. After the establishment of CTCs, HFs were directed to immediately transfer suspected cases to them, where all activities were coordinated by the DRRTs. IDRS-DCOs kept the records on a spreadsheet. Table 27 summarises the records collected from the two districts each month.

Table 27: Cholera clinical records captured in District1 and District4

| Months | District1 | District4 |
|----------------|-----------|-----------|
| August 2015 | 65 | 394 |
| September 2015 | 187 | 826 |
| October 2015 | 294 | 763 |
| November 2015 | 143 | 161 |
| December 2015 | 70 | 49 |
| January 2016 | 0 | 56 |
| February 2016 | 36 | 81 |
| March 2016 | 65 | 72 |
| April 2016 | 61 | 66 |
| May 2016 | 0 | 76 |
| June 2016 | 16 | 9 |
| Total | 937 | 2,553 |

Analysis of cholera data from District1

(1) General overview of collected clinical records

Table 28 summarises all the records captured in District1 and Table 29 summarises death records only. A total of 937 records (cases and deaths) was collected, 768 (82%) of which were captured from the onset to the peak of the outbreak (August to December 2015), and 169 were collected after the CTC was closed (January to June 2016). The following observations were made from the records summarised in the 2 tables above:

- several data elements in individual records were either not captured or documented. For example, there were no test results, treatment decisions and testing information for 14, 119, and 410 cases, respectively, and none had information confirmation.
- 14 deaths were indicated as being tested, but neither results nor treatment decisions were recorded. For patients who died in HFs/CTC, 1 had no information on testing.

The following assumptions were made during the analysis about gaps observed:

- patients died at home were not treated, and so tests were performed on dead bodies.
- out of 9 patients who died in HFs/ CTC, 8 were tested either before or after death.

- nearly all patients who reached HFs or CTC were treated, and so all 9 patients who died in HFs/CTC were treated before death.
- records with no information on patients' treatment were regarded as untreated.

Table 28: Cholera records captured in District1 - August 2015 to June 2016

| S/n | Cholera records | Aug–Dec 2015 | Jan–Jun 2016 | Total |
|-----|---|--------------|--------------|-------|
| 1 | Total suspected patients (cases and deaths) | 768 | 169 | 937 |
| 2 | Total tested patients (cases and deaths) | 412 | 115 | 527 |
| | a) positive results | 260 | 29 | 289 |
| | b) negative results | 138 | 86 | 224 |
| | c) no results given | 14 | 0 | 14 |
| 3 | Patients not tested | 356 | 54 | 410 |
| 4 | Patients treated | 674 | 138 | 812 |
| 5 | Patients treated and had test records | 387 | 95 | 482 |
| | a) had positive results | 260 | 29 | 289 |
| | b) had negative results | 118 | 66 | 184 |
| 6 | Patients not tested but were treated | 287 | 43 | 330 |
| 7 | Patients reached facilities but no information on treatment decisions | 88 | 31 | 119 |
| | a) Tested negative | 20 | 20 | 40 |
| | b) Not tested | 68 | 11 | 79 |

Table 29: Cholera death records from District1 - August 2015 to June 2016

| Sn | Cholera deaths | Aug–Dec 2015 | Jan–Jun 2016 | Total |
|----|---|--------------|--------------|-------|
| 1 | Total deaths recorded | 15 | 0 | 15 |
| 2 | With testing information | 14 | 0 | 14 |
| | a) positive results | No results | 0 | N/A |
| | b) negative results | No results | 0 | N/A |
| 3 | a) At facilities /CTC (tested but no results) | 8 | 0 | 8 |
| | b) At facility/CTC without testing records | 1 | 0 | 1 |
| 4 | At home (tested after death) | 6 | 0 | 6 |

By using the contingency tables theory described in section 3.4.1 categorical relationships between selected variables in Table 28 and Table 29 were established. The results are presented in pairs of frequency counts and frequency distributions.

(2) Relationship between testing for cholera and treatment decisions

Table 30: Test status frequency counts and treatment decisions

| Test status / treatment | Treated | Not treated | Total |
|-------------------------|---------|-------------|-------|
| Positive results | 289 | 0 | 289 |
| Negative results | 184 | 40 | 224 |
| Tested but no result | 8 | 6 | 14 |
| Not tested | 330 | 80 | 410 |
| Total | 811 | 126 | 937 |

Table 31: Frequency distribution, testing status and treatment decisions

| Test status / treatment | Treated | Not treated | Total |
|-------------------------|---------|-------------|--------|
| Positive results | 0.3084 | 0.0000 | 0.3084 |
| Negative results | 0.1964 | 0.0427 | 0.2391 |
| Tested but no results | 0.0085 | 0.0064 | 0.0149 |
| Not tested | 0.3522 | 0.0854 | 0.4376 |
| Total | 0.8655 | 0.1345 | 1.0000 |

Key message:

- Testing and treatment decisions: 56.24% of all cases and deaths were tested for cholera (30.84% positive, 23.91% negative, and 1.49% no test results) and 40.69% $P(X4 / Y1)$ of patients were not tested. However, 86.55% of all cases were treated.
- Testing and results: 97.34% $(N_1+N_2/ N_1+N_2+N_3)$ of tested cases had results produced

The distribution suggests there was little likelihood of patients being tested, but the likelihood of producing test results was high. Also, being tested or not and the results produced did not determine treatment decisions.

(3) Relationship between cholera confirmation tests and test results

Table 32 and Table 33 present the relationship between test results and tests confirming the presence of cholera.

Table 32: Frequency counts of test results and confirmation tests

| Confirmation/Test results | Confirmed | Not confirmed | Total |
|---------------------------|-----------|---------------|-------|
| Positive results | 0 | 289 | 289 |
| Negative results | 0 | 224 | 224 |
| No test results | 0 | 14 | 29 |
| Total | 0 | 527 | 527 |

Table 33: Relative frequency distribution of test results and confirmation tests

| Cholera confirmation/ Test results | confirmed | not confirmed | Total |
|------------------------------------|-----------|---------------|--------|
| Positive results | 0.0000 | 0.5484 | 0.5484 |
| Negative results | 0.0000 | 0.4250 | 0.4250 |
| No test results | 0.0000 | 0.0266 | 0.0266 |
| Total | 0.0000 | 1.0000 | 1.0000 |

Key message:

The data indicate that out of all the cases tested none was confirmed, meaning that treatment decisions were made without the test results being confirmed.

(4) Relationship between treatment outcomes and treatment decisions

Table 34 and Table 35 present the relationship between treatment decisions and treatment outcomes for suspected cholera patients.

Table 34: Frequency counts of treatment outcomes and treatment decisions

| Outcomes/ Treatment | Survived | Deaths | Total |
|---------------------|----------|--------|-------|
| Treated | 803 | 9 | 812 |
| Not treated | 119 | 6 | 125 |
| Total | 922 | 15 | 937 |

Table 35: Relative frequency distribution - treatment outcomes and decisions

| Outcomes/ Treatment | Survived | Deaths | Total |
|---------------------|----------|--------|--------|
| Treated | 0.8570 | 0.0096 | 0.8666 |
| Not treated | 0.1270 | 0.0064 | 0.1334 |
| Total | 0.9840 | 0.0160 | 1.0000 |

Key message:

- 98.40% of all suspected cases survived; the likelihood of surviving when treated was 98.86% (803/812) and the case fatality rate (CFT) was 1.6%.
- The probability of patients who were treated dying was 0.96% and those who died without/before treatment was 0.64%.
- 9/15 (60%) of those who died reached HFs for treatment.

The distribution indicates that nearly 2 people died for every 100 suspected cases, and for every 100 patients that were treated 1 died, and so suspected cases were more likely to live when treated. Since test results of deaths were not recorded, nor was it known whether they were tested before death, the relationship between test results and treatment outcomes could not be established.

Analysis of data from District4

(1) General overview of the collected clinical records

Table 36 shows the number of cholera records captured in District4, 2,191 (85.8%) of which were captured during the peak of the outbreak and 362 thereafter, which were captured in two hospitals where cholera patients were referred to after the CTC closed.

Table 37 summarises the death records, which indicate:

- only 14% (305/2191) of patients were tested for cholera during the peak of the outbreak compared with 88.7% (321/362) thereafter, which indicates that more tests were carried out for patients in hospitals than at the CTC.
- 18 deaths happened at the CTC/HFs, 2 at home, and 6 on the way to the CTC/HFs. It was not indicated whether the patients who died at the CTC/FHs while being treated were tested before or after death.

Table 36: Cholera records captured in District4 – August 2015 to June 2016

| S/n | Cholera records | Aug–Dec 2015 | Jan–Jun 2016 | Total |
|-----|---|--------------|--------------|-------|
| 1 | Total suspected cases and deaths | 2,191 | 362 | 2,553 |
| | Captured at CTC | 2127 | 0 | 2127 |
| | Captured at health facilities | 64 | 362 | 426 |
| 2 | Total tested performed (cases and deaths) | 305 | 321 | 626 |
| | positive results | 118 | 12 | 130 |
| | negative results | 123 | 230 | 353 |
| | no results were given | 64 | 79 | 143 |
| 3 | Patients who were not tested | 1,880 | 41 | 1,921 |
| 4 | Total patients treated | 2,181 | 359 | 2,545 |
| | positive results | 111 | 10 | 121 |
| | negative results | 121 | 229 | 350 |
| | Tested but no results | 64 | 79 | 143 |
| | Not tested but treated | 1,880 | 41 | 1,921 |
| | Testing status not indicated | 6 | 0 | 6 |
| 5 | Deaths before treatment and tested | 6 | 2 | 8 |

Table 37: Cholera death records captured in District4 - August 2015 to June 2016

| S/n | Death records | Aug–Dec 2015 | Jan–Jun 2016 | Total |
|-----|--|--------------|--------------|-------|
| 1 | All deaths recorded | 22 | 4 | 26 |
| 2 | With test records | 22 | 4 | 26 |
| 3 | With positive test results | 16 | 3 | 19 |
| | In facilities/CTC after treatment | 9 | 1 | 10 |
| | In facilities/CTC before treatment | 1 | 0 | 1 |
| | On the way to HFs/CTC | 2 | 1 | 3 |
| | At home | 2 | 1 | 4 |
| | On the way to HF/CTC while being treated | 1 | 0 | 1 |
| 4 | With negative test results | 6 | 1 | 7 |
| | in facilities/CTC after treatment | 5 | 1 | 6 |
| | On the way to the HF/CTC | 1 | 0 | 1 |

(2) Relationship between testing for cholera and treatment decisions

Table 38 and

Table 39 show the relationship between tests conducted on patients who reached HFs/CTC and treatment decisions.

Table 38: Testing status frequency counts and treatment decisions

| Testing status/treatment | Treated | Not treated | Total |
|------------------------------|---------|-------------|-------|
| Tested with positive results | 123 | 7 | 130 |
| Tested with negative results | 352 | 1 | 353 |
| Tested but no results | 143 | 0 | 143 |
| Not tested | 1921 | 0 | 1921 |
| Testing not indicated | 6 | 0 | 6 |
| Total | 2545 | 8 | 2553 |

Table 39: Frequency distribution- testing status and treatment decisions

| Test status/treatment | Treated | Not treated | Total |
|------------------------------|---------|-------------|--------|
| Tested with positive results | 0.0482 | 0.0027 | 0.0509 |
| Tested with negative results | 0.1379 | 0.0004 | 0.1383 |
| Tested but no results | 0.0560 | 0.0000 | 0.0560 |
| Not tested | 0.7524 | 0.0000 | 0.7524 |
| Testing not indicated | 0.0024 | 0.0000 | 0.0024 |
| Total | 0.9969 | 0.0031 | 1.0000 |

The distribution suggests that testing for cholera and treatment decisions were independent events. Only a small number of cases were tested, and treatment decisions did not depend on being tested or the type of test results.

(3) Relationship between confirmation of the presence of cholera and test results

Table 40 and Table 41 show the relationship between test results and test confirmation.

Table 40: Frequency counts of test results and cholera confirmation

| Cholera confirmation/Test results | confirmed | not confirmed | Total |
|-----------------------------------|-----------|---------------|-------|
| positive results | 0 | 130 | 130 |
| negative results | 0 | 353 | 353 |
| without test results | 0 | 143 | 143 |
| Total | 0 | 626 | 626 |

Table 41: Relative frequency distribution- test results and cholera confirmation

| Cholera confirmation/Test results | Confirmed | Confirmed | Total |
|-----------------------------------|-----------|-----------|--------|
| positive results | 0.0000 | 0.2077 | 0.2077 |
| negative results | 0.0000 | 0.5639 | 0.5639 |
| without test results | 0.0000 | 0.2284 | 0.2284 |
| Total | 0.0000 | 1.0000 | 1.0000 |

Key message:

None of the tested cases was confirmed as being a true-positive or false-negative result. This suggests that test results were not confirmed, and confirmation was not regarded as mandatory to inform treatment decisions.

(4) Relationship between treatment outcomes and test status

Table 42 and Table 43 indicate the relationship between testing and treatment outcomes.

Table 42: Frequency counts of treatment outcomes and test status

| Treatment outcome/testing | Survived | Deaths | Total |
|---------------------------|----------|--------|-------|
| Tested | 608 | 18 | 626 |
| Not Tested | 1,913 | 8 | 1921 |
| No testing information | 6 | 0 | 6 |
| Total | 2,527 | 26 | 2,553 |

Table 43: Relative frequency distribution of treatment outcomes and tests

| Testing/treatment outcomes | Survived | Deaths | Total |
|----------------------------|----------|--------|--------|
| Tested | 0.2382 | 0.0071 | 0.2452 |
| Not Tested | 0.7493 | 0.0031 | 0.7524 |
| No testing information | 0.0024 | 0.0000 | 0.0024 |
| Total | 0.9898 | 0.0102 | 1.0000 |

Key message:

- A patient had a 97.12% (608/626) chance of surviving if he/she had been tested.
- 69.2% (18/26) of deaths were of patients who were being treated and CFR was 1.02%.

The results show that more patients died when receiving care than those who died at home or on their way to HFs.

(5) Relationship between treatment outcomes and treatment decisions

Table 44 and Table 45 show the relationships between treatment decisions and outcomes.

Table 44: Frequency counts of treatment outcomes and treatment decisions

| Treatment outcome/treatment decisions | Survived | Deaths | Total |
|---------------------------------------|----------|--------|-------|
| Treated | 2,527 | 18 | 2,545 |
| Not treated | 0 | 8 | 8 |
| Total | 2,527 | 26 | 2,553 |

Table 45: Frequency distribution of treatment outcomes and treatment decisions

| Treatment outcome/treatment decision | Survived | Deaths | Total |
|--------------------------------------|----------|--------|--------|
| Treated | 0.9898 | 0.0071 | 0.9969 |
| Not treated | 0.0000 | 0.0031 | 0.0031 |
| Total | 0.9898 | 0.0102 | 1.0000 |

Key message

The probability of suspected cases dying was 1.02%, and dying while being treated was 0.71%. The relationship indicates that treated patients were more likely to live.

Comparison of key results for the two districts

Table 46: Comparison of key results from District1 and District4

| Dimensions | District1 | District4 |
|----------------------------------|--|---|
| The scale of the outbreak | 937 suspected cases and deaths | 2,553 suspected cases and deaths |
| Source of records | All records were indicated as being captured in the district hospital designated as a CTC. | <ul style="list-style-type: none"> • 83.7% were captured in the CTC • 16.3% in two hospitals |
| Tests performed and test results | <ul style="list-style-type: none"> • 56.24% were tested for cholera (30.84% +ve, 23.91 -ve, and 1.49 no results). • Those tested, 54.84% were positive. In every 10 tested cases, 5 were positive. | <ul style="list-style-type: none"> • Only 24.52% were tested (5.09% +ve, 13.83% -ve, and 5.6% no results) . • Those tested, 20.77% were positive. In every 10 tested cases, 2 were positive |
| Treatment decisions | 86.55% of all suspected cases were treated irrespective of being tested or otherwise | All suspected cases were treated irrespective of being tested or otherwise. |
| Confirmation tests | No confirmation test was recorded. | No confirmation test was recorded. |
| Treatment outcomes | <ul style="list-style-type: none"> • Overall case fatality rate was 1.6%, and 1.12% for treated patients. • 60% of deaths happened when patients were being treated. • 98.40% of all suspected cases survived. • The probability of surviving when treated was 98.86%. | <ul style="list-style-type: none"> • Overall case fatality rate was 1.02%, and 0.71 for treated patients. • 69.2% (18/26) of deaths happened when patients were being treated. • 98.98% of suspected cases survived • Probabilities of surviving when treated was 99.69%. |

Table 46 summarises key findings on the clinical value of cholera clinical records collected from District1 and District4. However, the clinical value of these records could not be established because, generally, clinical records were not used to inform treatment decisions. Patients were treated without being tested or considering the type of test result. Likewise, testing results were not subjected to confirmatory testing. As a result, the sensitivity and specificity of tests could not be measured, and to the large extent the data incorrectly represented the outbreak situation in the community.

6.1.2. Malaria records

Malaria clinical records were investigated in HF1Dist4 which is a hospital in District4 to assess how they are used to inform clinical decisions. As stated in earlier, data were collected from the OPD, IPD and laboratory for the HMIS registers used between September 2015 and June 2016. OPD and IPD registers recorded test requests sent to the lab and results. Hence, the number of test requests, positive results, negative results and test requests with no results was tallied each month as summarised in Table 47. The records showed out of the 620 test requests, 68 (11.0%) were recorded as having positive test results, 193 (31.1%) had negative results, and 359 (58%) had no test results.

Table 47: Malaria records captured in OPD and IPD registers at HF1Dist4

| Months | Test requests | Positive results | Negative results | Tested but no results |
|----------|---------------|------------------|------------------|-----------------------|
| Sep-2015 | 126 | 11 | 61 | 54 |
| Oct-2015 | 53 | 5 | 14 | 34 |
| Nov-2015 | 93 | 17 | 22 | 54 |
| Dec-2015 | 159 | 18 | 29 | 112 |
| Jan-2016 | 77 | 3 | 11 | 63 |
| Feb-2016 | 54 | 1 | 28 | 25 |
| Mar-2016 | 43 | 9 | 23 | 11 |
| Apr-2016 | 15 | 4 | 5 | 6 |
| Total | 620 | 68 | 193 | 359 |

From the laboratory, malaria records were carefully tallied from the registers because they were used to chronologically record test requests and the corresponding results of all diseases, based on when samples were taken or received. Table 48 shows the recorded 5,487 tests conducted and the corresponding results, 4.8% of which were positive and 95.2% were negative.

Table 48: Malaria test records collected from lab registers

| Months | Tests conducted | +ve results | -ve results |
|----------|-----------------|-------------|-------------|
| Sep-2015 | 932 | 57 | 875 |
| Oct-2015 | 1262 | 58 | 1204 |
| Nov-2015 | 987 | 27 | 960 |
| Dec-2015 | 1337 | 57 | 1280 |
| Jan-2016 | N/L | N/L | N/L |
| Feb-2016 | N/L | N/L | N/L |
| Mar-2016 | N/L | N/L | N/L |
| Apr-2016 | 969 | 64 | 905 |
| Total | 5,487 | 263 | 5,224 |

N/L = Records were not located

Table 49 summarises the number of test requests and results captured in OPD and IPD registers and the number of records in laboratory registers.

Table 49: Malaria records in different sources at HF1Dist4, in testing categories

| Dimensions of clinical records | Lab registers | OPD & IPD registers | Difference |
|--------------------------------|---------------|---------------------|------------|
| Test requested/conducted | 5,487 | 620 | 4,867 |
| Positive results | 263 | 68 | 195 |
| Negative results | 5,224 | 193 | 5,031 |
| No results | 0 | 359 | -359 |

Categorical analysis using contingency tables

As in the analysis of cholera records, contingency tables were used to establish the relationship between (i) malaria test requests and the production of test results; (ii) the

production of test results and types of test kits used; (iii) test results and confirmatory tests; (iv) testing information and treatment decisions; (v) treatment decisions and outcomes. However, the data presented in Table 49 show a significant difference between the number of test requests and results in clinicians' registers and the records in laboratory registers. In addition, the records were incompletely documented, and confirmatory tests had not been conducted. Therefore, the clinical value of malaria records could not be established, because some data elements needed for a categorical analysis were incomplete.

Incomplete documentation of malaria records was common in different registers. For example, in one IPD register, 26 patients were admitted in a month as severe cases of malaria, but neither laboratory requests nor results were documented. The next section discusses factors affecting the quality of clinical records at HF level, hence the quality of disease surveillance data.

6.2. Factors affecting the quality of clinical records in HFs

Assessing the value and other data quality dimensions of disease surveillance records at HF level seemed to be tricky and challenging. Firstly, qualitative results indicated a shared misunderstanding of what comprises data quality in the DSS, as the term data quality was used to refer to the availability, completeness, timeliness or correctness of data. Completeness and timeliness dimensions seemed to be regarded as more important, since during interviews, they emerged whenever the quality of data was discussed, although what participants referred to was completeness and timeliness of reporting (RC and RT) rather than the data itself. The clinical value of data was not even mentioned, and accuracy was discussed only when participants were promoted.

Secondly, surveillance data of all priority diseases were captured from the same medical records, and so data quality problems could not be observed for malaria and cholera records separately but for all diseases under surveillance. Generally, the quality of disease surveillance records in HFs was a serious problem, attributed to different factors discussed below.

(1) Information culture

Information culture refers to "shared assumptions, beliefs and ideas about obtaining, processing, sharing and using information in decision making and organisational management" (Safie et al., 2017, p. 266). The information culture in the DSS affected the quality of data in HFs in several ways.

First, the capturing of clinical records was poor. For example, the cholera records analysed early were incompletely, inconsistently or incorrectly documented. The date

formats were different in individual records and across records, as the UK (dd/mm/yy) and US (mm/dd/yy) date formats were mixed, making it impossible to ascertain the timeliness of the recording reporting and testing of cases or treatment outcomes. For malaria, the number of test requests in clinicians' records was different from those in laboratory records, and several dates were missing in OPD and IPD registers, suggesting that not all test requests and results were documented. Some records had names and test results or requests but without other information, while others had names and treatment decisions only. When asked to clarify this observation, the IDSR-HFP said:

“Registers are not filled in as required. A doctor would fill in a patient’s demographic data and diagnosis without anything about laboratory test requests and results (...) it becomes difficult to understand those records since we cannot establish whether the results were positive or negative” (HF1Dist4).

Second was the poor documentation of records. For example, not all records had the same format for unique identification. Identifications in clinicians’ records were different from corresponding records in laboratory registered. Thus, it was practically impossible to compare test requests with the corresponding test results.

Third was the inaccuracy in capturing disease surveillance records due to the illegibility of clinical records in registers.

“Legibility of clinical records is a big challenge to me. Sometimes I fail to extract records from registers because I find it difficult to understand what doctors write” (HF1Dist4)

Fourth was the non-institutional management of data in HFs, as this was largely left to the IDSR-HFPs, with no arrangement made for the auditing and use of data, which meant that the IDSR-HFPs did not receive the necessary cooperation from other staff to ensure that valuable and accurate data were captured.

“the quality of the data reported from health facilities are poor because they are not reviewed before being submitted” (DIST3P2).

“getting malaria records is a big problem from patients registers (...) people are not motivated to collect data. There are times it seems as if they are doing it for my benefit, while in fact they are doing it for the hospital” (DIST4P2).

IDSR-HFPs were also responsible for storing data, and so in their absence data management activities are likely to be suspended. For example, it was not possible to access surveillance records in two HFs during fieldwork because the IDSR-HFPs were absent. Elsewhere, a surveillance officer said he had no data to provide because his personal laptop had crashed containing data captured over two years.

(2) Technical guidelines for disease surveillance

First, the disease surveillance technical guidelines presented some challenges for capturing data with a true clinical value. Diseases under surveillance are suspected

based on standard case definitions (SCDs), which are criteria for deciding whether a person has a particular disease or other health-related condition by specifying clinical and limitations on time, place and person (MoH-Tanzania, 2011). The guidelines also recommend laboratory testing as part of the response protocol but, as expressed by one district manager, the present a contradiction between treatment and testing procedures.

“I should acknowledge that there is a challenge in deciding the treatment path for suspected cholera patients. The guideline requires highly dehydrated patients to be administered with both fluids and antibiotics, but if dehydration is not critical, they should be given fluids only. However, when a patient tests positive for cholera, ten other people are likely to be contaminated, having been exposed to the same source. So, during the outbreak, we do the testing just to confirm the presence of the disease and once a case is confirmed, any other patient with the same symptoms is regarded as having cholera and is treated, unless proved otherwise” (Dist1P2).

When carried out after treatment starts, testing is useless because the results will not be used to inform treatment decisions, and so the diagnostic procedure will fail to isolate the cholera bacteria. Treating suspected cases before testing is also likely to exaggerate the number of cases, thereby misrepresenting the outbreak situation in the community. The small number of tested cholera cases in the previous section was probably due to generalised treatment.

“There is a problem with the number of cholera cases. If you look at the number of those who were tested, many were negative, because not all who were suspected of having cholera had it (...) A doctor might wrongly treat patients as cholera cases, even those with a short period of diarrhoea caused by another illness” (Reg1P1).

Second are the limitations of lab facilities and testing procedures. According to the IDSR technical guidelines (MoH-Tanzania, 2011, p.91), cholera is tested by culturing and examining stool/rectal swabs under a microscope to detect the presence of the characteristic darting movement. It takes at least 48 hours to identify the organisms, which can only be done at the national laboratory. Thus, the collecting, transporting and testing of samples and receiving results takes longer, which is inconsistent with the high rate of infection of cholera and the requirement to immediately treat suspected cases.

(3) Operational and resource challenges

First was the management and storage clinical records. In HFs with more than one clinician and OPD room, data are captured by different practitioners on different shifts, using separate or shared registers. There were separate registers for IPD patients. Locating registers in these settings was a challenge because they were kept by different individuals. For example, it took several days to locate some registers with malaria records in HF1Dist4, for various reasons.

Second was the shortage of data collection tools in HFs, they are frequently out of stock.

“There are times we don’t get them for a long time. For example, we have been without data capturing tools for more than a week now (...) some other records we don’t have access to” (HF1Dist4).

HF’s were not able to address this problem because the tools are produced centrally.

“When registers are out of stock, test results are written in notebooks which patients take home, hence unavailable in hospital records” (HF1Dist4).

Third is the workload and understaffing in HF’s, as IDSR-HFP’s were expected to manage information on top of their clinical duties and being responsible for public health interventions in the community. As a result, they had little time to concentrate on ensuring that good quality surveillance data were captured.

(4) Clinical practices

Firstly, clinicians were insufficiently using data to inform clinical decisions. For example, clinical records indicated that most patients, whose malaria test results were missing or negative, had been treated (prescribed with anti-malaria medication), and suspected cholera patients were treated even without being tested or when test results were negative.

Second is the delivery of services in private HF’s, which were reported to submit an alarmingly large number of malaria records different from the known disease situation in the community.

“they will not let a client who feels unwell go without diagnosing him with a certain disease (...) given the endemic nature of malaria, it is always the most probable cause” (DIST4P1).

The problem was attributed to the profit-making mentality leading to over-diagnosis of malaria cases without laboratory tests.

Third was the failure to adhere to standard clinical practices. District and regional coordinators expressed concern about the misdiagnosis of disease and symptomatic diagnosis practices without laboratory tests. While the problem was more common in HF’s without laboratory facilities, it was also observed in HF’s with laboratory facilities, as stated by one of the IDSR-DCos.

“We found that for all bloody diarrhoea cases reported only one stool sample was cultured in the laboratory (...) since the hospital has a modern laboratory, our expectation was to find most of the reported cases were cultured in the laboratory, but this was not the case” (Dist4P1).

Surveillance data from this hospital show that in one month 60 bloody diarrhoea cases were symptomatically and conclusively diagnosed without laboratory tests.

6.3. Chapter summary

This chapter has quantitatively and qualitatively examined the clinical value of HF clinical records from which disease surveillance data are extracted, and factors affecting the quality of these records. Cholera data from two districts and malaria from one HF were used for analysis. Generally, the findings indicate that clinical records were hardly used to inform clinical decisions, and so it impossible to ascertain their usefulness in determining treatment outcomes.

For cholera, only 56.24% and 24.52% of suspected cases in District1 and District4 were tested, 30.84% and 5.09% of which, respectively, were positive. However, 86.55% and 100% of all suspected cases in the two districts, respectively, were treated for cholera. Similarly, laboratory tests were not confirmed to establish the sensitivity and specificity of the test results. Despite CFRs for District1 and District4 being low (1.6% and 1.02%, respectively) and the probability of the survival of treated patients being higher (98.86% and 99.69%, respectively), these indicators could not be attributed to the usefulness of clinical records to inform clinical decisions. Moreover, the records did not clearly reveal whether patients were tested before or after being treated and were incompletely and inconsistently documented.

For malaria data collected from HF1Dist4, their clinical value could not be established due to the lack of common identifiers in laboratory and clinicians' records, the failure to capture records, and incompletely documented records. Other records were missing in the hospital because they were written in notebooks which patients took home when registers were out of stock. Moreover, the number of tests conducted significantly differed from the test requests and what was documented in clinical registers.

The qualitative findings further revealed that the quality of surveillance clinical records is a problem in HFs due to the poor information culture, operational and resource challenges, limitations caused by surveillance guidelines, and failure to adhere to standard clinical practices.

The results in this chapter indicate that, to improve disease surveillance data through technological change, the information management and use culture and clinical practices in HFs needs to be addressed first. Otherwise, the use of technology to capture and report surveillance data, will duplicate and proliferate the data quality problem of source clinical records. The next chapter examines whether eIDSR use has improved data quality, focusing on reporting quality and data accuracy and factors affecting eIDSR use.

CHAPTER 7

The influence eIDSR on data quality

7.0. Introduction

This chapter responds to the third objective of this study by examining the value added by the eIDSR intervention to reporting quality and accuracy of disease surveillance data. It answers the following specific questions:

- f) how has eIDSR affected the quality of reporting disease surveillance data?
- g) how has eIDSR affected the submission of accurate data?
- h) what implementation-related conditions influenced eIDSR use for submitting reports at HF level.

The chapter is organised as follows. Section 7.1 presents the quantitative results and section 7.2 the qualitative results. Section 7.3 triangulates the quantitative and qualitative results and 7.4 concludes the chapter. Table 50 summarises key findings in this chapter.

Table 50: Summary of key findings in this chapter

| Main message | Specific findings |
|--|---|
| The influence of eIDSR intervention on reporting quality | <ul style="list-style-type: none"> • On average, the rate and trend of submitting weekly reports was very poor and inconsistent in both individual HFs and districts. • Submission of case-based records was also very poor. • Of the few weekly reports and case-based records submitted, the majority were late. • The trend of submitting reports followed a similar pattern by the majority of the units, which suggests that eIDSR use was influenced by related factors across all units. |
| The influence of eIDSR use on improving accuracy of data | <ul style="list-style-type: none"> • Data accuracy was poor, reflecting the inaccuracy of those in the paper-based system. • Measures to ensure the data were accurate before being submitted through eIDSR could not be established. • The accuracy of the data in eIDSR could not be established, mostly due to the lack of common identifiers between them and the original clinical records in HFs. |
| Factors influencing eIDSR use | <ul style="list-style-type: none"> • There was no significant difference in eIDSR use across HFs or districts despite variations in implementation-related features. |

7.1. The influence of eIDSR use on reporting quality

The term *reporting quality* was defined in chapter 3 as the rate of complete reports submission (RC) and timeliness submission (RT). In this section cholera records collected from District1 and District4 were used to analyse reporting quality of case-based reports submitted through eIDSR, while statistical system logs on eIDSR use were used to analyse reporting quality submitted weekly.

7.1.1. Reporting completeness of case-based reports of epidemic-prone diseases

District1 Performance

Table 51 indicates the number of cholera cases in the paper-based DSIS, monthly HMIS numerical records and the eIDSR records, all originating from the same HMIS medical records in HFs. HMIS and eIDSR records were also extracted from DHIS2 in which they were stored as separate and unrelated datasets.

Table 51: Reporting completeness rate of cholera cases in District1

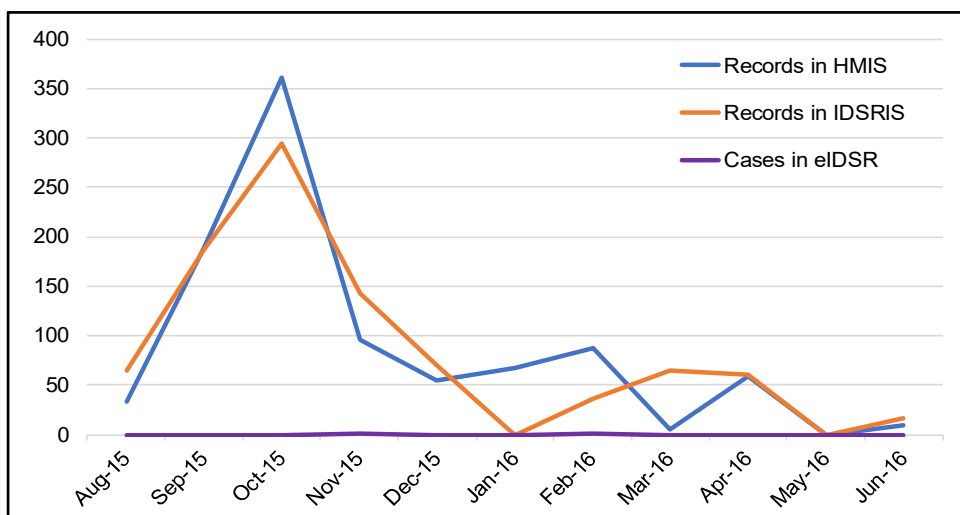
| Months | (a) HMIS records | (b) DSIS records | (c) eIDSR records | RC (c/b) |
|------------|------------------|------------------|-------------------|----------|
| Aug-2015 | 34 | 65 | 0 | 0% |
| Sept-2015 | 188 | 187 | 0 | 0% |
| Oct-2015 | 361 | 294 | 0 | 0% |
| Nov-2015 | 96 | 143 | 1 | 0.7% |
| Dec-2015 | 55 | 70 | 0 | 0% |
| Jan-2016 | 67 | 0 | 0 | 0% |
| Feb-2016 | 88 | 36 | 1 | 2.8% |
| March-2016 | 5 | 65 | 0 | 0% |
| April-2016 | 59 | 61 | 0 | 0% |
| May-2016 | 0 | 0 | 0 | 0% |
| June-2016 | 10 | 16 | 0 | 0% |
| Total | 963 | 937 | 2 | 0.21% |

A total of 937 records were captured in the paper-based DSIS and 2 were submitted through eIDSR by two HFs, which were not sampled by this study. All DSIS records indicated as being captured at HF1Dist1, which was also designated as a CTC during the outbreak, but none was submitted through eIDSR. Contrarily, the 963 HMIS records were reported from 20 HFs of which only 403 (41.8%) were from HF1Dist1. Also, similar reporting pattern was observed in the DSIS and HMIS records, as seen in Figure 30.

Key message

- Although validation of the HMIS records against the source clinical records in HF was beyond the scope of this study, Figure 30 confirms that HF1Dist1 was not the only source of cholera records as documented in the DSIS.
- The District1 RC rate through eIDSR was only 0.21%. The HF1Dist1 rate was 0.0% because no record was submitted through eIDSR. HF2Dist1 and HF3Dist1 did not report cholera cases in either DSIS or eIDSR.
- The source and number of cholera cases captured in DSIS were incorrect.

Figure 30: Cholera records captured in HIMIS, DSIS and eIDSR, District1.



District4 performance

Table 52 presents the cholera records captured in District4 through HIMIS, DSIS and eIDSR from August 2015 to June 2016. Table 53 indicates the records captured in the three HFs sampled from District4. All 2,553 DSIS records were reported from HF1Dist4, HF2Dist4 and the CTC. HF1Dist4 and HF2Dist4 reported more cases before the CTC was established and after its closure. Most of the records (83.7%) were captured at the CTC. Some 62 eIDSR records were captured from 7 HFs and 941 HIMIS numerical records were captured from 24 HFs.

Table 52: Reporting completeness rates of cholera records in District4

| Period | (a) HIMIS records | (b) DSIS records | (c) eIDSR records | RC rates(c/b) |
|------------|-------------------|------------------|-------------------|---------------|
| Aug-2015 | 229 | 394 | 53 | 13.45% |
| Sept-2015 | 392 | 826 | 3 | 0.36% |
| Oct-2015 | 34 | 763 | 0 | 0.00% |
| Nov-2015 | 146 | 161 | 2 | 1.24% |
| Dec-2015 | 55 | 49 | 0 | 0.00% |
| Jan-2016 | 8 | 56 | 0 | 0.00% |
| Feb-2016 | 6 | 81 | 0 | 0.00% |
| March-2016 | 20 | 72 | 0 | 0.00% |
| Apri- 2016 | 16 | 66 | 0 | 0.00% |
| May-2016 | 14 | 76 | 0 | 0.00% |
| June-2016 | 21 | 9 | 4 | 44.44% |
| Total | 941 | 2,553 | 62 | 2.43% |

Table 53: Trends of cholera records in DSIS captured from HF3 in District4

| Months | HF1Dist4 | HF2Dist4 | HF3Dist4 | CTC |
|----------------|----------|----------|----------|--------|
| August 2015 | 29 | 27 | 0 | 338 |
| September 2015 | 0 | 0 | 0 | 821 |
| October 2015 | 0 | 0 | 0 | 758 |
| November 2015 | 0 | 0 | 0 | 161 |
| December 2015 | 0 | 0 | 0 | 49 |
| January 2016 | 10 | 46 | 0 | closed |
| February 2016 | 23 | 58 | 0 | closed |
| March 2016 | 11 | 61 | 0 | closed |
| April 2016 | 18 | 48 | 0 | closed |
| May 2016 | 21 | 55 | 0 | closed |
| June 2016 | 5 | 4 | 0 | closed |
| Total | 117 | 299 | 0 | 2,137 |

Figure 31 compares the reporting trends through eIDSR, DSIS and HMIS. Table 54 compares the number of cholera records submitted through eIDSR by the sampled HF3s with the corresponding records in DSIS and HMIS.

Figure 31: Cholera records captured in eIDSR, DSIS, and HMIS, District4

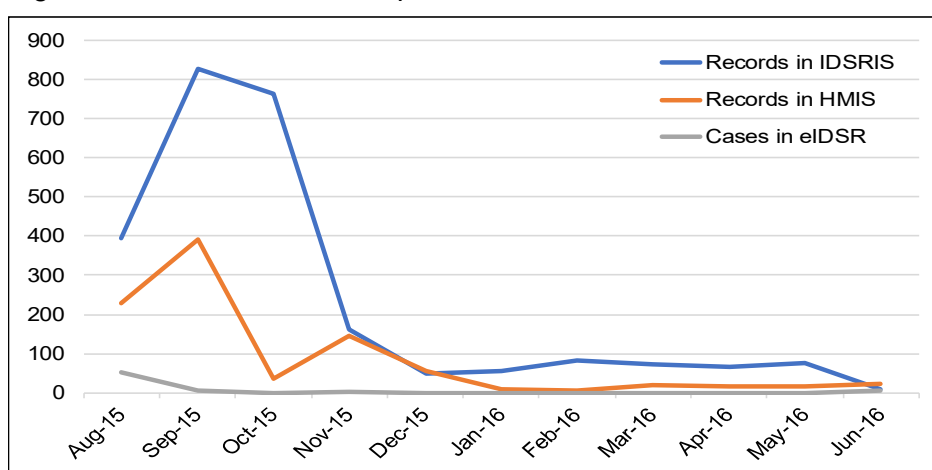


Table 54: Cholera records in eIDSR, DSIS and HMIS submitted by sampled HF3s

| Sampled HF3s | (a) DSIS records | (b) HMIS records | (c) eIDSR records | RC (c/a) |
|--------------|------------------|------------------|-------------------|----------|
| HF1Dist4 | 117 | 96 | 48 | 41.03% |
| HF2Dist4 | 299 | 382 | 4 | 1.34% |
| HF3Dist4 | 0 | 41 | 0 | 0.00% |
| Total | 416 | 519 | 52 | 12.5% |

Key message

- The trend in HMIS establishes that HF3s were still capturing cholera records when CTC was operational (August to December 2015), which implies that some of the cases recorded at CTC were referrals from HF3s.

- There was a significant difference between the number of DSIS and HMIS records after CTC closure, which suggests that either some of the DSIS records captured from HMIS records in HFs or DSIS records were incorrect, or both.
- RC rates for District4, HF1Dist4 and HF2Dist4 was 2.43%, 41.03% and 1.34%, respectively, showing that eIDSR use did not improve the reporting of cholera cases.

7.1.2. Reporting timeliness of case-based reports of epidemic-prone diseases

District performance

Table 55 presents the RT rate for the sampled districts and Table 56 for the sampled HFs. Given the small number of cholera records submitted through eIDSR, the RT assessment was expanded to include records of all other epidemic-prone diseases submitted from August 2015 to June 2016. In addition, since the DSIS source records of all districts could not be accessed, the RT rate was computed based on submitted records only. Timeliness was derived from the difference in time between identifying and reporting cases, which was one of the elements of individual reports.

Table 55: RT rate through eIDSR for epidemic-prone diseases in sampled districts

| Districts | All epidemic-prone records in eIDSR | eIDR RT rate |
|-----------|-------------------------------------|--------------|
| District1 | 159 | 13% |
| District2 | 11 | 9% |
| District3 | 37 | 16% |
| District4 | 165 | 73% |

Table 56: RT rate through eIDSR for epidemic-prone diseases in sampled HFs

| Sampled HFs | Records submitted through eIDSR | eIDSR RT rates |
|-------------|---------------------------------|----------------|
| HF1Dist1 | 0 | N/A |
| HF2Dist1 | 84 | 0% |
| HF3Dist1 | 3 | 0% |
| HF1Dist2 | 0 | N/A |
| HF2Dist2 | 0 | N/A |
| HF3Dist2 | 0 | N/A |
| HF1Dist3 | 0 | N/A |
| HF2Dist3 | 31 | 13% |
| HF3Dist3 | 0 | N/A |
| HF1Dist4 | 97 | 80% |
| HF2Dist4 | 15 | 47% |
| HF3Dist4 | 0 | N/A |

Key message

- Comparatively, District4 had a better RT performance (73%), largely due to HF1Dist4 contributing 59% (97/165) of submitted records.

- The two tables indicate that even for the few records submitted through eIDSR, the majority were not on time.
- eIDSR use did not improve the timely reporting of epidemic-prone diseases.

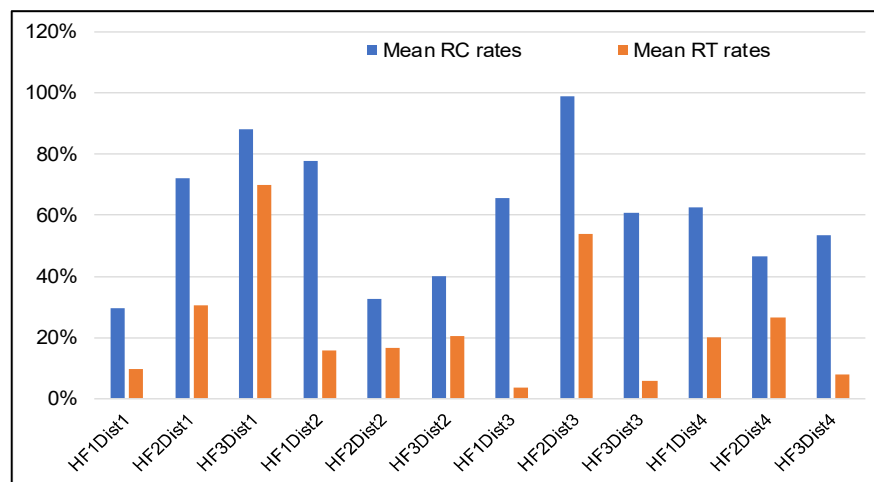
7.1.3. Reporting quality for numerical weekly reports

Besides case-based individual reports, other priority diseases under surveillance are numerically submitted weekly through eIDSR as one report. When an HF submits a weekly report, eIDSR marks both the submission (measure of RC) and time (measure of RT). Thus, in the sampled units, reporting quality was examined from when eIDSR started being used to the last week of December 2016. RC and RT were computed as described in page 62. For operational purposes in DSS, 80% was considered the minimum RC and RT target in a reporting period.

Mean RC and RT scores for the sampled HFs and districts

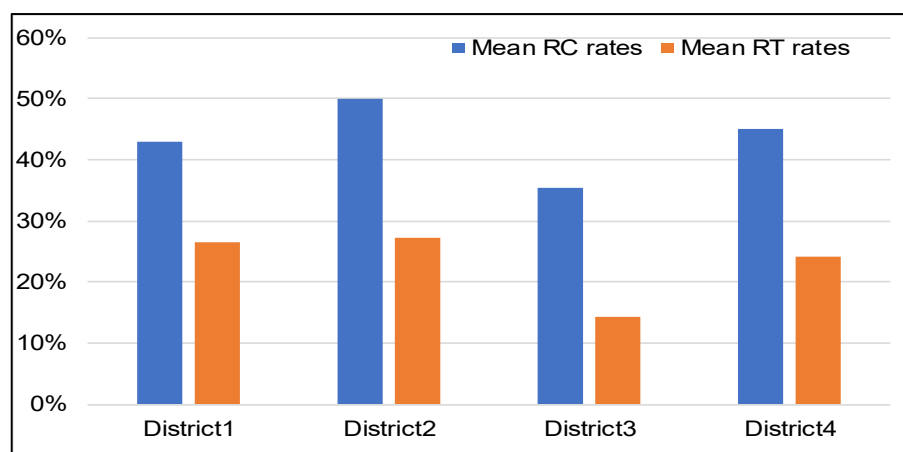
Figure 32 visualises the mean eIDSR RC and RT rates for weekly reports for the 12 sampled HF in District1, District2, District3 and District4, respectively.

Figure 32: Weekly mean RC and RT rates for the sampled 12 HFs



HF3Dist1 and HF2Dist3 mean RC scores of 87.88% and 98.85%, respectively, were above the 80% minimum target. None of the HF had a mean RT score of 80%. Figure 33 indicates the mean RC and RT rates for the 4 sampled districts, none of which had reached the minimum 80% target.

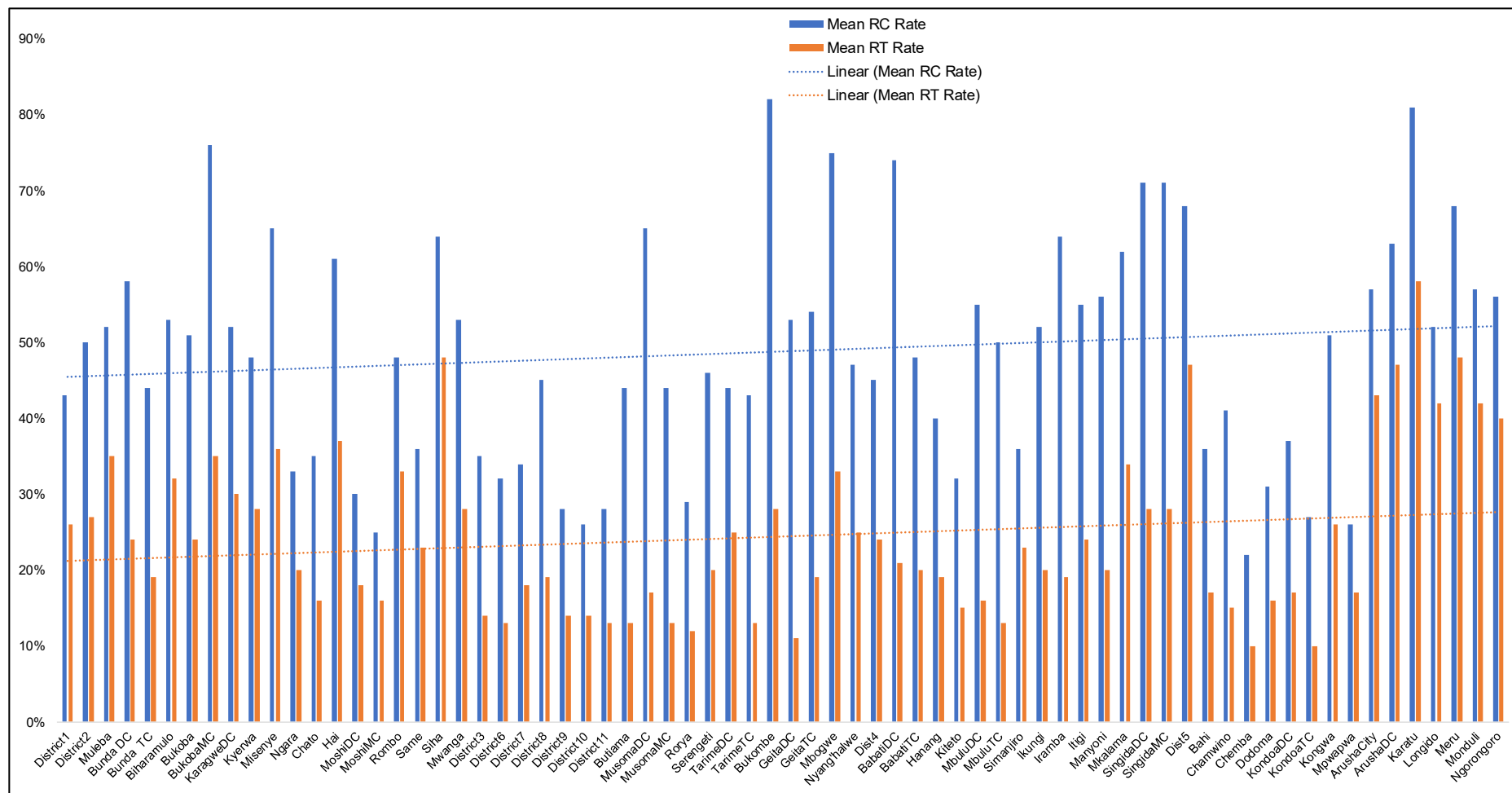
Figure 33: Mean RC and RT rates for the four sampled districts



The mean weekly reporting rate was expanded to include all 70 councils/districts in the 10 regions in which eIDSR had been deployed by December 2015. Figure 34 presents the districts' mean RC scores chronologically from the pilot district to the last to be equipped with eIDSR. The districts in Dar es Salaam and Mwanza were renamed to reflect the study design.

- The mean RC rates range between 22% and 82% in which only two councils exceeded the 80% minimum target (Bukombe and Arusha DCs).
- The mean RT rates range between 10% and 58%, suggesting that even when reports were submitted, they were not on time.
- The linear dotted lines indicate slightly increasing RC and RT scores over time, which signifies that districts equipped earlier had a lower mean rate than those equipped later. The pattern suggests that the districts that had been using eIDSR longer were likely to have a poorer performance.
- The lower mean RC and RT rates for the district suggest that eIDSR was used infrequently by HF users to submit weekly reports.

Figure 34: Mean RC and RT rates for the 70 districts covered by December 2015



The trend in reporting quality over time

This section reveals the trend in weekly RC and RT over time of the sampled HFs and the 70 councils, covering the period from deployment to December 2016 (an interval of 165 weeks for the pilot district).

Figure 35 and Figure 36 present smooth lines indicating the trend in RC and RT, respectively, of the sampled HFs. The RC trend indicates the following:

- HFs in the same district had a similar reporting trend for most of the covered period.
- Only HF2Dist3 had a consistent RC trend, unlike the rest.
- The plots indicate an improved RC trend from week 115 onwards (between May and June 2016), except HFs in District3.
- Relatively, all HFs in District4 (the last to be equipped) had the lowest submission rate soon after being equipped.

Regarding RT graphs

- The trend of HFs in districts indicates a similar pattern - irregular, very low and declining to a common point.
- RT curves were always lower than those of RC.
- All district hospitals (HFDist1, HFDist2, HFDist3, and HFDist4) had a poorer RT performance than other HFs in the same district.
- HF1Dist1, HF1Dist3, HF3Dist3 and HF3Dist4 had the worse RC trend.

Key messages on weekly RC and RT of the sampled HFs

- The RC and RT smooth lines indicate that data submission trend was generally poor and inconsistent in most HFs.
- The pattern suggests that all HFs experienced similar organisational circumstances influencing eIDSR use.
- Apart from HFs in District3, the trend suggests there was an intervention or change that improved eIDSR use from May 2016, but this was short-lived, and the rate of change differed across HFs.

Figure 35: Smooth lines - RC trend of health facilities in District1 to District4

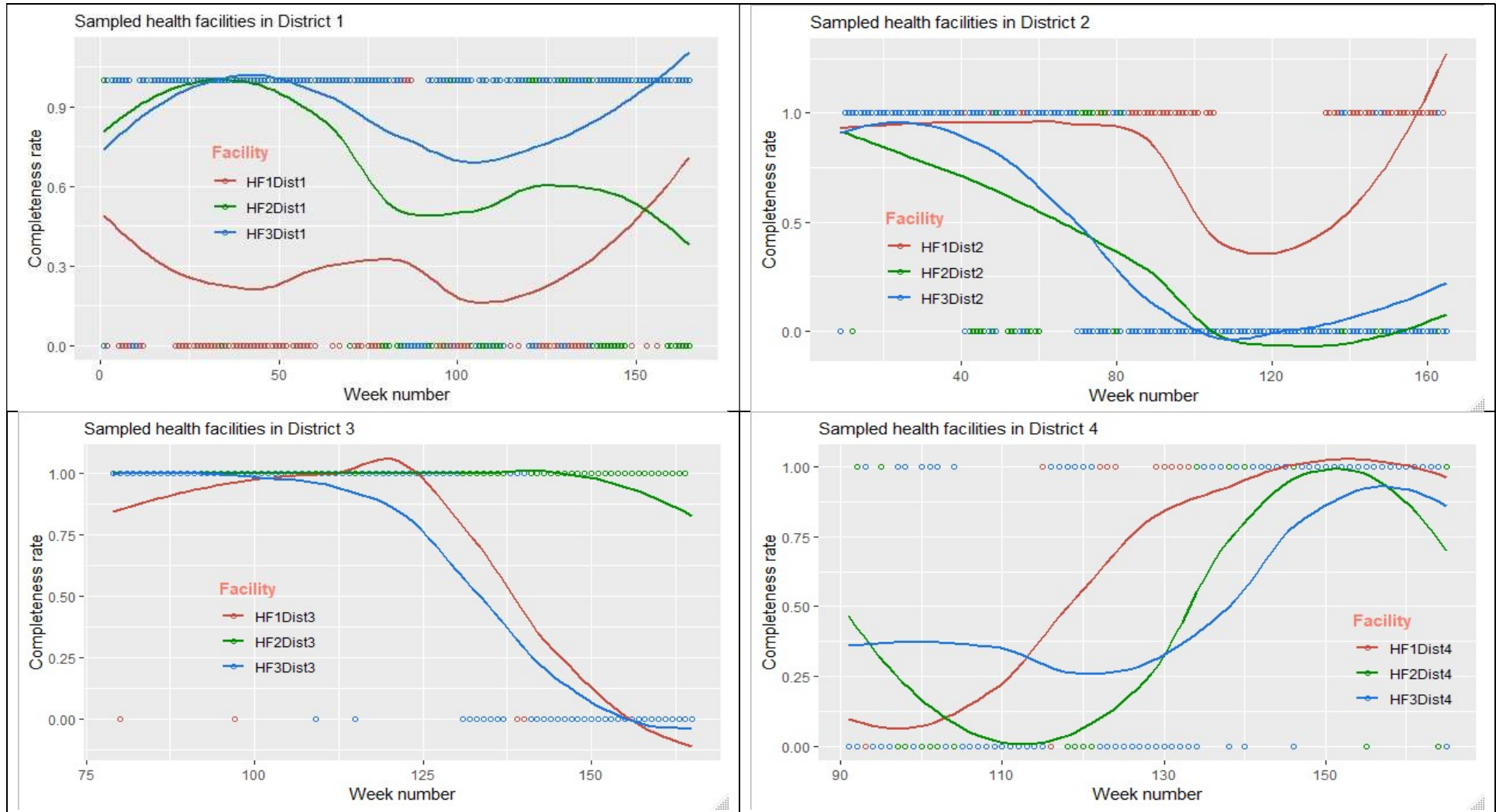


Figure 36: Smooth lines - RT trend of health facilities in District1 to District4

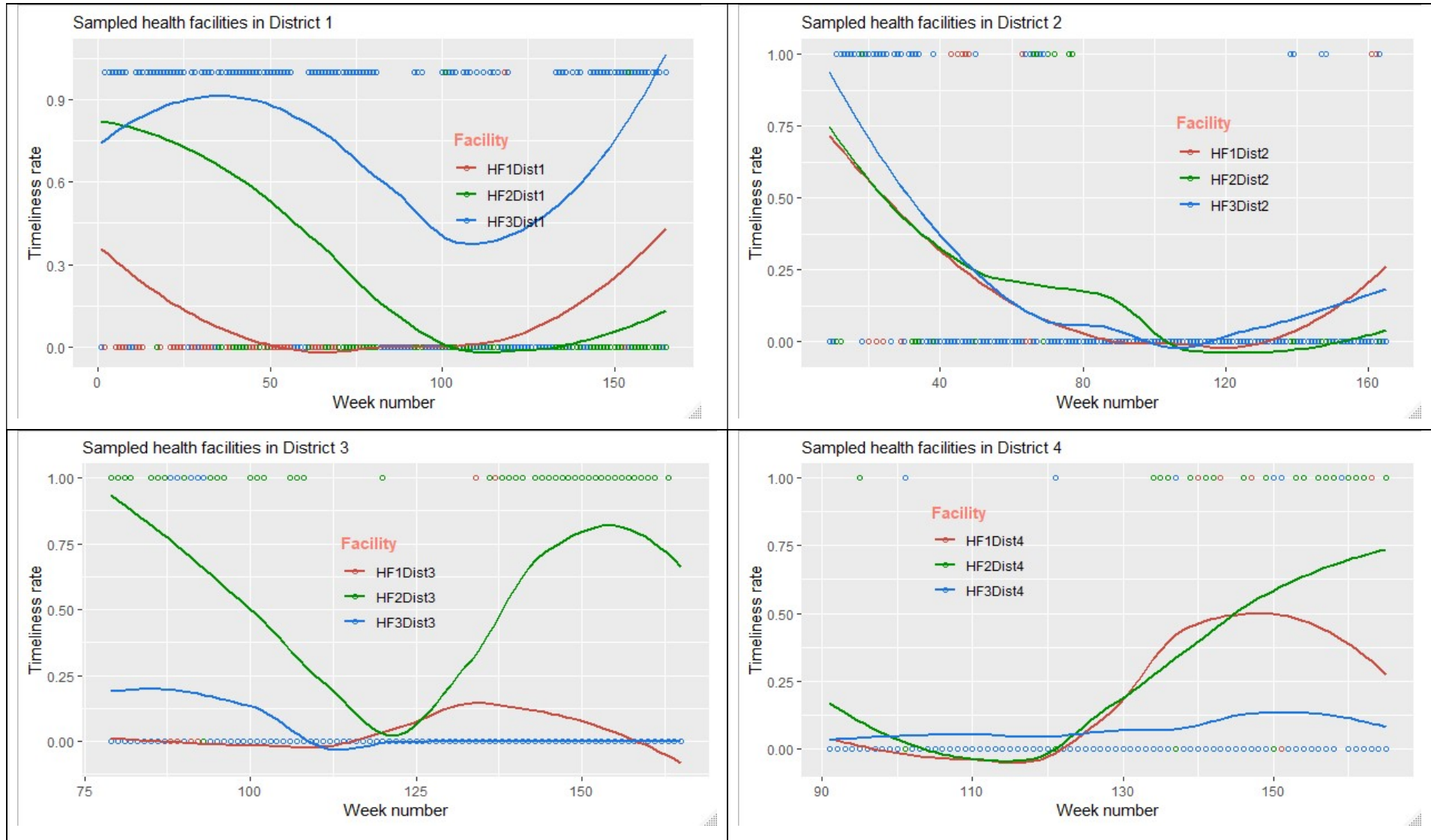


Figure 37 to Figure 39 are smooth plots comparing the RC and RT trend of different districts in different regions equipped at different times or implementation stages. The plots in Figure 37 compare the RC and RT trend of each of the 4 sampled districts, which shows that the RT score was always lower than that of the RC. The upper plots in Figure 38 compare the 4 sampled districts, which show that they all had an inconsistent and mostly declining reporting trend.

The plots in the lower part of Figure 38, Figure 39 and Figure 40 compare the RC and RT trend across all districts in the first 5 regions in which eIDSR was implemented, namely, Dar es Salaam, Mwanza, Kagera, Mara and Kilimanjaro. The plots indicate that District1 (Dar es Salaam), District2 (Mwanza), Muleba (Kagera), Bunda DC and Bunda TC (Mara), which were regarded as pilot districts, had a similar reporting pattern to those equipped at different times during scaling up.

Key messages on the weekly RC and RT trend of the districts

- The declining reporting trend of all districts suggests that most of their HF's used eIDSR frequently soon after it was installed and less frequently as time progressed.
- This suggests that all districts experienced organisational circumstances, which determined eIDSR use, and the same intervention that improved eIDSR use around the 100th week from when it was installed, despite the difference in the scale of change across districts and regions. In some, eIDSR use increased rapidly and continued consistently up to the end of the study period, while in others, the change was gradual and short-lived. Even with the change in reporting trend, the effect on RT was much less than on RC.
- Generally, eIDSR was hardly used in all districts as well as in districts equipped at different implementation stages. This implies that efforts to scale up eIDSR were not supported by evidence of an improvement in the quality of the disease surveillance data submitted.

Figure 37: Comparing the reporting quality trend of each of the four sampled districts

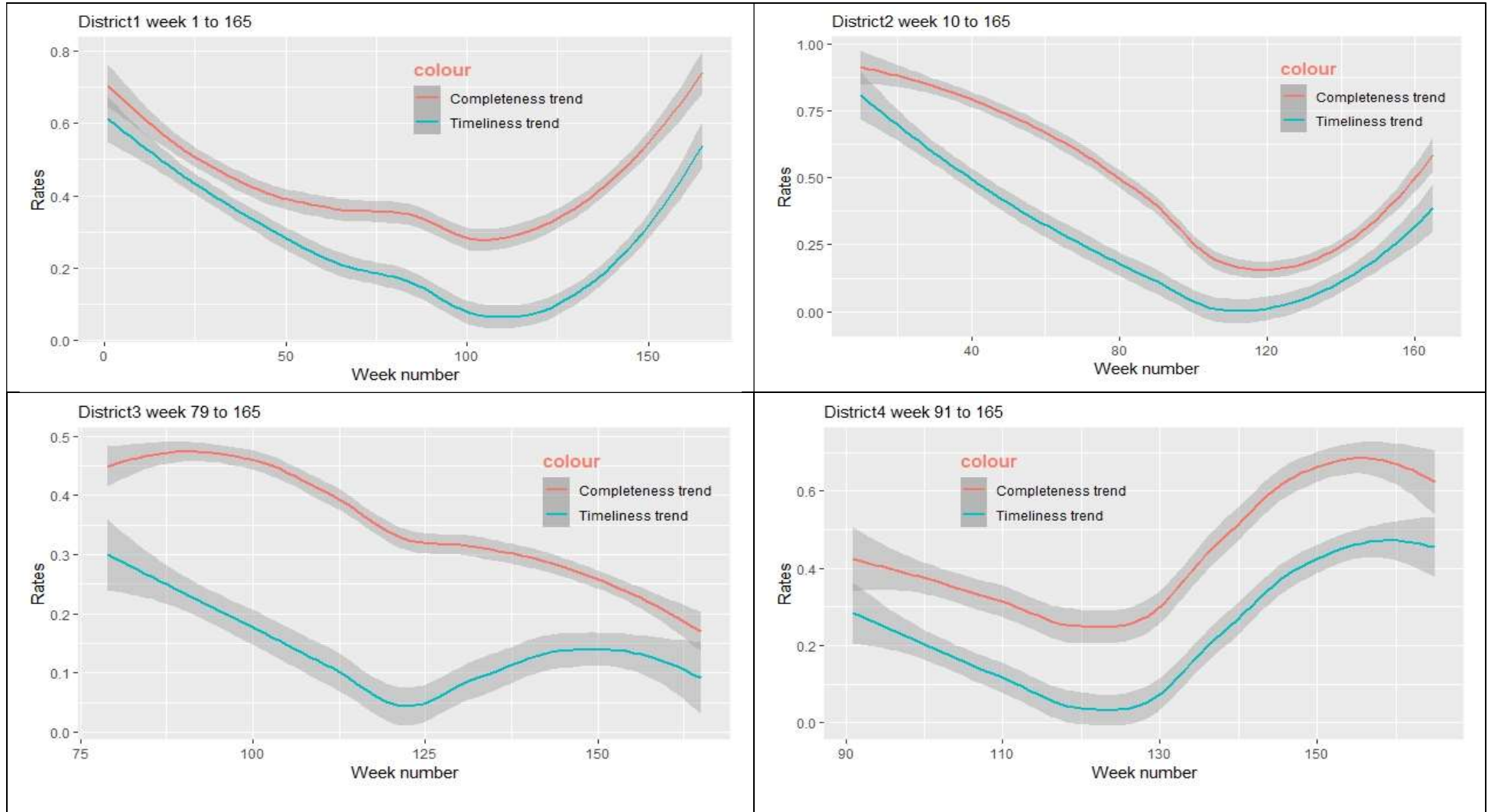


Figure 38: Comparing the reporting quality trend of the 4 sampled districts and 3 districts in Dar es Salaam region

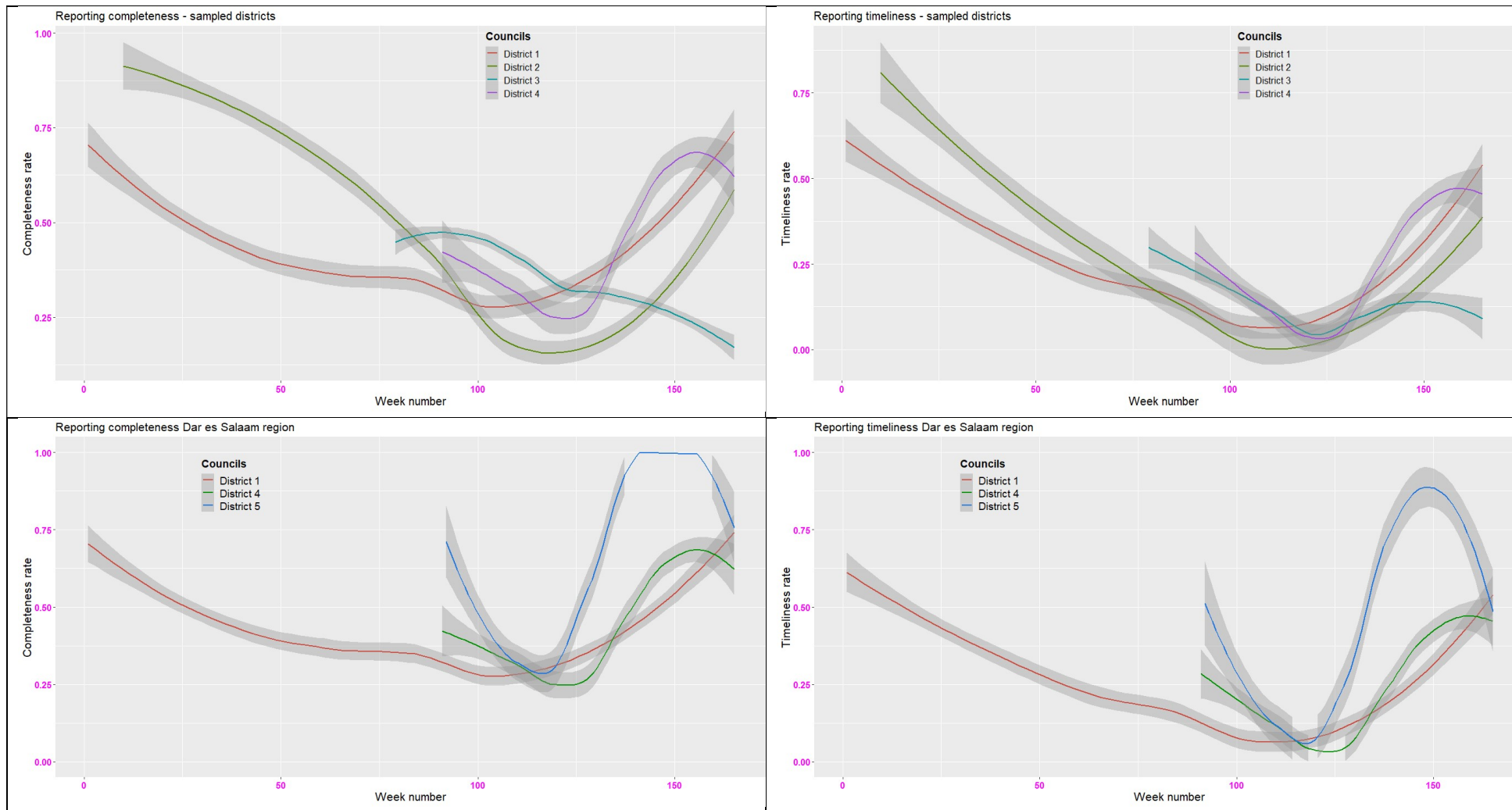


Figure 39: Comparing the reporting quality trend of all the districts in Mwanza and Kagera regions

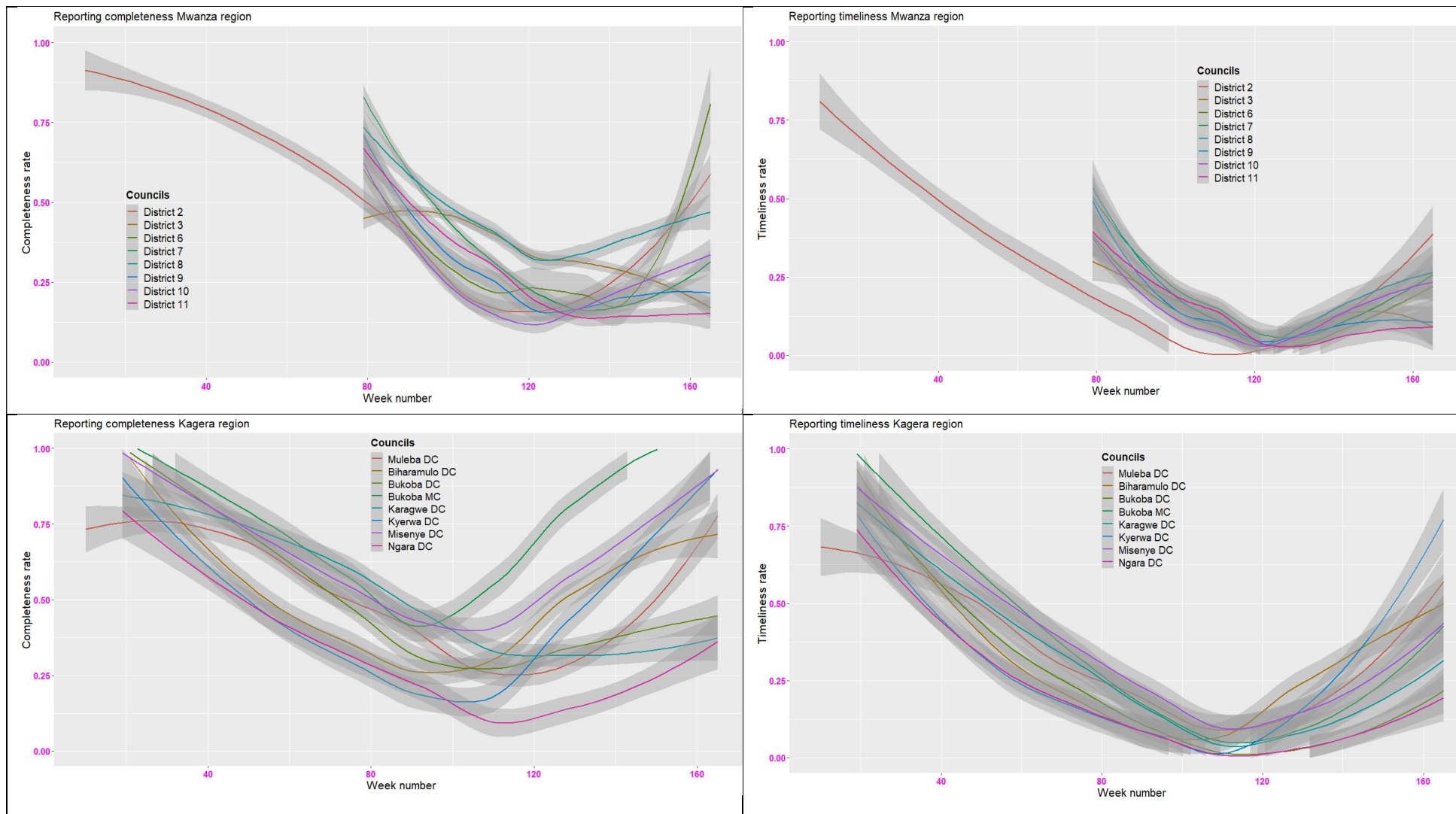
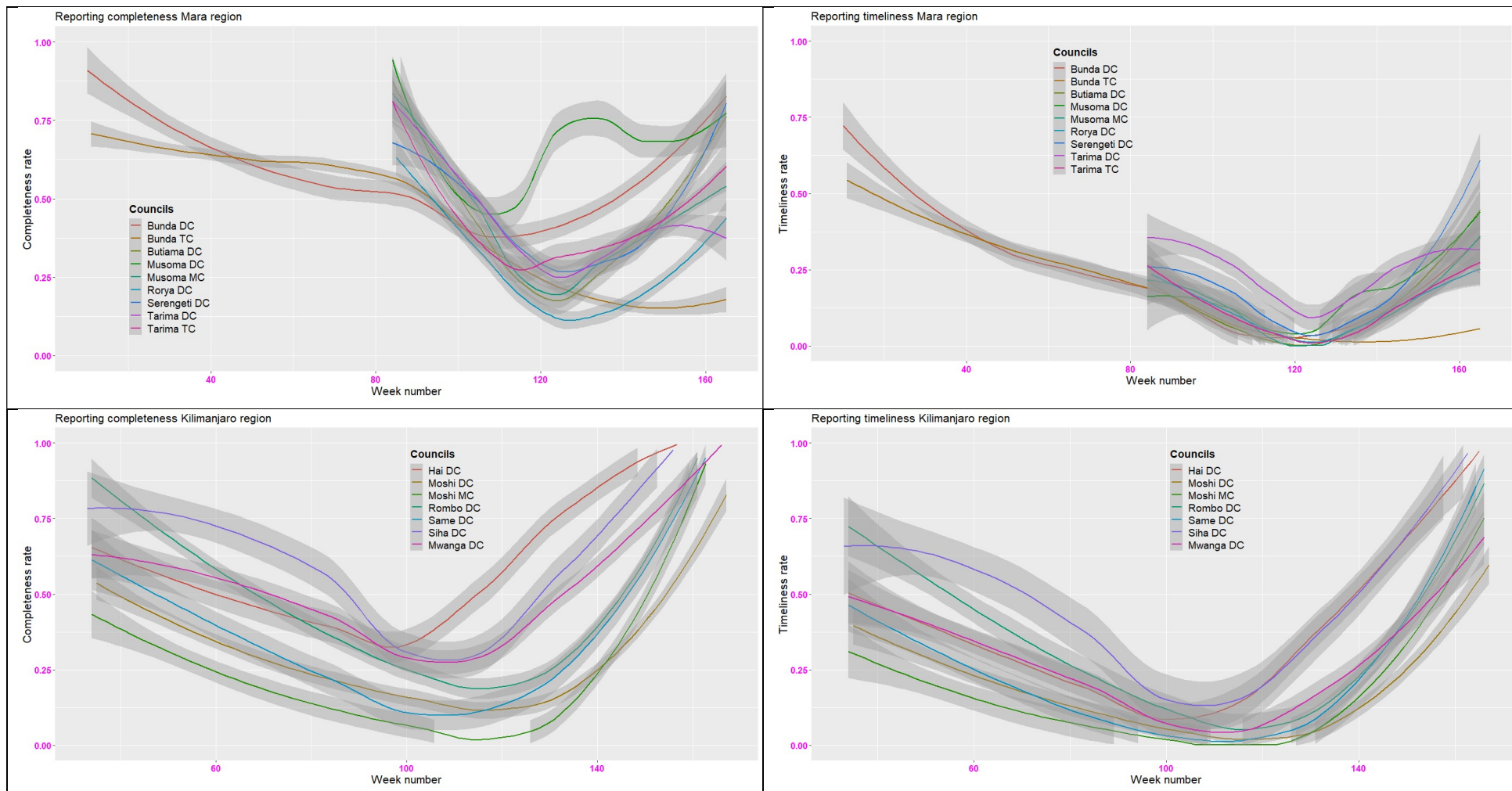


Figure 40: Reporting quality trend plots for districts in Mara and Kilimanjaro regions



7.2. Conditions that influenced reporting quality through eIDSR

This section refers to the analysis approach presented in section 3.4.1 (4). It presents the results of the quantitative analysis of the contextual factors relating to eIDSR implementation, which were likely to influence how eIDSR was used for submitting weekly reports. Such factors and their numerical values are as indicated in sections of panel datasets in Table 57, which a dataset indicates relevant contextual factors for the HFs, and Table 58 with factors relevant for the districts.

Table 57: Data about eIDSR implementation-related features for health facilities

| FacilityID | Completeness | Timeliness | DistrictNum | WeekNum | Deployment | HFLocation | HFType | HFOwnership |
|------------|--------------|------------|-------------|---------|------------|------------|--------|-------------|
| 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| 1 | 0 | 0 | 1 | 2 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 1 | 3 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 1 | 4 | 1 | 0 | 1 | 1 |
| 4 | 1 | 1 | 2 | 19 | 1 | 1 | 1 | 1 |
| 4 | 1 | 0 | 2 | 20 | 1 | 1 | 1 | 1 |
| 4 | 1 | 1 | 2 | 21 | 1 | 1 | 1 | 1 |
| 4 | 1 | 0 | 2 | 22 | 1 | 1 | 1 | 1 |

Table 58: Data about eIDSR implementation-related features for districts

| DistrictNum | Completeness | Timeliness | WeekNum | Deployment | Location |
|-------------|--------------|------------|---------|------------|----------|
| 1 | 0.567 | 0.478 | 1 | 0 | 0 |
| 1 | 0.597 | 0.463 | 2 | 0 | 0 |
| 1 | 0.627 | 0.522 | 3 | 0 | 0 |
| 4 | 0.388 | 0.225 | 103 | 1 | 0 |
| 4 | 0.375 | 0.2 | 104 | 1 | 0 |
| 4 | 0.35 | 0.131 | 105 | 1 | 0 |

Regression analysis models were built incrementally based on two assumptions. First, a linear relationship existed between outcome variables with a set of continuous explanatory variables, hence following normal distributions. Second, a non-linear relationship existed between outcomes and explanatory variables, hence forming binomial distributions because of the mix of categorical, discrete and continuous values of the variables. The Akaike Information Criterion (AIC) estimator was used to estimate the quality of models to establish a better fit. The models were built for the 12 sampled HFs, followed by all 70 councils that had been equipped with eIDSR by January 2016.

7.2.1. Health facilities

Linear models (LM)

The intercepts 0.59711 and 0.24793 for the linear models model0.RC and model0.RT in the next page are the mean RC and RT scores of all HFs without the influence of explanatory variables.

(a) RC linear regression model: Model0.RC output

```
> model0.RC <- lm(Completeness ~ 1, data = DataFacilities)
> summary(model0.RC)

Call:
lm(formula = Completeness ~ 1, data = DataFacilities)

Residuals:
    Min       1Q   Median       3Q      Max
-0.5971 -0.5971  0.4029  0.4029  0.4029

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.59711    0.01288   46.37  <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4906 on 1451 degrees of freedom
```

(b) RT linear regression model: model0.RT output

```
> model0.RT <- lm(Timeliness ~ 1, data = DataFacilities)
> summary(model0.RT)

Call:
lm(formula = Timeliness ~ 1, data = DataFacilities)

Residuals:
    Min       1Q   Median       3Q      Max
-0.2479 -0.2479 -0.2479 -0.2479  0.7521

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.24793    0.01134   21.87  <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.432 on 1451 degrees of freedom
```

Generalised linear model (GLM)

The next step was to assume that the panel data would fit a GLM which follows a binomial distribution, because explanatory variables are categorical (assuming 0 and 1 values).

The model0.RC1 intercept (0.39343) and model0.RT1 intercept (-1.10966) on the next page indicate the RC and RT mean scores are different from zero ($p < 0.05$), and are different from the linear distributions presented earlier, hence a non-linear distribution.

(a) Reporting completeness - GLM model0.RC1 output

```
> model0.RC1 <- glm(Completeness ~ 1, data = DataFacilities, family = binomial())
> summary(model0.RC1)

Call:
glm(formula = Completeness ~ 1, family = binomial(), data = DataFacilities)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.348  -1.348   1.016   1.016   1.016

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  0.39343    0.05351   7.353 1.94e-13 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 1957.8  on 1451  degrees of freedom
Residual deviance: 1957.8  on 1451  degrees of freedom
AIC: 1959.8

Number of Fisher Scoring iterations: 4
```

(b) Reporting timeliness – GLM model0.RT1 output

```
> model0.RT1 <- glm(Timeliness ~ 1, data = DataFacilities, family = binomial())
> summary(model0.RT1)

Call:
glm(formula = Timeliness ~ 1, family = binomial(), data = DataFacilities)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.7549 -0.7549 -0.7549 -0.7549  1.6701

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.10966    0.06077  -18.26 <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 1626.4  on 1451  degrees of freedom
Residual deviance: 1626.4  on 1451  degrees of freedom
AIC: 1628.4

Number of Fisher Scoring iterations: 4
```

Generalised Linear Model with Mixed Effect (GLMER)

Building on the non-linear relationship between RC and RT scores and explanatory variables, it was further assumed that there was a random effect attributed to the variation within and between explanatory variables introduced to the outcome variables. The model was built, starting with introducing a random effect caused by the variation between HFs only, then increasingly including the fixed effect introduced by other explanatory variables.

On the next page are the outputs of the better fit RC and RT GLMER models. The random error introduced by the variation between HFs significantly affected the mean RT rate at the 95% confidence interval ($P < 0.05$) but not the mean RC rate. The GLMER models fit better than the GLM models because the AIC values of the former, 1697.5 for model1.RC and 1386.6 for model1.RT, are less than those of the latter.

(a) Reporting completeness – GLMER model1.RC output

```
> model1.RC <- glmer(Completeness ~ 1 + (1|Facility), data = DataFacilities, family = binomial())
> summary(model1.RC)
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) ['glmerMod']
Family: binomial ( logit )
Formula: Completeness ~ 1 + (1 | Facility)
Data: DataFacilities

      AIC      BIC   logLik deviance df.resid
1697.5  1708.0   -846.7  1693.5    1450

Scaled residuals:
   Min       1Q   Median       3Q      Max
-5.3194 -0.7340  0.3814  0.7259  1.5157

Random effects:
Groups Name          Variance Std.Dev.
Facility (Intercept) 1.387     1.178
Number of obs: 1452, groups: Facility, 12

Fixed effects:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  0.6110     0.3484   1.754  0.0795 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

(b) Reporting timeliness - GLMER model1.RT

```
> model1.RT <- glmer(Timeliness ~ 1 + (1|Facility), data = DataFacilities, family = binomial())
> summary(model1.RT)
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) ['glmerMod']
Family: binomial ( logit )
Formula: Timeliness ~ 1 + (1 | Facility)
Data: DataFacilities

      AIC      BIC   logLik deviance df.resid
1386.6  1397.2   -691.3  1382.6    1450

Scaled residuals:
   Min       1Q   Median       3Q      Max
-1.4770 -0.5053 -0.3347 -0.2271  4.4042

Random effects:
Groups Name          Variance Std.Dev.
Facility (Intercept) 1.198     1.095
Number of obs: 1452, groups: Facility, 12

Fixed effects:
              Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.4492     0.3274  -4.426 9.58e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Best fit model

The GLMER was built iteratively by progressively adding the fixed effect of individual explanatory variables to the RC and RT models. Likewise, the AIC values were compared to evaluate the quality of the models. Explanatory variables without significant effect were removed from the final models and the best fit models are presented on the next page as model5.RC and model5.RT for RC and RT respectively.

(a) Reporting completeness - GLMER model5.RC output

```
> summary(HFmodel5.RC)
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) ['glmerMod']
Family: binomial ( logit )
Formula: Completeness ~ 1 + weeks + I(weeks^2) + Location + Type + Ownership + (1 | Facility)
Data: FacilitiesDF

      AIC      BIC   logLik deviance df.resid
1557.8  1594.8   -771.9  1543.8     1445

Scaled residuals:
  Min       1Q   Median       3Q      Max
-11.0341  -0.6261  0.2106  0.7293  2.5518

Random effects:
Groups Name          Variance Std.Dev.
Facility (Intercept) 0.7226   0.8501
Number of obs: 1452, groups: Facility, 12

Fixed effects:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  3.419e+00  4.665e-01  7.329 2.31e-13 ***
weeks        -5.413e-02  4.936e-03 -10.965 < 2e-16 ***
I(weeks^2)   2.063e-04  2.557e-05  8.067 7.23e-16 ***
LocationRural 1.675e+00  7.865e-01  2.129 0.033233 *
Type1        -2.140e+00  7.867e-01 -2.720 0.006535 **
Ownership1   2.973e+00  7.871e-01  3.778 0.000158 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
              (Intr) weeks  I(w^2)  LctnRr  Type1
weeks         -0.472
I(weeks^2)    0.350 -0.936
LocationRr1  -0.211  0.001  0.001
Type1         -0.220  0.006  0.003 -0.722
Ownership1   -0.192 -0.015  0.001  0.531 -0.561
```

(b) Reporting timeliness - GLMER model5.RT output

```
> summary(HFmodel5.RT)
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) ['glmerMod']
Family: binomial ( logit )
Formula: Timeliness ~ 1 + weeks + I(weeks^2) + ownership + (1 | Facility)
Data: FacilitiesDF

      AIC      BIC   logLik deviance df.resid
1165.0  1191.4   -577.5  1155.0     1447

Scaled residuals:
  Min       1Q   Median       3Q      Max
-11.3427  -0.4044  -0.2554  -0.1254  7.7484

Random effects:
Groups Name          Variance Std.Dev.
Facility (Intercept) 0.8778   0.9369
Number of obs: 1452, groups: Facility, 12

Fixed effects:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  2.176e+00  4.068e-01  5.348 8.88e-08 ***
weeks        -9.502e-02  6.091e-03 -15.600 < 2e-16 ***
I(weeks^2)   4.458e-04  3.276e-05  13.611 < 2e-16 ***
ownership1   1.871e+00  6.548e-01  2.858 0.00427 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
              (Intr) weeks  I(w^2)
weeks         -0.514
I(weeks^2)    0.405 -0.953
ownership1   -0.363 -0.058  0.039
```

Interpretation of the final RC model

HFmodel5.RC indicates that the effects of timeline and HF location, type and ownership on RC performance were significantly different from zero ($p < 0.05$).

- as the length of time increased the mean RC rate was negatively affected by a factor of 0.05419, and so eIDSR use declined significantly over time.
- if HFs were in a rural area it affected the mean RC rate positively by a factor of 1.675, and so were likely to have better performance than HFs in urban areas.
- if an HF was a hospital, it affected the mean RC rate negatively by a factor of -2.14, and so hospitals were likely to have a worse performance than PHFs.

- public HFs affected the mean RC rate by a factor of 2.973, and so were likely to perform better than private HFs.
- The difference in eDSR use between HFs equipped at different implementation stages was insignificant.

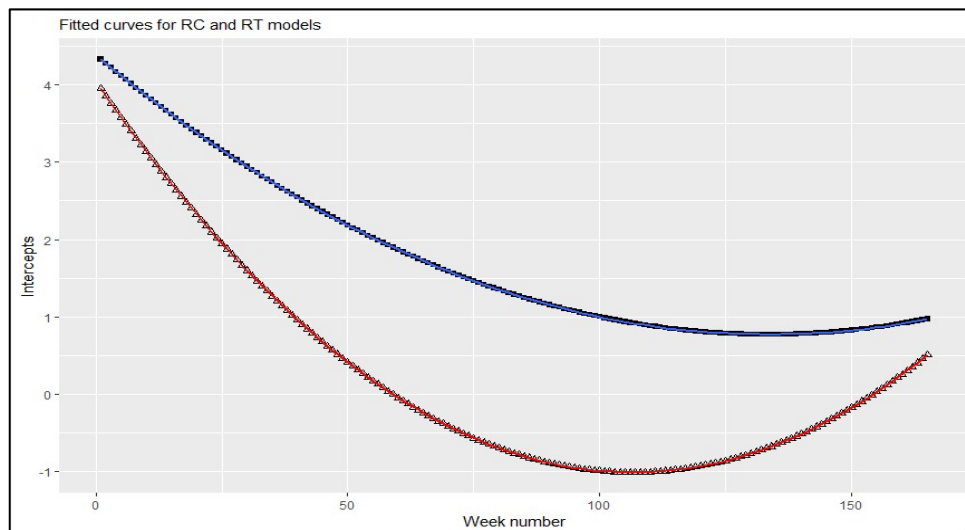
The HFmodel5.RT model output suggests that:

- Timeline and ownership had a significant effect on the mean RT rate ($p < 0.05$). As the length of time increased from deployment, the mean RT rate was negatively affected by a factor of 0.09502, hence a declining RT trend. Public HFs affected RT positively by a factor of 1.871, and so were more likely to submit data on time than private HFs.
- Location, type and district had an insignificant effect ($p > 0.05$), which means that the type of HFs in different districts, settings and deployment stages made no difference to the timely submission of reports.
- The variation attributed by a random effect on RT was 0.8778 compared with 0.5962 on RC, which means that an HF's individual effect on RT was greater than on RC.

Choice of best fit distributions

Curve fitting plots were used to assess the quality of the HFmodel5.RC and HFmodel5.RT presented in Figure 41. The model fit the nature of the data better because plot shapes reflect the patterns of the smooth plots of most HFs.

Figure 41: Fitted curve GLMER RC and RT rate models for health facilities



Key: Blue – HFmodel5.RT; Red – HFmodel5.RC

7.2.2. Districts' performance

The same process used for building models for HFs was followed for the councils using three explanatory variables: timeline in weeks, location and deployment stage. All 70 councils were included in the models, since RC and RT data and values of explanatory

variables were available in the DHIS2. Including all 70 districts instead of the 4 sampled for this study increased the strength and fit of the model. Below are the outputs of the models with a better fit.

Reporting completeness – GLMER Dist.model4.RC output

```
> summary(Dist.model4.RC)
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) ['glmerMod']
Family: binomial ( logit )
Formula: CompletenessRate ~ weeks + I(weeks^2) + (1 | District)
Data: DistrictsDF

      AIC      BIC   logLik deviance df.resid
 7183.0  7210.2 -3587.5  7175.0    6595

Scaled residuals:
   Min       1Q   Median       3Q      Max
-13.3985  -0.3135  -0.0242   0.3164   1.7760

Random effects:
 Groups Name          Variance Std.Dev.
District (Intercept) 1.045     1.022
Number of obs: 6599, groups: District, 70

Fixed effects:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  6.859e+00  2.177e-01  31.50  <2e-16 ***
weeks        -1.420e-01  3.035e-03 -46.78  <2e-16 ***
I(weeks^2)   6.389e-04  1.385e-05  46.13  <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
              (Intr) weeks
weeks        -0.753
I(weeks^2)   0.613 -0.947
```

The Dist.model4.RC output above indicates that timeline and deployment had a significant effect on mean RC ($p < 0.05$), affecting the mean RC rate negatively by a factor of 0.1671 and 0.9197, respectively. This implies that as the length of time increased from deployment, the RC trend of districts was likely to decline. Also, districts equipped at the pilot stage were likely to have a worse RC trend than those equipped during scaling up.

(c) Reporting timeliness – GLMER Dist.model4.RT output

```
> summary(Dist.model4.RT)
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation) ['glmerMod']
Family: binomial ( logit )
Formula: TimelinessRate ~ 1 + weeks + I(weeks^2) + (1 | District) + Location + Deployment
Data: DistrictsDF

      AIC      BIC   logLik deviance df.resid
 4482.0  4522.8 -2235.0  4470.0    6593

Scaled residuals:
   Min       1Q   Median       3Q      Max
-4.3716  -0.1936   0.0954   0.5778   3.3085

Random effects:
 Groups Name          Variance Std.Dev.
District (Intercept) 0.02861  0.1692
Number of obs: 6599, groups: District, 70

Fixed effects:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  3.4371330  0.2375206  14.47  < 2e-16 ***
weeks        -0.1498892  0.0051522 -29.09  < 2e-16 ***
I(weeks^2)   0.0007083  0.0000249  28.45  < 2e-16 ***
Location     0.4707426  0.1074792   4.38  1.19e-05 ***
Deployment    1.1915464  0.1664091   7.16  8.05e-13 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
              (Intr) weeks  I(w^2)  Locatn
weeks        -0.727
I(weeks^2)   0.690 -0.984
Location     -0.269 -0.031  0.038
Deployment   -0.236 -0.303  0.250 -0.118
```

The Dist.model4.RT output above indicates that the effect of timeline, location and deployment on the mean RT rate was different from zero ($p < 0.05$), which means that:

- The increase in the number of weeks affected the mean RT rate negatively by a factor of 0.1499, and so the RT trend was likely to decrease over time since deployment.
- Urban districts were likely to have a better RT trend than rural districts, and those equipped during piloting were better than those equipped during scaling up.

7.3. Influence of eIDSR use on submission of accurate data

This section examines the influence of eIDSR on the submission of accurate surveillance records. Cholera clinical records from two districts analysed in chapter 6 and malaria clinical records collected from HF1Dist4 were used as a “gold standard” to validate the accuracy of their respective copies submitted through eIDSR. Two parameters were used to assess the accuracy of data submitted through eIDSR: the correctness of the number of records submitted through eIDSR and the accuracy of data elements/fields in identifiable records.

Cholera records

The number of source cholera records from District1 and District4, and those submitted through eIDSR, were presented in section 7.1. It was established that only 0.21% and 2.43% of original clinical records were submitted through eIDSR in District1 and District4 respectively. While none of the sampled HFs in District1 had submitted records through eIDSR, HF1Dist4 and HF2Dist4 submitted 41.03% and 1.34%, respectively, HF3Dist4 did not submit cholera records. Accordingly, the number of cholera records in the eIDSR was inaccurate.

The accuracy of data elements in the few individual records submitted through eIDSR could not be evaluated because the formats of clinical records were inconsistent. For example, patient IDs in District1 were recorded as “TAN-SEP-Dist1-03-xxx” and in District4 as “TAN-Reg-Dist4-15-xxx”. Records unique ID in eIDSR had 9 to 11 digits (eg. 2342-153672), which were generated by the system. While the IDs in the origin clinical records shared the first 11 digits, each record in eIDSR had a unique ID. Likewise, clinical records captured the exact age (years and/or months), but eIDSR captured age in ranges (5-60 months; 1- 5 years; 5-60 years, and 60+).

In addition, clinical records had more demographic and treatment information than records in eIDSR. For example, names and addresses were not captured in eIDSR records, and source records in DSIS had a full account of treatment from the onset of the disease to the outcome, which was different from those in the eIDSR. Due to the eIDSR design limitation presented in chapter 5, parameters such as case confirmation,

referrals and treatment outcomes, which are reported after notification of cases, could not be updated.

Accordingly, eIDSR did not improve of accurate cholera records, nor did it provide sufficient relevant features for verifying the accuracy of submitted data.

Malaria records

The nature of malaria records at HF1Dist4 was presented in chapter 6. This section presents the results on verification of the accuracy of the number of records in the eIDSR. Malaria records, submitted through eIDSR, were categorised into the number of laboratory tests performed, the number of positive test results, and the number of clinically diagnosed cases (treated as malaria, without a laboratory-confirmation test). These groups were further categorised into age groups of under five, and five years and above. Accuracy verification focused on the first two categories only: the number of tests performed and the number of positive test results.

Table 59 compares the number of malaria tests performed and submitted through eIDSR with those in the laboratory, OPD and IPD registers. Table 60 compares the number of positive test results in the same sources. Monthly HMIS records submitted in the DHIS2 database were included to expand the comparison since they were all captured from the same medical records but stored as separate datasets in the DHIS2 database.

Table 59: Number of source malaria test records in HF1Dist4 and in eIDSR

| Period | Test requests from OPD & IPD | Test records in lab | Test records in eIDSR |
|----------------|------------------------------|---------------------|-----------------------|
| August 2015 | SR/NL | SR/NL | 96 |
| September 2015 | 126 | 932 | 0 |
| October 2015 | 53 | 1,262 | 0 |
| November 2015 | 93 | 987 | 0 |
| December 2015 | 159 | 1,337 | 0 |
| January 2016 | 77 | SR/NL | 345 |
| February 2016 | 54 | SR/NL | 795 |
| March 16 | 43 | SR/NL | 267 |
| April 2016 | 15 | 969 | 250 |
| May 2016 | SR/NL | SR/NL | 525 |
| June 2016 | SR/NL | SR/NL | 1,183 |
| Total | 620 | 5,487 | 3,461 |

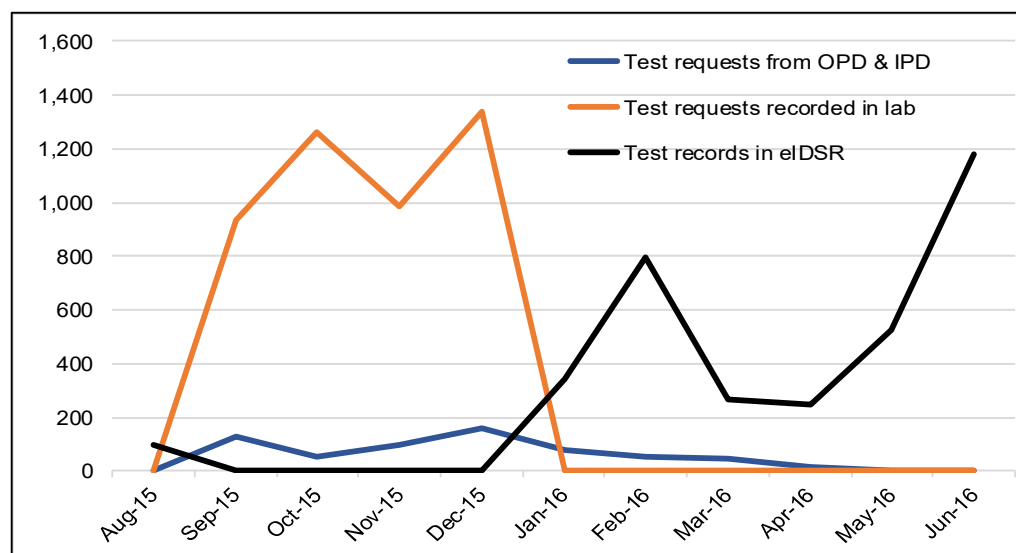
SR/NL: Source registers were not located

Table 60: Malaria positive cases in sources, HMIS, and eIDSR - HF1Dist4

| Period | Positive results in Lab | Positive results – clinical records | Positive results in HMIS | Positive in eIDSR results |
|----------------|-------------------------|-------------------------------------|--------------------------|---------------------------|
| August 2015 | SR/NL | SR/NL | 320 | 75 |
| September 2015 | SR/NL | 11 | 325 | 0 |
| October 2015 | 58 | 5 | 737 | 0 |
| November 2015 | 27 | 17 | 378 | 0 |
| December 2015 | 57 | 18 | 727 | 0 |
| January 2016 | SR/NL | 3 | 441 | 177 |
| February 2016 | SR/NL | 1 | 420 | 400 |
| March 16 | SR/NL | 9 | 369 | 106 |
| April 2016 | 64 | 4 | 334 | 128 |
| May 2016 | SR/NL | SR/NL | 474 | 429 |
| June 2016 | SR/NL | SR/NL | 392 | 388 |
| Total | 263 | 68 | 4,917 | 1,703 |

SR/NL: Source registers not located

Figure 42: Number of malaria test records at HF1Dist4 and those in eIDSR

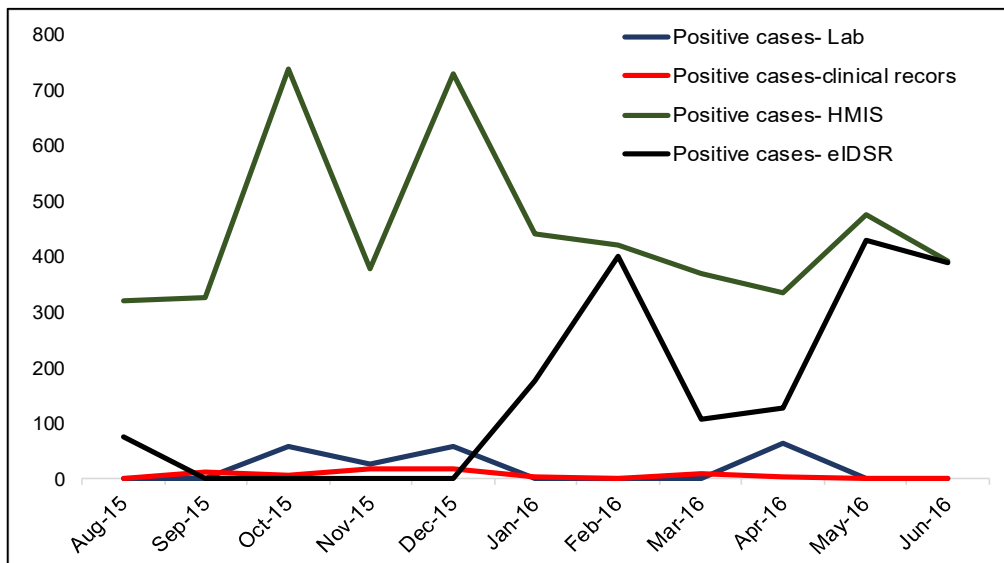


The results presented in Table 59 and the corresponding plots in Figure 42 indicate that malaria records were not submitted through eIDSR from September to December 2015. In the months when records were submitted, they do not tally with any of the source records, i.e. OPD and IPD test requests, nor the number of tests performed in the laboratory. Likewise, there was a significant difference between the test requests from OPD and IPD and those registered in the laboratory, for reasons given in section 6.1.2.

Figure 43 indicates that malaria records were inconsistently submitted through eIDSR from January to June 2016, but the number did not tally with the corresponding clinical records collected at the HF, nor HMIS records in the DHIS2, but the number of HMIS records in February, May, and June 2016 closely tally with those submitted through eIDSR. This suggests that HMIS and eIDSR records were captured from the same

source and so, if they were accurately captured, they would consistently tally for all months.

Figure 43: Malaria positive test results captured in eIDSR and other sources



Key message on accuracy of malaria records

As explained in section 6.2, not all malaria clinical records at HF1Dist4 could be located and there was also a mismatch between clinicians' test requests, the requests recorded in the laboratory and the results. Likewise, the accuracy of the malaria records in the eIDSR could not be validated because their source was unknown. Therefore, eIDSR use did not improve submission of accurate malaria records by HF1Dist4.

7.4. Qualitative results

7.4.1. eIDSR usage and the effect on reporting quality and data accuracy

This section presents the qualitative results on the effect of eIDSR use on the quality of disease surveillance data. For the reasons explained in section 6.2, the interview and documentary data show that data quality was described more in reference to RC and RT or as a general concept. Thus, in the results presented below, data quality refers to RC, RT and accuracy, either exclusively or inclusively.

The findings indicate that eIDSR implementers and users at lower levels had conflicting views on the effect of eIDSR use on data quality. Firstly, during interviews the implementers were quick to suggest that eIDSR use was improving reporting quality.

“the eIDSR has been helpful to health facilities and we have evidence of improved timeliness and completeness as the main performance indicators of the system” (MoHP1).

“In terms of data quality, to some extent, there is a change (...) to a certain level I would say there is a change in [the] reporting process in regions where eIDSR is deployed. One is [the] availability of data” (MoHP5).

This view was shared by some of the IDSR-DCos and IDSR-RCos

“eIDSR has changed the way users report, especially those in remote rural HFs. Previously, users were cooking and submitting data, knowing there was no way this would be known” (Dist3P2).

“In our region, they started with District2 as a pilot. It performed well since 80% of the data was submitted on time. Every week submission of immediate and weekly reports ranged between 70% to over 80%” (Reg2P1).

Despite the above narratives, no evidence was provided. When prompted to substantiate their position, contradictory explanations were given.

“Data quality for some of the areas is a problem (...) I agree with you that there is a difference between the actual number of cholera records captured at health facilities and those in the eIDSR” (MoHP1).

“There are a lot of issues with data quality and other stuff, but these things get rectified as we go along” (MoHP5).

The alternative explanations were consistent with documented evidence in different implementation-related reports.

“Overall, the reporting rate is 51%, and reports received on time (by Monday 3:30 pm) are about 20% (...) completeness and timeliness for Reg1 were (38%, 19%) and for Reg2 it was (52%, 19%)” (Report1).

“Some of the health facilities have never sent the reports (through eIDSR), even the booklets were not filled. They were as new as [when they] were provided during the training session” (Report2).

“In general, the reporting trend for both regions was below 80% (...) Reg2’s overall reporting trend up to week 29 in 2015 was 49%, and the district which showed the highest reporting trend was 63% (...) Dist3 was 32% and Dist2 was 55%” (Report2).

Secondly, most participants at the region, district and HF level were categorical that eIDSR use had not improved data quality.

“I think what has been useful is all about sending data. Nothing more” (HF1Dist1)

“The usage of eIDSR in my district is approximately 50% (...) eIDSR has not supported the reporting process as anticipated” (Dist2P1).

“In our region, by December 2015 4265 cases of cholera had not been submitted through eIDSR (...) if you look at District1 with 115 health facilities, only 5 submitted reports (...) in District4 with 256 health facilities, only 130 to 140 submitted reports” (Reg1P1).

Accordingly, the use of eIDSR did not positively affect the quality of disease surveillance data. Both users in lower level and implementers knew that, but later on, for some reason, claimed otherwise. Factors attributed to the failure of eIDSR use to improve data quality are discussed in the next sub-section.

7.4.2. Reasons for the failure of eIDSR use to improve data quality

Section 5.2.2 presented several implementation-related factors that constrained eIDSR use by HFs to submit data, which affected reporting quality and the submission of

accurate data. Further to challenges at the HF level, the findings revealed the factors are attributed to change management strategies, implementers' presumption that a digital solution would be the answer, unsuitability of the design to HF users, and information culture.

Change management strategies

As established in section 5.3, the implementation of eIDSR did not include organisational strategies for changing behaviour or introducing new practices to enhance eIDSR use. The DSIS setup, management, data flow and storage did not change, nor did the data capturing tools and procedures. Furthermore, reports submitted through eIDSR were duplicates of the paper-based DSIS reports, which in turn depended on the HMIS paper-based medical records as the source of surveillance data. Thus, the availability and accuracy of data submitted through eIDSR depended on facilitation of the underlying system.

"I cannot say that there have been any changes (...) I can see the situation is still the same (...) Therefore, no change can be associated with eIDSR because even the process of reporting is the same as we have been doing" (HF3Dist2).

"Nothing has changed. We are still doing what we were doing with the paper-based system in terms of capturing records and reporting. We are submitting the same records through mobile phones" (HF2Dist2).

"records that are redundantly reported through HMIS and eIDSR should be collected through eIDSR only to avoid doing the same thing twice (...) with the current setup, figures will always be different when you compare HMIS and eIDSR reports" (Distr3P1).

These concerns indicate that eIDSR inherited and extended the same challenges of the information system, which triggered its adoption. The eIDSR implementers overlooked the need for organisational change strategies and practices to enhance the capturing of accurate data in HFs and submitting them through eIDSR.

"they should improve the registers in the wards. Doctors are saying that writing a diagnosis in them is a challenge, and so they should listen to them to know the nature of the challenges they face. It would help me to see the final diagnosis when I collect the registers" (HF1Dist1).

Assumption that eIDSR has the capacity to influence data accuracy

Coordinators and implementers regarded eIDSR as an information-system watchdog with the power to make HF users submit timely and accurate data. It was perceived that HF users would use eIDSR responsibly and submit quality data, simply because they were reminded to submit reports and knew that someone would be assessing the data.

"Previously, users were cooking and submitting data knowing there was no way this would be known. For now, (...) they know that the validity of what they report through eIDSR would be questioned based on copies of paper-based reports" (Dist3P2).

“At some point, eIDSR drew the attention of users, especially when they receive an SMS and email notification on their devices” (MoHP5).

This assumption was not accompanied by frequently following up users and/or giving them feedback, and so they were unaware of whether they were submitting useful data.

“There should be some sort of feedback using any possible approach. It would motivate users and encourage them to do their work. One can correct mistakes and failures when reminded through feedback” (HF2Dist1).

“I don’t receive feedback after submitting reports (...) I am used to the fact that there is no feedback based on what I report” (HF2Dist3).

Restricted access by health facility users

The eIDSR was designed in such a way that it does not allow HF users to view, update or edit reports after submitting them because they do not have access to the DHIS2 database. Moreover, notifications of epidemic-prone diseases are reported based on data to trigger a response by the management. Information regarding laboratory tests, treatments and outcomes are collected later as part of the response procedure. This information flow was not considered in the design of eIDSR, leading to the submission of inaccurate or incomplete data.

“there is no way to update data after submitting them. I don’t get results of laboratory tests performed outside our facility or when the case is referred to a different facility. So, there is no way I can update records already submitted” (HF2Dist4).

“To be honest, sometimes we make a lot of mistakes when we report through eIDSR (...) the worst thing is the fact that there is no room for me to edit or correct the information after submitting it. This is very disturbing” (HF3Dist3).

Information culture practices

Firstly, the conventional data management practices, discussed in section 4.3.1, affected the ability of eIDSR to facilitate the capture and submission of good quality data. Those practices were preferred, both at the HF and management level, even with eIDSR use.

“the district IDSR coordinator continues to ask for data from us through the mobile phone (...) which I send through SMS text messages” (HF3Dist2).

“For system users like me, the paper-based system seems to be easier to use than eIDSR” (HF1Dist4).

“I am using the paper-based system because I have seen that, if I use reports submitted through eIDSR I will have very few data (...) I prefer to compile using the manual system” (Dist1P1).

“people’s culture is a big challenge that we cannot resolve in one or two days (...) This challenge is observed at all levels” (MoHP5).

Thus eIDSR did not change the circumstances and practices, discussed in section 6.2, which affected the quality of disease surveillance data before being reported through eIDSR, and IDSR-DCos were not validating the data sent by HF users.

“There are district coordinators who are not honest. They are not fulfilling their role since they don’t scrutinize data submitted from health facilities” (MoHP1).

Secondly, the submission of poor quality disease surveillance data by HFs was always problematic, even with the conventional DSIS. Thus, the problem continued with the use of eIDSR.

“Some of the health facilities have never sent reports, even the books were not filled. They are as new as were given to them during the training session” (Report2).

“Some facilities sent reports, but the books were not filled. So, the data sent were from an unknown source (...) some facilities just fill [in] the weekly total values for malaria [cases] without the daily cases” (Report1).

Thirdly, the feedback given to eIDSR users was either lacking or insufficient and this problem was not exclusive to data submitted through eIDSR but was echoed by all HF participants as a source of demotivation to use eIDSR.

“There was no feedback. We don’t get feedback even with the paper-based reporting system. We just submit” (HF2Dist4).

“No-one has ever asked me why I am not reporting (...) I think the situation is the same as I told you” (HF3Dist4).

“Nevertheless, there is a big problem in getting data from these major hospitals, and so we don’t get their data” (Reg1P1).

When feedback was provided, it was mostly when users had not submitted data requested by the management or they had submitted data indicating alarming situations, such as a disease outbreak.

“The only way I can get feedback is when I don't submit reports for a long time. That is when the district IDSR coordinator will remember to call me to inquire about data” (HF3Dist2).

This was confirmed by district participants.

“A large number of cases I have encountered are bloody diarrhoea and keratoconjunctivitis. I called the health facilities to find out whether those cases were valid (Distr1P1)”

Fourthly, political leaders at the district level influenced the submission of data from HFs and hence eIDSR use. This was more evident in areas hard hit by outbreaks such as cholera. Appointed political leaders would control the number of cases or deaths to be reported for political reasons. They did not want to be perceived by the appointing authority as being incompetent or ineffective in dealing with outbreaks.

“you will find a district commissioner commanding that reports should not be submitted. They debate whether or not to report when the number of cases increases (...) at the end of the day they don’t report at all and that is why we rely on the paper-based report” (MoHP1).

7.4.3. The potential of eIDSR features to influence good data quality

Despite the factors that hindered the ability of eIDSR to capture and submit quality data, the analysis results revealed some supportive eIDSR intervention features that could positively influence the production of good quality data as described below.

Technical and technological factors

First was the supportive mobile phone penetration and ownership as discussed in 1.5.9 and 4.4.1.

“Since we are using mobile phones, we focus on establishing coverage of the network first. For example, we started using Vodacom (...) now we are also using Airtel and Tigo networks” (MoHP3).

“using mobile phones has the potential to change this situation since it simplifies reporting and reduces costs (...) because users are using their own mobile phones do not pay for connectivity” (MoHP1).

Second was users’ familiarity with the USSD technology deployed, as presented in section 4.4.1, and users required minimum training because no specific application was needed on users’ phones.

“The good thing which led to the choice of USSD technology is its usability. Mobile money in Tanzania is one of the mobile phone technologies most used. Almost everyone, even very old people, know how to send and receive money through their mobile phone (...) therefore, the convenience of using or understanding the technology has not been an issue” (MoHP5)

Third is the fact that the eIDSR application facilitates the instant submission and verification of data, and the sending of alerts and reminders. These features could be useful for improving different aspects of data quality if explored.

“Two of the key components of eIDSR are alerts and notifications modules. We have programmed it to detect the threshold for reporting the outbreak of different diseases. Whenever a report comes in and an outbreak is suspected, an SMS and email would automatically be sent to the district, regional and national teams” (MoHP5).

“eIDSR makes me feel more responsible as it sends me reminders to report” (HF2Dist1).

“I remember when we started the intervention a lot of notifications were reported by health facilities which sent an alarm to management. They followed this up and found that they were false alerts due to the wrong submission of data. It caused facility users to pay attention to the accuracy of what they were submitting since they knew that once they report something, someone will be looking at it” (MoHP5).

“they can access the report from the DHIS2 at district level and the district IDSR coordinator has to approve reports before finally submitting them (...) they can easily know if a certain facility has submitted an alarming report and counter-check” (MoHP2).

Another useful design was the integration with the DHIS2 database, which provides several analytical features for assessing data accuracy.

“There is an opportunity for triangulating data reported through HMIS on a monthly basis with those reported through eIDSR (...) to cross-check the two sources and establish any issue that might question the quality of the data” (MoHP5).

Fourth was the individual commitment and institutional support revealed in two HFs, which had a better reporting performance. The difference was attributed to users’ efforts to submit reports successfully, despite being confronted with cross-cutting technical challenges.

“When I come in on Monday, the first thing I do is collect all the books and extract the disease surveillance records (...) Usually, many eIDSR users report toward the end of the day, making the system congested. To avoid that, I try my best to prepare my report and submit it by noon to avoid network problems (...) Many times I fail to submit due to technical problems and end up delaying submitting reports (...) I keep on trying up to four days later and submit the report on Friday instead of Monday as required. Occasionally, I wake up at midnight to submit reports” (HF3Dist1).

“After working for some time, I came up with my own design which simplifies the reporting process. You can see here I have indicated which type of records I need. Therefore, I extract disease surveillance records twice a week. On Friday morning I compile records captured from Monday to Thursday and on Monday those captured from Friday to Sunday. This helps me to finish the exercise early. After tallying the two I fill in the paper-based report form and then submit it through eIDSR (...) I have tried to submit reports several times and failed (...) As a result, sometimes I have to submit at night (...) occasionally, I have had to wake up around 1.00 am to submit data that would take up to 4.00 am because the system responds very slowly” (HF2Dist3).

The HF management also supported eIDSR users in data management activities by recognising the time and space they needed to capture and submit data.

“When I come in on Monday, I distribute my tasks to other people to give me time to concentrate on reporting activities” (HF3Dist1).

“I usually start compiling data for reporting around 9.00 am and finish around noon” (HF2Dist3).

In addition, they received support in identifying relevant surveillance records and compiling reports.

“Each clinician knows how many cases they have received in a day including immediate notifiable cases which they report to me. At the end of the week, I compile all the daily records and compile a weekly report” (HF3Dist1).

“Usually, the medical doctor in charge assists me. Once we complete compiling a manual report, he goes back to his duties and I submit it through eIDSR (...) when I am not around, the doctor in-charge sends the report to me as an SMS that I enter into eIDSR, since my mobile phone is registered to access it. Therefore, whether or not I am around, reports will be submitted(...) It has made me active and the doctor-in-charge is happy because he knows I would always report even when he forgets” (HF3Dist1).

“Two of us were trained to use eIDSR but I am the one doing the reporting work. She helps me only when I am not around” (HF2Dist3).

7.5. Chapter summary

This chapter has presented the results of the analysis of the effect of eIDSR use on data quality, and the factors affecting the submission of data through eIDSR.

Firstly, an empirical approach to the study of data quality was adopted to investigate the data quality dimensions regarded as more important by the disease surveillance system. These were RC and RT (reporting quality) and data accuracy. The results indicate that eIDSR use did not improve the submission of case-based reports of epidemic-prone diseases, nor weekly numerical reports, resulting in poor mean RC and RT. Similarly, reports were submitted fairly regularly soon after deployment, followed by an inconsistent and declining trend for most of the study period. RT rates were consistently lower than RC rates for all units, indicating that of the few reports submitted through eIDSR, the majority were not submitted on time.

Furthermore, the surveillance records submitted through eIDSR were numerically inaccurate. Only 0.21% and 2.43% of cholera records captured in District1 and District4 had been submitted through eIDSR. The accuracy of malaria numerical records reported through eIDSR from HF1Dist4 could not be validated because of a discrepancy in the existing source records, particularly the absence of common identifiers between them and those in the eIDSR database.

Secondly, using mixed-effects multi-level regression analysis, idealised randomised implementation-related conditions were analysed to determine their potential influence on eIDSR use for the submission of weekly reports. Despite a variation in the reporting quality of HFs attributed to location, ownership, type, mother district and deployment phase, or location and deployment phase for districts, the quality of reporting by all units declined with time, which indicates that eIDSR use was generally poor and deteriorated as scaling up progressed. The difference in reporting quality between districts covered at the initial implementation stage and those equipped during scaling up was insignificant.

The qualitative results revealed that the failure of eIDSR to improve data quality can be attributed to the implementation approach and information culture. Implementation-related factors are characterised by the absence of a change management strategy, non-use of implementation framework, the unrealistic assumption of the benefit of using eIDSR, unresolved technical challenges, and system design limitations. Factors concerning the information culture were attributed to the preference for conventional and non-institutional information system management practices, the lack of feedback given to users, and interference from political leaders in reporting surveillance data.

Despite the challenges above, the eIDSR intervention presented features which could potentially improve data quality. First were a supportive mobile phone network, users' familiarity with the technology deployed, and the features supporting the capture and submission of good quality data. Second were the institutional support given to users by HF leaders and users' commitment to using the system.

Therefore, the use of eIDSR for submitting reports was sub-optimal and inconsistent, thereby not adding value to the quality of disease surveillance data. This signifies that eIDSR had not been effectively implemented. The next chapter extends the analysis done in this chapter by examining the value added by the eIDSR intervention on delivering outbreak notifications and how data are analysed and used to inform response to disease outbreaks.

CHAPTER 8

The influence of eIDSR on data analysis and use

8.0. Introduction

This chapter responds to the second part of the third objective. It sought to determine whether and how the use of eIDSR influenced data use to inform the response to disease outbreaks. Two aspects of data use were examined:

- 1) whether and how data submitted through eIDSR were analysed.
- 2) whether and how data submitted through eIDSR were used to inform response actions during disease outbreaks.

Table 61: Summary of key results in this chapter

| Main themes | Specific findings |
|--|--|
| Data analysis | <ul style="list-style-type: none"> • Data collected through eIDSR were not analysed at HFs because users at this level had no access to data after submission. • Evidence of data analysis at management level was missing |
| Data used to notify and respond to outbreaks | <ul style="list-style-type: none"> • eIDSR was not regarded as a reliable source of outbreak notifications, and so the data submitted were not used to inform responses to outbreaks. • Conventional reporting approaches were used to get notifications of suspected outbreaks. |
| Interpretation and conclusion | <ul style="list-style-type: none"> • The novelty of eIDSR was used to justify its benefits rather than the value it adds to data use practices. • Poor data use practices were not exclusive to eIDSR, but were attributed to the organisational culture of the inadequate processing and use of information |

In the subsequent sections, the results on the evidence of data analysis are presented first, followed by the evidence of data use.

8.1. Analysis of data submitted through eIDSR

Data analysis practices are an important indication of the culture of data use, illustrating that data are not only collected but they are processed and interpreted to support decision-making processes (Nutley, 2012). Two main themes emerged from the findings, evidence of data analysis practices and factors affecting them.

8.1.1. Evidence of data analysis practices

The results indicate that data analysis is necessary at all levels of the disease surveillance hierarchy for generating information to inform timely and appropriate public health actions.

“Data analysis is one of the core functions of disease surveillance that should be strengthened at all levels of health care and at the community level (...) the analysis may be done electronically or manually” (MoH-Tanzania, 2011, p. 41)

Moreover, the guidelines stipulate that the two main outcomes of data analysis during outbreaks is to produce information that will help to identify the most appropriate action

to take to control the situation, and to show a change in the trend of diseases over time (MoH-Tanzania, 2011). However, this research found that data submitted through eIDSR were not analysed, and that factors explaining poor data analysis practices in HFs differed from those at management level.

Analysis practices in HFs

eIDSR users in HFs did not analyse data because they did not have the time or skills to do this, and so they expected the managers to support them.

“the data should be analysed and interpreted for us to understand what they mean and the implications for us to make the necessary interventions (...) if you look at it now, records are just submitted but you have no idea how to interpret them” (HF2Dist2).

“I have not received any report generated from the data I submit (...) my expectation is that those who receive our reports should analyse the data and give us the interpretation of what we report” (HF3Dist3).

These claims are confirmed by eIDSR implementers in a supportive supervision report.

“majority of the health facilities visited don’t do any data analysis (...) there is a need to build more capacity to the health facilities staff on elementary data analysis and use” (Report2).

In addition, the eIDSR application restricts HF users from changing or viewing data after submitting them. Thus, analysis could only be for data captured in the paper-based system before submitting them to the district to establish basic facts on the burden of diseases measured by the frequency of cases captured in HFs and from the community.

“The system has helped us to know areas where we should improve. For example, the increased number of malnutrition and meningitis cases (...) I have compiled a report showing the total number of cases in a year (HF2Dist3).

“I usually prepare my reports in which I identify cases frequently captured by our hospital in a month. We usually do a presentation, and so when it comes to my turn, I do a presentation to show the burden of diseases” (HF2Dist4).

In other HFs, this level of analysis was not a routine practice, but could be triggered by emergency situations.

“I don't have a report I have generated for local usage from the data I collect (...) I do not present data at hospital meetings. Maybe during cholera outbreaks. Only cases relating to maternal deaths are the ones I have seen being discussed in our morning meetings” (HF1Dist4).

Therefore, the results strongly indicate that a certain amount of analysis was done manually in HFs, but not of data submitted through eIDSR, because users had no access to the DHIS2 database. Thus, questioning the analysis of the latter at HF level was irrelevant.

Analysis practices at district and regional level

Managers at the district, regional and national level have access to data submitted from HFs and have been trained to use data analysis features in the DHIS2 database.

“Regional and district [managers] have been trained in how to do analysis on their own” (MoHP1).

The content of eIDSR training manuals include data analysis techniques such as:

“messages and interpretation, standard report, dataset report (...) GIS, data visualisation, pivot table, and data quality (...) to help participants understand and explain the functions of surveillance which are cases identification, recording and reporting suspected cases, analyse and interpret data, investigate and confirm suspected cases, respond and provide feedback, and evaluation” (Report2).

Participants gave the impression that data were analysed at managerial level.

“I would say we have some reports generated from data submitted through eIDSR” (MoHP1).

“I think we have produced one report” (Dist1P2).

When prompted to provide evidence, different explanations were given.

“I don't have an example of a surveillance report generated from eIDSR” (Dist3P2).

“I am not using the data submitted through eIDSR (...) I do not get time to analyse data submitted through eIDSR by health facilities or give them feedback” (Dist2P1).

“I will look at it later because the computer I am using now is new, and so it does not have old documents” (Dist1P2).

Some participants said they were analysing data and viewing reports in the DHIS2 database.

“If I log into the DHIS2 system, I can compare what has been reported with the data reported through the paper-based system. I can generate data from the system (...) I usually log in each Monday and Friday. Sometimes I do that when in meetings” (Reg1P1).

“They capture disease surveillance records from OPD registers as required, summarise them in the IDSR paper-based report and then submit them through eIDSR. When you compare records from these sources, you will find they are the same” (Dist3P1).

When asked to demonstrate how these practices were carried out, they could not even log into the DHIS2, because they had either no login credentials or had forgotten them. This was also noticed in one implementation progress report prepared after covering ten regions:

“Regional and district focal persons do not access DHIS2 system frequently (...) in order to strengthen the eIDSR the following should be done (...) improve data analysis skills through the DHIS2” (Report1).

There were exceptional cases indicating that data were being analysed and interpreted, despite the lack of documentary evidence, which happened when health facilities submitted data indicating risky situations.

“I remember when this system helped us a lot. By going through the reported malaria cases, it helped us to understand why there were complaints about malaria. I worked with a laboratory and malaria control coordinator and realised that most of the reported cases were not malaria but had been reported for a reason (...) we had a dengue fever outbreak, but it was not detected. As a result, reports of malaria cases increased significantly” (Dist1P1).

“Some time ago, one health facility reported 27 cases of bloody diarrhoea. As a result, we received a call from the regional medical officer. She wanted to know what had happened and whether we had investigated. When we visited the health facility, we found those records had been wrongly reported. The clinician concluded the cases were bloody diarrhoea by what the patients said without being examined” (Dist3P2).

These narratives indicate that coordinators sought to understand the data submitted through eIDSR only when they gave alarming signals, and even then, documentary evidence of the action taken in response to those data could not be produced.

Data analysis practices at the national level were no different from those at district and regional level. The participants explained that they had the skills to analyse data submitted through eIDSR and were doing so.

“We have the capacity to receive, process and act on the data we receive (...) the capacity is there (...) we receive the report and then we analyse it promptly and respond and even share it with WHO (...) I would say we have some reports generated from data submitted through eIDSR” (MoHP1).

However, what managers claimed to be data analysis practices was assessing eIDSR use by HFs as opposed to producing consumable information.

“I know a couple of reports have been written by the MoH and partners about the implementation process and how they have succeeded” (MoHP5).

“We do presentations where we show areas in which are doing well, like when we sensitised RMOs from regions about eIDSR” (MoHP1).

This view was also found in eIDSR implementation reports. Whenever the subject of data analysis is raised it refers to reporting quality as opposed to the data.

“Overall, the reporting rate is 51%, and reports received on time are about 20%” (Report1).

“The overall regional reporting trend up to week 29 in 2015 was 49%”. (Report2).

When asked to provide evidence of data that had been analysed, the previous position changed with the explanation that they were not using data submitted through eIDSR.

“We receive data through the traditional paper-based system. Sometimes they submit them through email, and we compile daily and weekly reports (...) sometimes during outbreaks they phone us with specific information like [the] number of new cases, old cases, and number deaths. That is the most reliable means of reporting at the moment” (MoHP1).

“Since the system was not good, the filing of individual cases was difficult, and so we needed to collect the records separately in the paper-based system and not through eIDSR” (MoHP2).

The results have shown that data submitted through eIDSR were not analysed at any of the levels of the DSS and this was not only a problem for data submitted through eIDSR. The failure to comply with data analysis requirements was largely attributed to the information culture problem, whereby the provision of information was substandard as expressed by the participants:

“There was no feedback. We don’t get feedback even with the paper-based reporting system. We just submit” (HF2Dist4).

“if you look at it now, records are just submitted but you have no idea how to interpret them” (HF2Dist2).

However, despite poor eIDSR use as established in the previous chapter, some data had been submitted, which should have been analysed and interpreted to justify the implementation of eIDSR.

8.2. Data use for notifying and responding to outbreaks

8.2.1. Outbreak notifications and response

Despite lack of evidence on data analysis the current study examined whether data were used without being processed. In order to establish how eIDSR data were used to support the response to a disease outbreak, this study sought to ascertain the operational procedures used to respond to the notification of an outbreak of an epidemic-prone disease (cholera) and a notifiable disease of public health importance (malaria).

Cholera outbreak

The action threshold for cholera is reached when one case is confirmed. The eIDSR is designed to promptly deliver notifications through SMS and email to each member of the RRTs once a suspected case is reported.

“once they suspect any of the epidemic-prone diseases like cholera, measles, meningitis, yellow/ rift valley fever, and Ebola (...) even before they take specimens for laboratory confirmation, and based on the standard definitions provided, they have to report instantly” (MoHP1)

“Every time a report comes in and it is a suspected outbreak, SMS and emails would be sent by the system to the district, regional and national teams to alert them, which they will start following up” (MoHP5).

“When a facility reports two or more cases of bloody diarrhoea then we become alert and start looking at it as a problem. For cholera, only one case triggers an outbreak” (Dist2P1).

Once notifications are received, several activities take place, starting with communicating with the source of the data.

“I would receive a message saying something like, ‘a certain facility has reported a certain case, please follow this up’. In response, I would make calls” (Dist1P1).

“You start following up through phone calls. If necessary, we organize ourselves and visit the facility” (Dist1P2).

“the first thing we do is to take the required medicines to the respective area or health facility, even when the case is not confirmed, but we take specimen before starting medication because once medication starts, it is difficult to establish the presence of the disease. The suspected patient continues to take the medication while a specimen is taken to the chemists for a laboratory test” (Dist2P1).

“Once the rapid response team is informed, it must start organizing itself to take control of the situation and avoid further spread of the disease. First, we would like to know the preliminary information, such as where the patient comes from, the history of his/her movements, residence, and the possible source of the problem (...) to know whether there are other sources that might cause the spread of the disease” (Dist4P1).

When an outbreak is confirmed and spreads to many people, temporary treatment centres are established to which all suspected patients are referred.

“Cholera cases are not recorded in facility reports since all facilities were directed to report any suspect case to the district, and the patients were transferred to special camps” (Dist1P2).

The role of eIDSR

The findings reveal that RRT members were not receiving notifications during the cholera outbreak.

“Initially, I was receiving notifications for epidemic-prone cases but now I don’t (...) I have not received those notifications for a long time now (...) I am not sure whether it is because people are no longer sending them, or something else. Possibly, messages are sent but not delivered” (Dist1P1).

“For cases like cholera, I have not come across any notification so far (...) we have not had many epidemic-prone diseases, but we have had cholera” (Dist1P2).

District1 had been using eIDSR for more than two years and was among those which were hard hit by the 2015-2016 cholera outbreak, but eIDSR was not used as the main source of notifications or information to inform the response. In District3, where eIDSR had been used for more than a year, the district IDSR-DCo did not seem to know how outbreak notifications were delivered.

“During cholera outbreaks, you cannot see the records until you log into the system to see reported cases. It is something that needs immediate attention, so they make a call straight away (...) I have never received such a notification. What I know is, when they make a call, I have to log into the system to confirm the case” (Dist3P2).

The results further revealed that even the regional coordinators were not receiving notifications.

“The system was supposed to send us notifications as well, but this isn't happening. This is one of the features lacking in the software design. It was supposed to be instructed to send us notifications when an outbreak is reported” (Reg2P1).

These findings suggest that the RRTs did not think that eIDSR was important for providing notifications or informing response actions, because they preferred the conventional means of reporting outbreak data.

“For immediate notifiable cases, I phone the district health officer directly” (HF2Dist3).

“In the case of epidemic-prone diseases, they would call me immediately or send an SMS” (Dist2P1)

“We use the data we receive through the paper-based system together with records reported to us through phone calls and SMS” (Dist3P2).

Malaria outbreaks

The action threshold for malaria is established when the number of positive cases reported in the current week shows a twofold increase to what it was in the past three weeks. In the paper-based DSIS, the change was established by routinely observing the data from each HF.

“We often compare the number of previous cases with that of current cases. When it happens that the trend from the previous to current number of cases is shooting then we raise some doubt” (Dist4P1).

When notifications are sent, the response procedure starts with verifying their validity by engaging the respective HF.

“When I receive a larger number of malaria records than expected, the first thing I do is go to the malaria coordinator to find out the number of malaria test kits that were given to that health facility. Then I compare that with the number of reported cases (...) I can establish the correctness of the submitted records” (Dist2P1).

Most of the actions taken in response to detected malaria outbreaks, as indicated by the results, end at the verification stage, because it was realised that the submitted data were incorrect or represented a different alarming health condition.

“I worked with a laboratory and malaria control coordinator and realised that most of the reported cases were not malaria” (Dist1P1).

“a few days ago, a health facility submitted strange malaria reports. A team led by HMIS and malaria coordinators went to investigate the nature of the problem. They found that the total number of OPD patients attended to in one month by that facility was fewer than the number of patients reported as malaria positive” (Dist4P1).

“There is a challenge with malaria data in general, because the claim that the number of malaria cases has gone down (and this is obvious in public health facilities) does not agree with what is recorded in private health facilities. When we investigate, the type of testing toolkit is blamed because they mistrust the MRDT” (Dist4P1).

When an outbreak is confirmed, the necessary response actions are taken, which might be context specific.

“We communicate with the health facility in charge and the local health officer and ask them to provide health education on how people should protect themselves from malaria. Sometimes the problem is attributed to the belief that (...) if men sleep under mosquito nets, they are vulnerable to becoming impotent or sterile” (Dist3P1).

The role of eIDSR

The eIDSR was set up to automatically detect the malaria action threshold and send notifications.

“The malaria threshold has been set at a twofold increase of confirmed [number of] malaria cases in the current week compared to the average of malaria cases in the previous three weeks. An alert will be sent automatically via SMS and email to the district, regional, and national team when [a] threshold is exceeded” (Report1).

However, outbreak notifications were not delivered as indicated in one report.

“Thus far, no districts have reported any alerts. Therefore, thresholds have not been exceeded at any health facility. There is a need to review historical data that are available so as to calibrate the epidemic thresholds” (Report1).

The results reveal that this was not attributed to the absence of outbreaks, but to the fact that few data were reported through eIDSR.

“We use the data we receive through the paper-based system together with records reported to us through phone calls and SMS” (Dist3P2).

“In reality they call or send an SMS to district coordinators” (Reg2P1).

“I am not using the data submitted through eIDSR” (Dist2P1).

8.3. Summary of key findings

This chapter sought to ascertain whether and how data submitted through eIDSR were analysed and whether and how data were used to notify and inform the response to outbreaks. The results indicate that data submitted through eIDSR were not analysed or used because eIDSR was not regarded as a reliable source of outbreak notifications, nor did it provide data to inform a response to an outbreak. The failure to use notifications sent through eIDSR is attributed to the fact that eIDSR was not used by HFs to consistently submit data, and coordinators did not prioritise eIDSR use, ignored notifications or were not registered to receive notifications. Frequent technical failure might also have led to inconsistent data being submitted by FHs, making eIDSR ineffective in detecting outbreaks.

Managers continued to use data submitted through the paper-based DSIS, SMS and phone calls, thereby discouraging HFs from using eIDSR, which they justified. In addition, HF users of eIDSR could not analyse the data submitted because they had no access to them after submitting through to the system.

Notwithstanding the incompleteness of data submitted through eIDSR, poor analysis of data was not confined to data submitted through eIDSR but was also true of the data submitted through the paper-based DSIS. Surveillance data could only be extemporarily analysed and used to inform actions when HFs submitted data indicating an alarming disease situation. However, the nature of analysis and use could not be studied because

these had not been documented. Therefore, the rapid scaling up of eIDSR was not informed by improved data use practices.

The next chapter summarises and discusses all the results presented in chapters 4 to 8, provides recommendations for effective implementation of eIDSR interventions and draws the conclusion of this thesis.

CHAPTER 9

Discussion, Recommendations and Conclusion

9.0. The focus of the thesis

Search of existing literature revealed that, this thesis is the first in SSA to explore the implementation effectiveness of an mSurveillance intervention implemented for national disease surveillance and response functions. It investigated the implementation of an application called eIDSR in Tanzania, which was built using a mobile phone-based mHealth solution integrated with SMS, email and DHIS2. A mixed-methods design was used to retrospectively explore the adoption and implementation of eIDSR in the first four years, from 2013 to 2016, and its effect on data quality and use, using cholera and malaria as tracer diseases.

As established in the literature search in chapter 2, a study referring to the eIDSR intervention was conducted in the course of writing this thesis by Mbelwa et al (2019) in which the eIDSR mHealth component was used as one of the two mHealth solutions to investigate factors influencing acceptance and use of mobile health applications by health workers in HFs in Tanzania. Besides referencing to the mHealth component of the eIDSR intervention, the study focused only on getting the view of users in 54 HFs in one district through a structured questionnaire to establish factors influencing acceptability and use of mobile applications using a unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al (2003). It did not cover the eIDSR intervention as a whole, its adoption and implementation, nor the available evidence on how it is being used for the intended purpose. This thesis presents significantly broader research in terms of the phenomenon of interest investigated, its methodological approach, number of interrelated topics covered, and breadth and depth of the analysis done, and therefore makes a novel contribution to the research on implementation of DHS in the context of SSA.

Chapter 1 provided the background to and rationale for the study and chapter 2 reviewed related studies reported from SSA countries. Chapter 3 presented the theoretical framework that guided this thesis and discussed the study design and methods. The results were presented in five chapters in response to the first three specific objectives of this thesis. The first objective sought to examine the adoption and implementation of eIDSR and was qualitatively addressed in chapters 4 and 5, with the former discussing the adoption of eIDSR and design of the eIDSR application and the latter examining the implementation approach, processes and activities. Chapter 6 addressed the second objective which assessed the value and accuracy of the clinical records in HFs before being submitted through eIDSR. The third objective examined the value added by eIDSR

use on surveillance data availability, accuracy, and use and was addressed in chapters 7 and 8. Objective 4 was set to recommend strategies for effective implementation of mHealth interventions for disease surveillance in SSA, addressed later in this chapter.

Section 9.1 synthesises the key findings presented in this thesis and section 9.2 discusses them. Section 9.3 addresses the 4th objective of this thesis by giving recommendations on how to effectively implement eIDSR interventions in SSA. Section 9.4 gives the conclusion of the thesis.

9.1. The summary and synthesis of the key findings

Drawn from the organisational change perspective, the process theory of change was used to qualitatively analyse how the decision to implement eIDSR was reached, the implementation climate, the implementation process, and data quality, analysis and use. The variance theory of change was used to quantitatively measure the relationship between eIDSR use and its effect on the reporting and quality of data, and between the context-based implementation factors and how eIDSR was used by HFs to submit data. The clinical value and accuracy of source clinical records at HF level were examined independently of eIDSR use to find out whether the intervention was capturing useful disease surveillance data. Below is the summary of seven overarching issues immersed from the specific results.

(1) The adoption of eIDSR intervention and the technological solution

The eIDSR intervention was introduced to improve the information component of the national DSS, which is organised from the community, HF, district, regional to the national level, but the HFs are the main source of surveillance data captured from the paper-based medical records component of the HMIS. There are surveillance focal persons in HFs, and coordinators at the district, regional and MoH level, who lead multidisciplinary RRTs for prompt response to disease outbreaks and other health emergencies. The DSS is guided by the IDSR strategy which provide technical guidelines for surveillance and response activities. It is supported by a paper-based DSIS through which data are submitted hierarchically from HFs to the national level as immediate case-based reports of epidemic-prone diseases, and as weekly, monthly or quarterly numerical reports of other disease of public health importance.

As shown in chapter 4 section 4.2.1 and 4.3.1, data captured through the DSIS and other disease-specific information systems are the duplicate of routine HMIS data. While the paper-based HMIS data were entered into the DHIS2 database at the district level, DSIS data were not. Because the DSIS failed to immediately provide sufficient, comprehensive and good quality data to inform the surveillance and response functions, eIDSR was envisioned to ensure the complete and timely submission of data, and address the

duplication and discrepancy of the surveillance data informally and formally captured by uncoordinated information systems with different reporting formats and frequencies.

The eIDSR solution was acquired locally by local experts, using a custom development model and the choice of the technology and design was mainly informed by previous unsuccessful attempts to implement a similar solutions, taking users' technical skills into account, as well as resource limitation, integrating it with DHIS2, mobile phone ownership, subscription and network penetration.

The eIDSR application was perceived by its implementers and users as an mHealth solution only, hence the original focus of this research, but the thesis established that it is an integrated DH solution encompassing the USSID mobile phone-based mHealth application for capturing and submitting data, the web-based DHIS2 for data storage and analytics, and an SMS and emails component for notifying outbreaks and delivering alerts and reminders. It being perceived as an mHealth solution only is attributed to the fact that implementers prioritised to improve data collection from HFs, hence the focus on rapidly deploying the mHealth component. The mHealth component provides HF users with a menu-based USSD interface mimicking the format of the paper-based reports. It delivers notifications of outbreaks to all RRT members simultaneously via SMS and email. Managers cannot submit data but can access them on DHIS2 and queries are raised outside the eIDSR through phone calls or SMS.

The eIDSR implementation climate at the adoption stage, discussed in section 4.5, was relatively supportive, in terms of the national ICT ecosystem, the government ownership, IPPs, and availability of resources for building and piloting the application. However, the intervention objectives, milestones, outcome measurements, implementation approach and plans were not defined or documented, and users at lower levels were not involved in designing the application or making implementation decisions. Even though several health system and organisational issues had to be considered or changed to facilitate the effective implementation of eIDSR, there was neither a change management strategy nor application of a validated implementation framework to guide the process.

These results suggest that the decision to implement eIDSR was strongly shaped by technocentric perspective and optimism about the benefit of DHIs without considering organisational and circumstantial complications potential to affect the implementation process. Likewise, the fact that there was no application of an informed framework to guide the implementation process suggests an organisational-wide lack of evidenced based practice in adapting innovative DH solutions.

(2) The process of implementing eIDSR

As presented in section 5.1, the eIDSR intervention was piloted in 67 of the existing 104 HFs in one district in November 2013. About 2 months later it was extended to 3 other districts, each in a different region, and thereafter rapidly scaled up in 70 districts with nearly 50% of all HFs in the country in the first 2 years. The main implementation activities were user training course organised district wise, and a few supportive supervision visits conducted by the national implementation team in some districts and HFs. The eIDSR application is not installed in users' phone but operates as a logical layer of the HF information infrastructure that depends on the functioning of the paper-based HMIS and DSIS, thus started to be used immediately after the training sessions.

Section 5.3 indicates eIDSR was implemented using the top-down approach in which all decisions were made by the national team and passed down through the conventional DSS coordination structure. Users understood the need and urgency of implementing eIDSR but the implementation approach was uninformed, lacked evidence of the benefits, and rushed without considering several organisational complications. User participation was unsatisfactory because the training sessions were the first activity in which they were involved. eIDSR was infrequently used to submit data due to technical challenges, non-institutional data management practices, the heavy workload to FHWs, use of personal mobile phones, and the per diem culture, which lead to training of irrelevant users. Also, technical support was poor such that concerns raised by users at the beginning of implementation were still unresolved 3 years later when this research was conducted.

As presented in section 5.5, the intervention had not been evaluated up to when this research was conducted, deployment phases were impromptu, depending on the availability of donor funding and the priorities they set, and the rapid scaling up was not informed by evidence of improved outcomes or best practices. Monitoring activities were reactive and limited to progress meetings held with some regional and district managers, and to supportive supervision visits to a handful of districts and HFs because of financial constraints and the limited capacity of the technical support team relative to the large number of units where eIDSR had been deployed within a short time. Districts managers failed to arrange supervision visits to HFs because they did not have the technical skills or resources needed to support eIDSR users.

The implementation approach and process of eIDSR reflected the pre-implementation considerations made or lack of, hence indicating that besides the desire to improve the information component of the surveillance system, there were other organisational forces

influencing the adoption and implement decisions. That is why, besides lack of evidence of the value added to the surveillance system, it was expeditiously scaled up.

(3) Organisational forces influenced adoption and implementation

These include the burden of communicable diseases and the need to promptly identify and report epidemics, hence making a strong case as to why implementing eIDSR was an important decision. Also, deploying eIDSR was perceived as a progress and recommendable efforts to modernise the DSS due to the prescribed benefits of digital solutions drawing from the peer pressure of the successful application of mobile phones for financial transactions and other countries implementing eIDSR-related interventions. Likewise, the implementation climate at the adaption stage was relatively supportive due to the fact growing ICT infrastructure, operationalisation of policy frameworks for DHIs, locally available technical support, political will and the government leadership and ownership of DHIs.

On the other hand, the rapid scaling up of eIDSR was influenced by implementers' desire to achieve full-scale implementation, which was perceived to signify implementation effectiveness, the techno-centric view of eIDSR and the financial support of donors.

The forces above potentially constrained a more measured implementation approach and M&E of the initial stages. Since evidence was not regarded as important consideration to support implementation decisions, financial resources were provided, and deploying eIDSR to scale was regarded as indicating effectiveness, the organisational change aspect of the intervention was overlooked and the implementation process was narrowly perceived to focus on conducting training and supervision visits.

(4) The value of source surveillance records

Chapter 6 investigated the value and accuracy of clinical records at HF from which disease surveillance data are captured. Establishing the value of clinical records was problematic because they did not sufficiently indicate whether they were used to inform treatment decisions. In District1 and District4, 86.55% and 100%, respectively, of suspected cholera cases were treated, but only 56.24% and 24.52% were tested, of which 30.84% and 5.09% were positive. The documentation of clinical records was a serious problem and worse for malaria records than cholera in that it was impossible to analyse their value. For many records, it was also unclear which came first between testing and treatment, several records were incomplete, confirmatory tests were not conducted, many records were missing, the number of records in the laboratory registers differed significantly from the corresponding test requests in clinicians' registers, and records in different registers could not be validated because they did not have common

identifiers. In one IPD register, 26 patients were admitted in a month as severe malaria cases, but neither laboratory requests nor test results were documented.

The qualitative results indicated that data quality is a common problem of clinical records in HFs attributed to organisational, operational, clinical and information culture challenges. The capturing, storage, management and use of data were very poor. Some patient registers could not be located, clinical records were illegible or recorded in inconsistent formats, standard clinical practices in diagnosing diseases were not observed such as performing testing before treatment, and the technical guidelines on testing and treating epidemic-prone cases were contradictory. This suggests that clinical records were rarely used to inform clinical decisions or service delivery and management functions in HFs, and if they were used, they misrepresented the real situation.

Clinical records were the main source of surveillance data, hence being of poor quality suggest that eIDSR was thus being used to capture data that potentially misrepresent disease situation and misinform surveillance and response functions. The technocentric and rushed implementation approach overlooked the need for examining and improving data quality at the HF level as part of eIDSR implementation process. Operationalising the technological solution was regarded as more important than what it was meant to change, thus indicating the presence of different motivational factors for scaling up, the poor culture of information use, and nonevidence-based practices as earlier argued.

(5) The value added by eIDSR solution to data quality

Chapter 7 quantitatively and qualitatively examined the influence of eIDSR on the reporting quality and accuracy of disease surveillance data. The quantitative results indicated that eIDSR was rarely used by HFs to submit reports, thereby not improving reporting quality or ensuring data accuracy. For example, in section 7.1.1, mean RC rates for cholera records were 0.21% and 2.43% for District1 and District4, respectively. None of the sampled HFs in District1 submitted cholera cases, while HF1Dist4, HF2Dist4, and HF3Dist4 had 41.03%, 1.34%, and 0.0% mean RC rates, respectively. Mean RT rates were worse than mean RC rates in all units. Since very few cases of epidemic-prone diseases had been reported through eIDSR, the analysis of RT rates considered cases of all epidemic-prone diseases reported through eIDSR. Even so, mean RT was poor for all sampled HFs and districts, ranging from 0% to 80%.

Results in section 7.1.3 found revealed that the use of eIDSR for submission of weekly numerical reports was also poor excluding 2 sampled HFs which had exceeded the 80% minimum target. The analysis of weekly reports was extended to include all 70 districts which had used eIDSR for at least 56 weeks. Among them, only 2 had reached the 80% mean RC minimum target, while the maximum mean RT rate was 58%. As shown in

Figure 34, the longer a district had used eIDSR, the worse its reporting quality, indicating that eIDSR use declined as scaling up progressed, and deployment was not supported by evidence of improved data submission trend.

Two aspects of the effect of eIDSR use on data accuracy were investigated in section 7.3: the accuracy of the number of records in eIDSR compared with the source clinical records, and the accuracy of data elements in individual cholera records. The former was inaccurate because only 0.21% and 2.43% of cholera records from all HFs in District1 and District4 had been submitted, respectively. The accuracy of individual cholera records in eIDSR could not be verified since they did not share unique identifiers with source clinical records. Similarly, it was impossible to verify the number of malaria records in eIDSR against the source clinical records in a HF because of the documentation challenges discussed earlier. The results conclude that the capturing and reporting of data are critical problems in HFs, irrespective of the information system or technology used, and the quality problem starts with the capturing of the HMIS medical records.

The quantitative results on data quality were consistent with the qualitative results presented in section 7.4. Despite eIDSR presenting a technological advantage which could potentially improve data quality and implementers' unsubstantiated claims that it was doing so, the results established that it had not, which was attributed to the undefined implementation approach, the absence of a change management strategy, the techno-centric view, implementers' unrealistic assumptions about eIDSR use, unresolved technical challenges, the design limitations of eIDSR, the preference for traditional and informal means of reporting, non-institutional data management practices, the lack of feedback, the interference of political leaders in reporting surveillance data, and the per diem effect whereby several people attended eIDSR training courses, while they were not in charge of surveillance functions, for the sake of getting allowances.

The patterns of reporting trends presented in figure 35 to 40 show that the reporting quality of all districts (and majority of sampled HFs) declined consistently to a common minimum point between May and June 2016, after which some improved gradually and others rapidly. They indicate that all areas where eIDSR had been deployed were subject to similar conditions that affected its use. When variations were observed, underlying causes were established such as the two HFs which relatively better RC rates because users were more committed to using eIDSR and supported by management. Also, when mobile phone network was improved or an action was taken to address a declining trend, a positive change in reporting trend was observed. In figure 37, the declining trend did

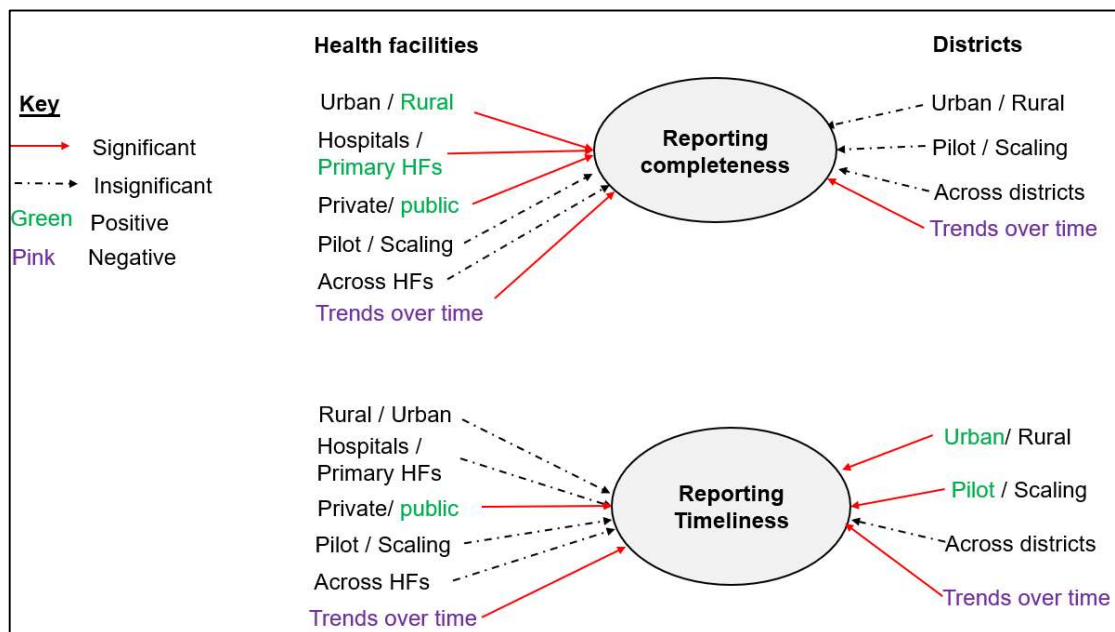
not change for District3 because, during fieldwork, the IDSR-DCo was having his last holiday before retiring and a replacement had not been appointed.

Therefore, a change of leadership might have had a continued negative effect on eIDSR use in HFs, illustrating the non-institutional information management approach and eIDSR use explained earlier.

(6) Implementation related factors affecting eIDSR use

A quantitative analysis was also done in section 7.2 on implementation-related factors likely to influence reporting quality, using generalised mixed-effect regression models within and across HFs and districts. The factors were HF ownership (public vs private) and type (hospitals vs PHFs); and location (urban vs rural), deployment stage (pilot vs scaling up) and timeline (in weeks) for both HFs and districts, as summarised in Figure 44 which shows that,

Figure 44: Context-based implementation factors likely to influence reporting quality of weekly reports by HFs and districts



- The RC scores of PHFs were likely to be higher than those of hospitals, rural than urban HFs, and public than private HFs. There was no significant difference in RC rates across HFs or deployment stages, or across districts, their locations or implementation stages.
- Public HFs were more likely to report on time than private ones, but location, type and implementation stage did not have significant difference on RT rates. Urban districts and those equipped during piloting were more likely to report on time than rural districts and those equipped during scaling up, respectively.

- The reporting quality of both HFs and districts declined significantly over time, implying that scaling up efforts were not supported by outcomes attributed to eIDSR use.

Generally, the results indicate that users were motivated to use eIDSR only momentarily after it was installed because the timeline shows a significant negative effect on the reporting quality trends. Other conditions do not suggest causing a significant variation on eIDSR use because the use was fundamentally poor across all units.

(7) Data analysis and use for notifying and responding to outbreaks

Chapter 8 presented the results on whether data submitted through eIDSR were analysed and used as a source of information to notify and respond to a disease outbreak. eIDSR use did not improve HFs' data analysis or use because they did not have access to data after submitting them. The managers did not regard eIDSR as a reliable source of surveillance data from HFs, hence preferring paper-based reports, SMS and phone calls. However, the technical and technological challenges eIDSR users faced did not seem to be the primary concern limiting data use by managers because they had access to data stored in the DHIS2 database which was not faced with technical challenges faced the mHealth application used by HFs. The poor analysis and use of data collected through eIDSR was also true of data captured through other means. Moreover, the failure to use data submitted through eIDSR by managers, questions the rationale for implementing it and the motivation for the rapid scaling up process.

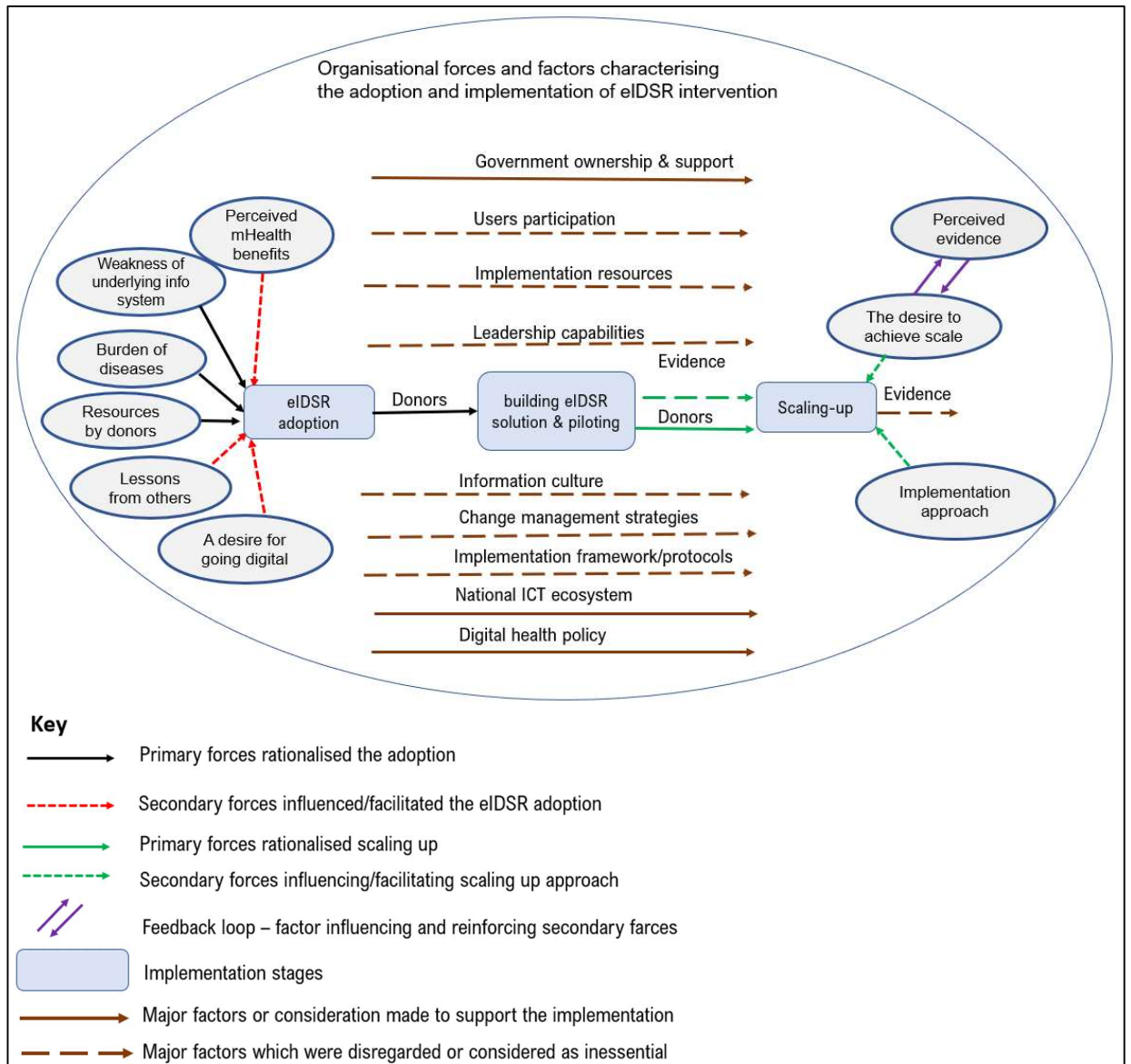
9.2. Discussion of the results

The results summarised and synthesised in the previous section answer the three main questions this thesis set out to answer which are (i) what characterised the adoption and implementation of eIDSR? (ii) whether the eIDSR was being effectively implemented, and (iii) what factors contributed to how eIDSR was being implemented?

9.2.1. What factors characterised the adoption and implementation of eIDSR?

The eIDSR intervention can be explained by forces that rationalised and facilitated its adoption, its implementation climate, and forces that influenced rapid deployment, as summarised in Figure 45.

Figure 45: Organisational forces and considerations characterising the adoption and implementation of the eIDSR intervention



(1) Organisational forces rationalised and influencing adoption

The decision to implement eIDSR was rationalised by organisational circumstances which required an innovative solution (PMI, 2014; USAID, 2018). These were the need to improve the dysfunctional DSIS, address the burden of communicable diseases and promptly identify epidemics (Mwanyika et al., 2013; Oresto et al., 2014; PMI, 2014). Besides, there were forces which facilitated the adoption including implementers' perception of the benefits of and progress made by using a DH solution, the purported narratives of successful adoption of related interventions by other countries (Kizito et al., 2013; Thierry et al., 2014), and the feasibility of USSID technology to capture disease surveillance data due to its wide application in Tanzania for money transactions and mobile banking (Economides and Jeziorski, 2017; Esselaar and Adam, 2013; Masamila, 2014). In addition, the assurance of getting the financial support of donors played a major

role in reaching the decision to adopt eIDSR, hence speeding up the initial implementation activities

(2) Implementation climate for eIDSR intervention

The implementation climate had a direct effect on the effectiveness of the implementation (Helfrich et al., 2007; Klein and Knight, 2005; Weiner et al., 2011; Weiner et al., 2009), hence mHealth implementation studies recommend a thorough consideration of factors affecting it before and after the start of an implementation process (Agarwal et al., 2016b; Brinkel et al., 2014; Krah and de Kruijff, 2016; Lemaire, 2013; Leon et al., 2012). This thesis established that 7 factors were either considered or considered not at the adoption stage or during implementation, hence defining the eIDSR implementation climate.

- The national ICT ecosystem was considered more carefully at the eIDSR adoption and implementation stages. Mobile phone ownership, subscription and network coverage were assessed prior to deployment, and the number of service providers was gradually increased parallel with scaling up. The mHealth application was also integrated in the DHIS2 which was already being used to capture monthly HMIS data.
- Financial resources for eIDSR implementation were provided by donors, but only for activities discharged by the national implementation team, with no funds allocated to districts and regional managers to enable them to support HF users or support HFs with no mobile phones or electricity to charge them.
- Information culture: eIDSR was implemented in the context of the poor culture of using information as established in previous studies (Ayebazibwe et al., 2019; Kikoba, Bigten et al., 2019a), and changing this was not part of the implementation package, which meant that eIDSR use would proliferate the existing information system challenges it was meant to address, such as poor reporting and data quality. The intervention faced similar organisational challenges, insufficient data collection tools, how information is managed (Ayebazibwe et al., 2019; Kikoba, Bigten et al., 2019a), the lack of organisational support (Curry and Moore, 2003) increased workload, and interference from political leaders interested in concealing data which would question their performance. In addition, the implementation process was not informed by evidence of improved surveillance outcomes or best practices as observed in related interventions (Martin et al., 2020; Randriamiarana et al., 2018; Toda et al., 2016).
- Leadership capabilities needed to effectively implement eIDSR were insufficient at all levels. The national implementation team was better equipped but it was small and lacked experience and the technical skills to support the magnitude and nature of the change introduced by eIDSR. Managers at lower levels did not have the skills, experience or time to support eIDSR use in HFs, or to ensure that data were validated, analysed and used.

- User participation was poor at all implementation stages and so users struggled to own the intervention and implementers failed to consider important preconditions for effective implementation (Krah and de Kruijff, 2016) such as reducing the workload, improving working conditions and information management practices in HFs, providing the resources needed, and ensuring that the users felt the immediate benefit of using eIDSR.
- Implementation frameworks are recommended for effective implementation of mHealth interventions (Agarwal et al., 2016a; Khoja et al., 2013; Labrique et al., 2013), but eIDSR did not have a framework or a change management strategy, as it was implemented in a routine fashion, with impromptu activities driven by funding availability or priorities set by donors. Phases were not pre-defined, milestones were not set, no timeframe was established to terminate paper-based reporting, and no systematic evaluation had been conducted.
- IPPs: the MoH operationalised the national eHealth strategy in 2013 (MoH-Tanzania, 2013a), whose policy and political legitimacy derived from the national health policy (MoH-Tanzania, 2007; MoH-Tanzania, 2009a). So eIDSR was implemented as part of the eHealth strategic objectives and a continuation of other interventions implemented at the national scale such as DHIS2 and HRHIS (Kikoba, Bigten et al., 2019a; MoH-Tanzania, 2018b; MoH-Tanzania, 2018c).
- Government ownership and support: the eIDSR was initiated and implemented by the epidemiology unit within the MoH, and so it was owned and fully supported by the government and championed by top officials in the national DSS. The later built a strong partnership with donors, mobile phone service providers and a local university to support the implementation of eIDSR (GHPC, 2020; Huang et al., 2017; Martin et al., 2020), model which is recommended for effective implementation (Aranda-Jan et al., 2014; Kruse et al., 2019).

(3) Forces influencing the rapid deployment of eIDSR

eIDSR was implemented without evidence to support its use in terms of improved outcomes or best practices. The outcome of project phases was not evaluated, because scaling up decisions were made based on other factors rather than evidence of improved outcomes, a common observation in donor drive mSurveillance interventions in SSA countries (GHPC, 2020; Martin et al., 2020; Randriamiarana et al., 2018; Toda et al., 2016). The supportive mobile phone infrastructure, the inflow of financial resources from donors and their priorities, the perceived benefits of using a DH solution, the optimism that eIDSR use would improve with time (Leon et al., 2012), and the desire to quickly achieve full-scale implementation, were the drivers of the rapid deployment process.

9.2.2. Was eIDSR being effectively implemented?

The implementation effectiveness of eIDSR is measured by the quality and extent to which its targeted users, HF users and managers, become increasingly skilful, consistent and committed to using it for the intended purpose (Klein et al., 2001; Klein and Sorra, 1996). The extent and consistent of eIDSR use by HFs to capture and submit surveillance data through the mHealth component was measured by how data are completely and timely reported as applied in related studies (Fall et al., 2019; Kizito et al., 2013; Thierry et al., 2014), and the quality of use by how the accuracy and completeness of source data are maintained when reported through eIDSR (Martin et al., 2020; Randrimiarana et al., 2018). For managers, the use was measured by extent to which they receive, analyse and use outbreak notifications and other routine data to inform surveillance and response functions.

This thesis established that eIDSR was not being effectively implemented up to when this research was done, because the use at HF level was extremely poor, inconsistent and progressively declined with time, and so there was no evidence of improved availability, quality, analysis and use of surveillance data. These findings are consistent with the reported poor evidence of mHealth interventions in SSA across health domains (Déglise et al., 2012a; Déglise et al., 2012b; Hall et al., 2014; Krah and de Kruijf, 2016), and, specifically, mSurveillance interventions for national surveillance and response functions (Brinkel et al., 2014; Nanyombi and Ejiri, 2016; Randriamiarana et al., 2018; Toda et al., 2017). Similarly, managers did not prioritise eIDSR as a reliable source of surveillance data, analyse or use data submitted through eIDSR, or provide feedback to HF users on the data they submitted (Ngwa et al., 2016). Several district and regional managers were either inactive users or had forgotten their credentials for logging into the DHIS2 database. As a result, HF users did not feel obliged to use eIDSR and some stopped submitting data.

9.2.3. Factors attributed to how eIDSR was being implemented

When innovations fail to produce the anticipated results, it should be determined by whether the failure is attributed to it being unfit in a given organisational context or by the poor implementation approach (Helfrich et al., 2007; Klein et al., 2001). The results in this thesis suggest that the eIDSR intervention was relevant to its context, because there was an urgent need to improve the paper-based DSIS, which had failed to provide good quality information to inform surveillance and response functions (Gueye et al., 2006; Mboera and Rumisha, 2005; MoH-Tanzania, 2011; Nsubuga et al., 2009; Perry et al., 2007; Rumisha et al., 2007). Users were influenced to accept and use eIDSR in the expectation that it would improve performance (Mbelwa et al., 2019). In addition, the intervention was owned, implemented and supported by the government and backed by

a strategic policy objective. Therefore, the ineffective implementation of eIDSR is not attributed to it being irrelevant to the expectations of its users in terms of performance (Mbelwa et al., 2019).

The intervention was ineffectively implemented because several organisational, technical, circumstantial and implementation-related complications were either unassessed or disregarded at the adoption stage, despite having a negative effect on eIDSR use (Aamir et al., 2018; Krah and de Kruijf, 2016; Marshall, C. et al., 2013a), because implementation focused on the technology only (Aamir et al., 2018; Mangam et al., 2016; Mbelwa et al., 2019), and the challenges that emerged during implementation were either unresolved or partially resolved with delay (Aranda-Jan et al., 2014; Krah and de Kruijf, 2016; Marshall, C. et al., 2013a; Randriamiarana et al., 2018).

For example, eIDSR was introduced without ensuring that data to be reported by HFs were of good quality and correctly represented the situation concerning the reported disease (Kikoba, Bigten et al., 2019a; Kikoba, B. et al., 2019b). The implementation approach was not informed by a framework and did not relate to the attainment of anticipated outcomes, because the organisational change needed to support eIDSR use was hardly considered. eIDSR was designed and implemented without the participation of key users, thereby ignoring their input that would improve implementation and use (Aamir et al., 2018; Krah and de Kruijf, 2016). In the process, known implementation problems were not addressed, such as technical challenges, insufficient use of eIDSR, poor information culture, continuation of informal reporting approaches, or a timeline for terminating the paper-based system (Aamir et al., 2018; Mangam et al., 2016; Ngwa et al., 2016). Moreover, as established earlier, due to the continued inflow of financial resources provided by donors, eIDSR was scaled up rapidly without obtaining evidence of its usefulness, which contributed significantly to it being ineffectively implemented.

The factors above indicate that while technical and technological challenges might inhibit implementation effectiveness of eIDSRs, they are not as serious as organisational circumstances surrounding the implementation initiatives. These findings agree with a study by Toda et al (2017) about the implementation of an eIDSR-related intervention in Kenya in which health system challenges were found to be complex to deal with than technological ones. Also, a systematic review by Krah and others (2017) concludes that the ambivalent evidence of mHealth interventions for community health in Africa is largely attributed to organisational and circumstantial complications.

9.2.4. Implications of the thesis for the implementation of mHealth interventions in SSA
In the literature review, it was established that mSurveillance studies reported from SSA do not suggest have idiosyncratic features or evidence different from mHealth solutions focusing on other health application domains (Aamir et al., 2018; Agarwal et al., 2016b; Brinkel et al., 2014; Déglise et al., 2012a; Déglise et al., 2012b; Hall et al., 2014; Krah and de Kruijf, 2016; Mangam et al., 2016; Ngwa et al., 2016). Also, they all suffer from related influences of weak health systems, infrastructural challenges, burden of disease, insufficient technical support, low level of technological skills, heavy FWHs workload, scarcity of implementation resources, and dependence on donors (Aamir et al., 2018; Brinkel et al., 2014; Krah and de Kruijf, 2016; Randriamiarana et al., 2018). Therefore, there are seven lessons/implications regarding mHealth interventions implemented in SSA that can be drawing from this thesis,

Firstly, the decision to mHealth interventions in SSA is influenced by explicit and implicitly organisational forces. While the former is the desire to improve performance (primary factors), hence the rationality for adoption, and the latter is not necessarily focusing on improving performance (secondary factors) and unlikely to be openly expressed, but they strongly influenced decisions because they stem from decision makers. Thus, any effort to implement mHealth interventions should take explicit and implicit forces into account and determine how they can potentially dictate and shape implementation decisions.

For example, eIDSR use by HFs was affected by the “per diem culture” (Barrington et al., 2010; Mangam et al., 2016; Rubona, 2001), whereby individuals not involved in disease surveillance activities were favoured to attend the training course to get the allowance, and some HFs leaders or owners attended training courses as a means of exercising management control (Asangansi, 2016; Nyella, 2007; Nyella and Mndeme, 2010). Consequently, the intended users disowned and avoided using eIDSR. In addition, being motivated by donor funding, implementers rapidly scaled up eIDSR, knowing it was not producing results. It could not be established whether this was a collective decision, or whether it was motivated by personal interests, but the latter is plausible, because deployment implied financial gain and credit for those involved (Barrington et al., 2010; Nyella, 2007).

These findings are consistent with a previous study by Asangansi (2016) whereby an mHealth solution for reporting routine HMIS data in Nigeria faced resistance by users because of the interruption it caused to the symbolic power structure existing within a highly bureaucratic and hierarchical organisational logic in the ministry of health. The open and non-hierarchical mode of communicating HMIS data introduced by an mHealth

solution posed a threat to conventional practices and the pre-existing role and power of officials in the MoH.

Secondly, despite geographically scaling up mHealth interventions being regarded as important, leading to or signifying effective implementation (Agarwal et al., 2016a; Labrique et al., 2018; Lemaire, 2013; Tomlinson, M et al., 2013), this can happen without evidence of improved outcomes. In Uganda for example, Nanyombi and Ejiri (2016) found that despite an mHealth based intervention being scaled out in all government HFs, health providers were not using it and the community was not aware that its existed. An evaluation study in Madagascar an eIDSR mHealth intervention which had been scaled up to two regions (Randriamiarana et al., 2018) found that there was no improvement in reporting surveillance data on time and the quality data was poor. Thus, when observed, scaling up effort should not be concluded as illustrating implementation effectiveness.

Thirdly, mHealth interventions should not be adopted without a clear implementation framework, which should provide, inter alia, clarification of all implementation aspects (Aamir et al., 2018). For example, the meaning ascribed to eIDSR implementers as to what effectiveness entails strongly influenced the implementation process. Adopting a digital solution was regarded as progress, irrespective of the results, and there was great excitement that eIDSR would immediately address all the information-related challenges established (Leon et al., 2012; Marshall, C. et al., 2013a) . Furthermore, this optimism shaped implementers' techno-centric view and so they overlooked the need to search for, replicate or sustain best practices or improve outcomes. Similarly, the integration anticipated through eIDSR was narrowly perceived as storing surveillance data in the DHIS2 database as a separate dataset from routine HMIS data without linking the two, while the latter duplicates the former.

Fourthly, while donor funding was needed to implement mHealth interventions, it might not necessarily ensure effectiveness. Ostensibly, donor support is provided for initiatives which demonstrate solid reasoning and implementation feasibility, and so evidence of improved outcomes is necessary for support to continue, because donors want to see a link between their money and results (Nyella and Mndeme, 2010). However, this thesis established that, despite knowing that eIDSR was being ineffectively implemented, donor support did not stop, which might not be distinct because a similar funding approach to health-related programmes in SSA is questioned in other studies (De Maeseneer et al., 2008; Martinez-Alvarez and Acharya, 2012; Nyella and Mndeme, 2010; Travis et al., 2004).

Fifthly, the low level of economic development and multiple priorities facing weak health systems in SSA inhibit investment in DHIs, thus dependence on donor funding strongly determined implementation effectiveness (Adeoye et al., 2017; Aranda-Jan et al., 2014; Labrique et al., 2018; Leon et al., 2012; Piette et al., 2012) because financial resources are key to a conducive implementation climate (Helfrich et al., 2007; Klein and Knight, 2005). However, since donor funding mechanism is likely to facilitate ineffective implementation when evidence of improved outcomes is not a precondition for funding continuation, more research is needed to gain an understanding into this questionable funding rationale. Likewise, contextual issues identified in this thesis should be further explored to enable health managers synergising and utilising donor funding opportunities to facilitate successful implementation, as suggested by Nyella and Mndeme (2010).

Sixthly, while mHealth interventions can potentially produce highly desired health outcomes, implementation decisions should not be rushed, and consideration should be given to ensuring that the implementation climate will enable interventions to be effective (Aamir et al., 2018; Aranda-Jan et al., 2014; Krah and de Kruijf, 2016; Marshall, C. et al., 2013a). As established in other related interventions (Mangam et al., 2016; Ngwa et al., 2016) the effectiveness of implementing eIDSR was undermined by complications that should have been addressed at the adoption stage. Technological or market pressure and donor funding should be carefully managed and related to health system needs and the implementation environment to ensure effectiveness (Aamir et al., 2018).

Seventhly, implementation of mHealth solutions such as eIDSR that have to be used routinely by healthcare workers should take risk factors and mitigation measures into consideration. For example, since HF users were obliged to submit weekly reports on time, those in rural areas had to walk a long distance from HFs or climb a tree in search of a network signal. Similarly, many had to wake up late at night to submit data as a solution to the heavy workload, system failure or network congestion experienced during the daytime. Data quality and handling protocols could not be ensured in such an environment and the privacy of patient records was potentially compromised. For some users, this was complicated and endangered their safety and health, which discouraged them or stopped them using eIDSR.

9.3. Recommendations for effective implementation of eIDSRs

This section responds to the fourth objective of this study which seeks to provide more specific recommendations for effective implementation eIDSR interventions in the context of SSA. The WHO/AFRO is encouraging all member states to implement and scale up eIDSRs to improve reporting quality and response to public health threats (WHO/AFRO, 2019b; Fall et al., 2018). If eIDSRs are to produce the anticipated results,

an implementation approach informed by practical experience in the context of SSA is necessary. The results presented in this thesis reveal several challenges affecting implementation of eIDSRs, which are hardly mentioned in related studies, (Adeoye et al., 2017; Kizito et al., 2013; Martin et al., 2020; MSH-Rwanda, 2018; Nanyombi and Ejiri, 2016; Randriamiarana et al., 2018; SORMAS, 2019; Thierry et al., 2014), hence add to the already established factors inhibit implementation effectiveness. Thus, to increase the rate of successful implementation of eIDSRs, this thesis recommends the following.

(1) Health system approach

The fact that eIDSRs do not operate in isolation but depend on the medical record system at HFs as the main source of data, they should be implemented as part of initiatives to strengthen the health system through improving the mainstream HIS (Aqil et al., 2009; Leon et al., 2012; van Dyk, 2014; Vasudevan et al., 2016) which will ensure that the organisational circumstances and complications identified in this thesis are considered in context. In particular, the poor culture of information use and malpractices in capturing, documenting and storing clinical records in HFs and poor data quality and analysis should be addressed when implementing eIDSRs. Recent studies on DH solutions used in HFs in Tanzania found similar data quality problems even in big hospitals using electronic medical records systems (Ayebazibwe et al., 2019; Kikoba, Bigten et al., 2019a; Kikoba, B. et al., 2019b). Thus, even if all diseases surveillance data captured in HFs were submitted through eIDSR as required, their established incorrectness and incompleteness would have misrepresented the actual disease situation in the community, thereby misinforming those responsible for preparing for outbreaks, and making plans for preventing, controlling and eradicating diseases.

This thesis strongly argues that the DSS, on its own, cannot introduce the necessary change needed to facilitate eIDSR effectiveness (Kaunda-Khangamwa et al., 2018; Lefevre et al., 2017; Mangam et al., 2016) because the production of good quality data requires greater organisational change efforts, such as improving the capturing and management of clinical data and building a culture of transparency and information use at all levels of the healthcare system (Aamir et al., 2018; Kikoba, Bigten et al., 2019a; Randriamiarana et al., 2018; van Dyk, 2014).

As presented in section 9.2.2 and recommended in previous studies (Aranda-Jan et al., 2014; Krah and de Kruijf, 2016; Marshall, C. et al., 2013a), pre-implementation evaluation is needed so that the implementation itself stands a better chance of being effective. When done, it should consider the participation of expected users in designing the technological solution, making implementation decisions, and defining the usage environment in line with their task and performance expectations (Mbelwa et al., 2019;

McCrorie et al., 2019). Also, implementation initiatives should be guided by informed change management strategies instead of focusing on technological functionalities and organisational forces internal and external to the DSS should be known and aligned to the technological change vision (Lefevre et al., 2017). To avoid unnecessary resistance by officials who might feel victimised by the change process, due to conflicts of interest or feelings of insecurity, organisational logics and identities should be identified and managed as suggested in previous studies (Asangansi, 2016; Nyella and Mndeme, 2010).

(2) Functional design

The DSS in SSA countries are guided by similar IDSR technical guidelines which provide a framework for producing, managing, using and disseminating data (WHO/AFRO, 2010b). So the guidelines are likely to strongly influence the design of eIDSRs (Fall et al., 2019) which may also be funded by the same or related donor organisations, thereby suggesting the replication of solutions across countries as illustrated by the eIDSRs in Tanzania (PMI, 2014) and Rwanda (Kizito et al., 2013; MSH-Rwanda, 2018; Thierry et al., 2014) which were implemented using similar technologies, have the same list of priority diseases, are integrated in the DHIS2, and the initial implementation activities were funded by the same donor. Nigeria (Adeoye et al., 2017; Shuaib et al., 2018; Tom-Aba et al., 2018b), Ghana (GHPC, 2020), Sierra Leone (Gleason et al., 2019; Martin et al., 2020; Sloan et al., 2020) and Madagascar (Randriamiarana et al., 2018), to name the few, are following suit.

This thesis has established that designing an eIDSR application by mimicking the IDSR paper-based DSIS can be unfriendly and unattractive to users. As found in a previous study (Aamir et al., 2018) deriving mHealth designs from existing healthcare information systems may not be effective. The design of eIDSR in Tanzania, which requires users to capture a long list of diseases, each with many data elements, does not give HF users access to data after submitting them, and does not produce short-term results. Thus, this thesis proposes a modular and flexible eIDSR design that will allow a few prioritised diseases to be captured, which can be gradually extended based on performance and a change in information needs.

(3) Technological flexibility

An eIDSR needs to be designed in such a way that information requirements or underlying technologies can be changed (Aamir et al., 2018; Peter et al., 2018). For example, USSD technology requires the real-time submission of data, and so if the network fails while users are submitting data, they have to restart the process (Perrier et al., 2015; Zhou et al., 2015). Therefore, instead of strictly using USSD technology, the

application should be designed to enable data to be submitted via a web interface, mobile apps, SMS text messages or offline entries, as recommended in a previous studies (Ayebazibwe et al., 2019; Marshall, C. et al., 2013a; Peter et al., 2018) and implemented in other eIDSR interventions (GHPC, 2020; Martin et al., 2020; MSH-Rwanda, 2018; Sloan et al., 2020; Tom-Aba et al., 2018b).

(4) Users' own mobile phones

The use of personal mobile phones minimises the implementation cost of mHealth interventions and can potentially motivate users and build a sense of system ownership (Aamir et al., 2018; Ngwa et al., 2016). In Kenya, distributed mobile phones to mSOS users was found unnecessary because users preferred using personal mobile phones to submit surveillance data and using them facilitated system usage (Toda et al., 2017). Nevertheless, such a model should not be generic for all mHealth interventions, but only used when proved relevant. For example, it can be relevant for interventions focusing on health promotion and mass communication (IBM, 2014), health education and reminders (Kaufman et al., 2017), or voluntary reporting of health conditions (Adeoye et al., 2017; Jamison et al., 2013), which do not need specific users to submit specific organisational data at a specific time, as required for surveillance data (WHO, 2019b). Dependence on personal mobile phones in the eIDSR intervention affected its use when owners were absent from work or unable to submit data. Therefore, HFs should own mobile phones to be used parallel with personal owned ones to facilitate the use of eIDSR for submitting data (Mbelwa et al., 2019).

(5) Leadership capabilities

The importance of relevant leadership capabilities for effective implementation of DHIs is stressed (Labrique et al., 2018; Leon et al., 2012). This thesis found that the use of the conventional leadership structure and roles within DSS is unlikely to lead to successful implementation. While government ownership and leadership are important for successful implementation, a sense of accountability is lacking when government officials simultaneously become owners, leaders, implementers and users of the adopted solutions. Checks and balances are needed to ensure that interventions add value and scaling up efforts are not rushed without evidence. As a solution, implementations could be outsourced to private companies under the close supervision of the MoH to allow the consultants to focus on ensuring eIDSRs' fidelity and health managers to focus on producing, analysing and using data. Once interventions are embedded in business processes and practices, and the necessary support and maintenance capacity is built, the responsibility can be gradually transferred to MoH officials. This approach may be useful for building a transparent information culture and validating the implementation process.

However, if donor funding provides those participating in the implementation process with an income, the suggested approach might face strong resistance from intervention owners and endanger it altogether. As established in other studies (Asangansi, 2016; Nyella and Mndeme, 2010), this approach might create a tension or be translated as loss of control by the owners. Therefore, careful consideration should be given to how to diplomatically communicate the idea without losing the support of the MoH that is greatly needed for effective implementation. To tackle these challenges, the implementation of DH solutions could be coordinated by a different government agency outside the MoH, such as e-Governance Agency in Tanzania (e-Government Agency, 2015) to avoid major implementation decisions being made unchecked.

(6) Resources mobilisation

While donor funding is available in SSA, it is unsustainable, and so internal arrangements are needed to mobilise resources to complement what donors provide and sustain the intervention when donor support ceases (Peter, 2018; Peter et al., 2018). For example, despite the national wide rolling out of eIDSR in Sierra Leone, there is uncertainty about its sustainability due to total dependency on donor funding (Martin et al., 2020; Sloan et al., 2020) and the intervention in Kenya was terminated after the cease of funding arrangement (Toda et al., 2017; Toda et al., 2016). Implementing eIDSRs as part of system-wide change initiatives or budgetary components could potentially minimise donor dependence and take advantage of economies-of-scale, because there are other DH solutions implemented under the MoH, such as the DHIS2 database (Ishijima et al., 2015; MoH-Tanzania, 2015c; MoH-Tanzania, 2018b; MoH-Tanzania, 2018c).

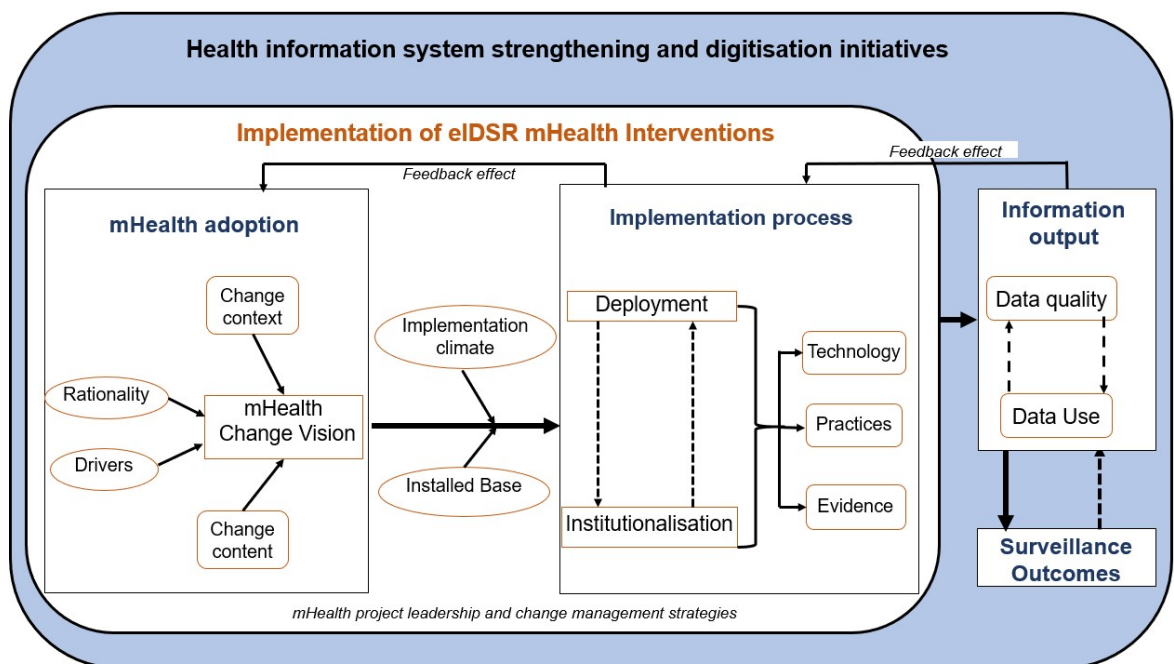
(7) Effectiveness of eIDSR interventions

Whereas most eIDSR-related studies use reporting or data quality to assess how DH solutions such as eIDSR are effectively used (Fall et al., 2018; Kizito et al., 2013; Thierry et al., 2014; Martin et al., 2020; MoH-Tanzania, 2011; Mwanyika et al., 2013; WHO/AFRO, 2019b), this thesis indicates the limitation and insufficiency of such metrics for not assessing the use of data for the intended purposes (Aqil et al., 2009; DeLone and MacClean, 2003). As argued in previous studies (Behumbiize et al., 2019; Fall et al., 2018; Kizito et al., 2013; Thierry et al., 2014; Martin et al., 2020), improvement in reporting and data quality may be exciting indicators of showing the effectiveness of eIDSRs, but it overlooks the role of culture of information use which is reported as being problematic even when data are collected (Kikoba, 2019; Kikoba et al., 2019; Ngwa et al., 2016; Randriamiarana et al., 2018). Therefore, the expand key performance indicators used to justify replication of eIDSR-related interventions in SSA (Fall et al., 2019; WHO/AFRO, 2019b) should include the value added to surveillance functions resulting from using the data captured through eIDSRs.

9.3.1. Proposed organisational change framework for effective implementation of eIDSR interventions in SSA countries

In order to realise the potential of mHealth and other digital health interventions in addressing diverse health care challenges, implementation frameworks are recommended (Agarwal et al., 2016a; Leon et al., 2012; Moshi et al., 2018; van Dyk, 2014). Thus, drawing on the empirical results and recommendations presented in this thesis, a technological organisational change framework is proposed to guide effective implementation of eIDSRs in SSA, hereby referred to as “MM framework for effective implementation of eIDSR in SSA countries” as presented in Figure 46.

Figure 46: A proposed framework to guide effective implementation of eIDSR mHealth interventions in SSA countries



In the proposed framework, eIDSR refers to mHealth-related interventions for national disease surveillance and response functions. The framework is built on the assertion that the implementation of eIDSRs requires an organisational change approach as an integral part of strengthening health system initiatives for improving health information, instead of being implemented as a standalone solution.

In addition, eIDSRs need to be built and implemented as modular extensions of existing health information infrastructure (HII) and digital technologies, hereby referred to as an install base (Hanseth and Lyytinen, 2010), because new DH solutions are likely to be acceptable, adaptable, user-friendly, maintainable, robust and sustainable when built on existing HII, instead of being developed from scratch (Nyala, 2009; Hanseth and Lyytinen, 2010). Install base are socially and technically open to new components and

facilitate and inhibit the design of new solutions (Lyytinen, 2010) as established in this thesis. In this way, existing components of HIS infrastructure, such as the DHIS2, conventional paper-based DSIS, HIS users, data formats, information management structure and technical capabilities, could be used as building blocks for effective implementation of eIDSRs.

Three major eIDSR implementation components or stages are proposed: the adoption stage when the decision to implement eIDSR is made; the implementation stage when the eIDSR application platform is developed, deployed for use (piloting and upscaling) and institutionalised into routine disease surveillance functions; and the information output stage, which is concerned with the value added to data quality by using eIDSR and to surveillance practices. The framework constructs are clarified in Table 1.

Table 1: A description of the framework constructs

| HIS strengthening and digitisation: <i>eIDSR initiatives implemented as part of ongoing organisational change process in strengthening health system focusing on improving and digitising routine HIS.</i> | | |
|--|--|---|
| Rationality | Specific issues to address | |
| System-wide complications | <ul style="list-style-type: none"> • Improve clinical practices, information culture, HIS infrastructure, health information policy, users' skills, information flow • Reduce workload of users who are frontline healthcare workers • Build leadership and technical capacity of DHIs • Integrate disease-specific surveillance functions in national disease surveillance systems. | |
| HIS digitisation | <ul style="list-style-type: none"> • Implement and evaluate national digital health policy or strategy • Build an evolving, flexible, integral, interoperable and locally supported digital health system infrastructure (eg. DHIS2). • Address information needs of all priority diseases under surveillance • Integrate eIDSR design in electronic medical records and laboratory information system | |
| Adoption stage – decision to implement eIDSR solution | | |
| Dimensions of change | Issues to focus on | |
| eIDSR change vision | Adoption rationale | Specifies organisational forces/circumstances rationalising and influencing the reason for implementing eIDSR |
| | Drivers of adoption | Identifies other organisational forces, explicitly or implicitly expressed by main decision makers with the potential to influence eIDSR adoption and implementation process. |
| | Change content | Specifies the adoption objectives, anticipated results, measurements and matrices, type of organisational change, health system levels affected or involved, targeted surveillance functions, and implementation plans, phases and milestones. |
| | Implementation context | Defines the organisational environment and how it limits or facilitates the change: eg. disease surveillance system setting, existing information system and source of data, disease-specific programmes, key users, implementation stakeholders, and information culture |
| Determinants of effectiveness | Implementation climate | These are circumstances needed to support eIDSR implementation: implementation policies and practices; information culture, national ICT ecosystem, government ownership/support, availability of financial resources, leadership capabilities, public-private partnership, and implementation champions. |

| | | |
|--|--|---|
| | Install base | Establishes the existing health information infrastructure (HII) and how it might facilitate or constrain mHealth design and its implementation approach, process, activities or anticipated results |
| Implementation stage – process and activities | | |
| Technology design | The eIDSR application | Specifies relevant mHealth technologies, application design and development, users' participation; the need for integration and/or interpretability of communication technologies (SMS, USSID, web, mobile apps, etc) |
| Deployment | eIDSR application | pilot deployment; establish results; scale up |
| | Practices | Establishes and replicates best implementation and information culture-related practices. |
| | Use of evidence | Use of positive results to inform scaling up decisions. |
| Institutionalisation | The eIDSR use | Embed eIDSR use in surveillance functions, sustain positive results and scaling up based on evidence |
| Feedback loop | <ul style="list-style-type: none"> • Institutionalise positive deployment outputs • replicate or revise deployment approach, process and activities. • Improve the implementation climate and the connection to the install base | |
| Immediate results (quick wins) – information outputs | | |
| Data quality and use | Establishes the value added to reporting and data quality (availability, accuracy, completeness, timeliness), and data analysis and use practices. | |
| Practices | Improved surveillance and response practices such as feedback mechanism, routine analysis and dissemination of data, preparing surveillance reports, research, and response activities. | |
| Feedback loop | Improved data quality motivates data analysis and use; data use influences attention to data quality | |
| Feedback effect | <ul style="list-style-type: none"> • Use implementation lessons to improve the eIDSR change vision, optimise facilitating factors, and minimise the effect of inhibiting factors. • Use information output to improve implementation approaches, processes and activities. | |
| Anticipated eIDSR results | | |
| Surveillance Outcomes | Establish, replicate and sustain anticipated surveillance-related outcomes. | |

The application of the proposed framework

The framework above can be applied in all SSA countries because firstly, as established in section 1.5.1, they face similar epidemiological situation characterised by weak health systems and heavy burden of communicable diseases, hence operationalising the WHO-initiated IDSR strategy as a framework for strengthening national disease surveillance and response functions (Fall et al., 2019; WHO/AFRO, 2010a). As an install base, the IDSR strategy influences the design and implementation process of eIDSR solutions. Secondly, as established in section 2.4.4 (pg 37 to 39), the eIDSR interventions in SSA countries are characteristically ineffectively attributed to uncondusive implementation climates and poor implementation approaches which are both considered in the proposed framework. Thirdly, majority of SSA countries are implementing DHIS2 as a mainstream HIS database which, as suggested in the framework, provides a digital health platform to support the integration of surveillance data with disease specific and routine health data.

The adoption element of the proposed framework is more relevant for countries that are yet to start implementing eIDSR initiatives as it focuses on addressing overreaching pre-implementation complications and create a supportive implementation climate.

9.4. Conclusion

This thesis investigated the implementation effectiveness of an eIDSR in Tanzania which reflect similar interventions implemented in other SSA countries. It provided a rich knowledge on the adoption and implementation approach, process and practices and how they influence and determine implementation effectiveness. It has employed a range of research methods and strategies to establish interrelated pieces of evidence for the results presented herein and recommended strategies that are likely to improve the success rate of implementing eIDSRs.

In the sub-sections that follow, an evaluation on whether and how the set research objectives were addressed is provided together with the thesis contribution, originality, limitations and future direction.

9.4.1. How research aim and objectives were achieved

This thesis succeeded to attend the overall aim and the four specific objectives it was set to address. The aim was to examine the implementation effectiveness of mHealth-related interventions for national diseases surveillance functions in the context of SSA countries, because implementation effectiveness of innovative solutions is a necessary precondition for achieving intended implementation outcomes (Klein and Knight, 2005; Weiner et al., 2011). The implementation of an eIDSR intervention in Tanzania was used as a case study and was retrospectively examined in its first 4 years as follows.

The first objective was set to provide an understanding of the adoption and implementation of eIDSR in order find out whether the approach, process and activities therein might have determined the results regarding implementation effectiveness. This objective was achieved largely through the analysis of data from observation, project documents, and interviewing of implementers and users at HF, district, regional and national level. The study involved a diverse large number of participants and study units, hence captured rich background information about the intervention and factors shaping its implementation. However, during the research it was revealed that donors played a big role from the inception stage of the project and throughout the implementation process, beyond providing financial support, but it was not possible to include them as that would require a prolonged process in seeking permission and possibly revising the study design. Had they been included they would provide important insights to enrich the findings.

The second objective sought to establish the clinical value and accuracy of source surveillance data at HF level before being submitted through eIDSR to ascertain their usefulness to inform surveillance and response functions. To address this objective, it was planned to study and analyse malaria and cholera clinical records captured for 12 months in all the 12 sampled HFs. However, this was not practical due to, inter alia, clinical records in HFs being inaccessible, unavailable, misallocated or hidden, hence requiring more resources to collect them than planned. Alternatively, cholera records captured from all HFs in two sampled districts and malaria records from one HF for 11 months were used for analysis. Despite the change of plan, the qualitative data collected indicated the situation of data quality and use across the study units to be similar to those of which data were analysed, thus the findings largely provide strong evidence of poor quality and culture of using clinical records to inform clinical decisions in HFs. The latter indicates eIDSR was being used to capture poor quality disease surveillance data.

The third objective was set to examine whether and how eIDSR use is adding value to quality, analysis and use of surveillance data, hence the measure of effectiveness implementation. This objective was met because it was possible to objectively measure eIDSR use for data submission and establish the pattern of use over time by using system logs and comparing data in eIDSR with source clinical data in HFs and HMIS data. Similarly, by using regression analysis modelling, the possible influence of implementation-related factors on eIDSR use was assessed. The quantitative findings were augmented with qualitative ones collected through observation, interviews and document analysis, indicating unsatisfactory use of eIDSR and data collected through it, together with attributed factors.

The last objective was set to provide recommendations on how to effectively implement mHealth-related interventions for diseases surveillance functions in the context of SSA countries. It was successfully addressed in this chapter. The findings of the first 3 objectives provide rich and new information which was used to provide recommendations and propose a framework that can be used to guide effective implementation of eIDSR interventions in the context of SSA.

9.4.2. Contribution of the thesis to policy and practices

This thesis investigated the implementation effectiveness of an integrated mSurveillance in Tanzania, named eIDSR, using an organisational change perspective. The organisational rationale and factors facilitated the adoption of the intervention were identified, drivers for the implementation approach, process and practices were discussed, and the nature of the value added to the disease surveillance and response functions was unveiled. The thesis revealed that beside technical challenges, the

ineffective implementation of eIDSR was attributed to organisational factors and the process through which the change was being implemented, and suggested an informed approach that could potentially lead to effective implementation of similar initiatives in SSA countries.

Moreover, this thesis offered a detailed discussion of the context-based complications requiring the consideration of health system stakeholders implementing strategic mHealth-related interventions at a national scale, and recommends how to circumvent them using a holistic health system-wide implementation approach that takes advantage of existing HII, as opposed to vertical initiatives. Moreover, it has shown how the greatly needed donor support may lead to negative implementation results, due to the conflicting interests and priorities of implementers and donors, and how to overcome this.

Recommendations presented in this thesis have the potential to inform the wider community of healthcare and digital health stakeholders on how to effectively implement eIDSRs by progressively and iteratively creating a positive implementation climate throughout the implementation continuum, and how to avoid unexpected results in the process of putting interventions to use. The proposed eIDSR implementation framework could be used to inform and develop technical guidelines for implementing eIDSRs and related interventions in the context of SSA countries and guide the development of evaluation protocols for ongoing implementation initiatives.

9.4.3. Theoretical contribution

This thesis contributes to the theoretical knowledge on the implementation effectiveness of mHealth-based interventions in view of OCT. It has advanced the understanding of OCT in the context of broader field of DHI implementation in resource-poor countries in SSA challenged by the burden of communicable diseases. The proposed framework in section 9.3.1 is arguably advancing theorisation of design and implementation of eIDSR-related interventions grounded in the literatures and empirical results presented in this thesis.

Moreover, the thesis provokes the need for further conceptualisation of factors determining implementation effectiveness of eIDSR interventions in the context of SSA.

First, it argues that even when factors regarded as necessary to successfully implement eIDSRs are considered, such as scaling up, public-private partnership, resource availability, supportive technological infrastructure, and integration in mainstream HIS, they cannot conclusively be used as indicators of implementation effectiveness. These factors were considered to a certain extent when implementing eIDSR, but this did not lead to effective implementation. Thus, the thesis emphasises the need for contextual

consideration and health system wide approach in implementing eIDSRs or studying implementation initiatives instead of the focus on technology and its context of use as reported in existing eIDSR-related studies.

Second, the thesis further illuminates the significance of context and process in studying mHealth-based interventions in SSA. The rationale for implementation initiatives and drivers for upscaling them up, need to be understood in evaluating or ensuring implementation effectiveness, because they might be justifiable but not important in determining implementation decisions, approach or process. The thesis has revealed the presence of implicit factors which did not contribute to effectiveness, but they were strong enough to dictate the implementation process, planned activities and users' commitment.

Third, the thesis questions the rushed deployment of eIDSR without evidence of an improvement in the availability, quality and use of data. It indicates that the change anticipated by implementing eIDSR was greater than the change of technological solution as perceived by implementers. Thus, suggests the need for specifying the type of organisational change required when implementing such interventions in order to improve effectiveness and avoid misleading conclusions about the usefulness of the technological solutions common in evaluation studies when the complexity of social, organisational, behavioural, technological and technical factors characterising the implementation context are not considered.

Fourth, the thesis expands the theoretical discussion on informed approach and indicators to assess the effectiveness of eIDSR-related interventions in SSA by revealing the role of the culture of information use as pivotal in justifying implementation efforts.

Fifth, this study has illustrated the plausibility of an integrated framework of OCT in studying the implementation of eIDSRs in SSA. Given the heterogeneity of factors triggering the inception of eIDSR in this context and factors influencing their implementation, the OCT has been shown to be relevant in exploring the implementation climate, approach, process, decisions, motivation and activities. It provides a relevant lens through which to assess the technological change process and outcomes and disclose the factors influencing them. For example, despite the USSD technology being effective and pervasive in money transactions and mobile banking in Tanzania, it did not show the same results when used for disease surveillance and response functions, and by examining the change process underlying explanations were observed.

9.4.4. Novelty of the study

This thesis presents original empirical research on the effectiveness of implementation effectiveness of mHealth interventions in the context of SSA countries, shown as follows.

- (1) It is the first study in SSA to investigate the implementation effectiveness of an mHealth-related intervention for national disease surveillance and response functions guided by the IDSR strategy.
- (2) It contributes to the existing discussion on the weak evidence base of mHealth interventions in SSA by indicating a gap in the implementation process and by providing rich insights into factors determining implementation effectiveness.
- (3) It establishes that mHealth implementation features, such as scaling up and integrating them in the mainstream HIS database, may not necessarily signify that the intervention has been effectively implemented, especially if it had not been informed by evidence of its usefulness, theoretically and practically.
- (4) Methodologically, it illustrates the relevance and importance of using a mixed-methods design for studies assessing mHealth implementations, which are often qualitative and descriptive. The qualitative component has the potential to provide a detailed description of the implementation approach, process and practices, and the quantitative component investigates the variability of independent factors with the potential to determine the relevance of the solution and its use to the context.
- (5) This is the first study to apply an OCT to study the effectiveness of implementing eIDSRs in SSA, thereby revealing implementation issues not discussed in previous studies.

9.4.5. Limitation and future direction.

This thesis presents several limitations. First, the study was somehow too ambitious as it included a wide range of topics that proved to be difficult to objectively and comprehensively study within the scope, resources and timeframe of the study. Also, the OCT was designed to serve other purposes, so it required adaptation to the context to this topic and while this study advanced the understanding of this theory in eIDSR, other adaptations may be appropriate for the context of other digital health initiatives..

Secondly, different donor organisations participated in the implementation of eIDSR in different capacities, by providing financial support, setting out implementation priorities and being involved in the implementation activities. However, since this was not foreseen during the study design, they were not included as participants in conducting this research. Therefore, important information about their part of story, especially on the rationale for funding arrangements, is missing in this thesis. Given the significant influence of donor funding for DHIs in SSA, future studies may consider consulting them, particularly to find out the funding rationale and how the scarce financial resources synergised and optimised to facilitate effective implementation initiatives.

Thirdly, the theoretical framework applied to conduct this research has not been validated. Therefore, the proposed framework for implementation effectiveness of eIDSR may be tested by being applied in ongoing eIDSR implementation initiatives in SSA.

9.4.6. Final remarks

This thesis revealed a gap in implementing mHealth-related interventions for diseases surveillance functions (eIDSRs) in the context of SSA. Despite the rationale to improve surveillance and response functions by adopting eIDSRs, implementation decisions are made without managers being well informed about the implementation climate and organisational change efforts required to successfully operationalise eIDSRs and ensure the quality and consistency of use for the intended purpose by relevant users in HFs and management level. Since implementers and donors supporting eIDSR initiatives focus on the technology only, implementations are under-resourced and rushed, and scaling up decisions are not supported by evidence of improved outcomes or practices.

The thesis has also revealed the existence of implicitly organisational forces such as the perception that using DH solutions means modernity and progress, scaling up means effectiveness, and implementation initiatives being opportunities for tapping donors' funds and getting extra income; which do not add value in improving organisational performance, but strongly influence implementation decisions. Unless identified and contextually addressed, these forces inhibit the attainment of implementation outcomes. Likewise, the thesis has questioned the rationality and the intention of financial support provided by donors to scale up unevidenced eIDSR interventions.

Moreover, the thesis has indicated the need for changing organisational culture of using and managing information and improving clinical practices as preconditions for producing good quality data to be captured through eIDSRs. Implementing DHIs should not be regarded as a panacea of information system challenges but as tools to support health systems strengthening initiatives.

Lastly, the thesis has shown the need for DHIs implementers and researcher to pay attention to implementation effectiveness as a necessary precondition for the highly sought evidence of the value added by eIDSR and other related interventions to anticipated health outcomes. It asserts that searching for evidence of DHIs independent of examining their implementation effectiveness, is likely to produce wrong conclusion or misrepresentation of the facts.

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Appendices

Appendix A: Transfer report – approval of the PhD research proposal

Postgraduate Research and Operations
Student Education Service
University of Leeds
Leeds LS2 9JT

T +44 (0) 113 343



UNIVERSITY OF LEEDS

Mathew Mndeme
c/o Medicine

CM/student records/trans2
(Direct Line 0113 343 5571)

03/12/2015

Dear Mr Mndeme

I am writing to inform you that following recommendations from your School the Programmes of Study and Audit Group has approved changes in the arrangements for your research degree studies. The revised arrangements are as follows:

Serial/Registration No: 200849052

Department/School: Medicine

Registration Category: PhD

Standard Period of Study: 36 months

Method of study: FULLTIME

Starting date: 01/09/2014

Maximum time limit for submission of your thesis: 31/08/2018


Title of Thesis: The effectiveness of mHealth interventions for strengthening surveillance of priority communicable diseases in low- income setting: the case of Tanzania

Supervisor(s): Dr H Fraser (main supervisor), Dr S Clamp, Dr T Mirzoev

The Transfer Assessment Panel identified that ethical review of your research is required but approval has not yet been granted. Please see section 5 of the joint report of the transfer assessment panel. Completion of these actions is the responsibility of the student. Further information about the ethical review process is available at: <http://ris.leeds.ac.uk/goodpractice>

All students are reminded that the thesis submitted for examination should represent research that may reasonably be expected of a capable and diligent student during the standard period of study and that, in normal circumstances, the writing up of the thesis should be completed within that period.

A copy of the transfer assessment report (prepared by your transfer assessment panel after the viva) is available for view in the Postgraduate Development Record (PDR) system. You are reminded that use of the PDR is compulsory for all PGR students. If you have any queries with the contents of this letter please contact the progress section of PGRO (email progress.temp@adm.leeds.ac.uk)


Yours sincerely

Mrs C M Mills
Senior Administrative Officer
Postgraduate Research and Operations

cc : Postgraduate Research Tutor
Supervisor(s)
File BF

Appendix B: MoH permission to study the eIDSR intervention

THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF HEALTH AND SOCIAL WELFARE

Telegrams "AFYA"
Tel: 255-51-20261 General
(All letters should be addressed to
The Permanent Secretary)



3 Samora Machel Street
P.O. Box 9083,
11478 DAR ES SALAAM,
Tanzania

Ref. No.GC.92/2126/01/26 25th June 2015

Dr Hamish S F Fraser
Yorkshire Centre for Health informatics
University of Leeds
Charles Thackrah Building
101 Clarendon Road, Leeds, LS2 9LJ
United Kingdom

Ref: Mathew Mdeme, PhD Candidate, University of Leeds, UK


Reference is made to the above heading.

This is to acknowledge receipt of your letter dated 1st May, 2015 on the above subject matter. The Ministry is committed to support Mr. Mathew Mdeme – your PhD candidate on obtaining an ethical clearance and supporting him in his ehealth/eIDSR study.

The Ministry believes that his study will add more value on how best to utilize the collected eIDSR data in decision-making processes for prevention and control of disease outbreaks in our Country and will fully support and assist him to fulfill his objectives.

The Ministry is looking forward to hear more from you.

Thank you for your cooperation.


Dr. Neema Rusibamayila
For: PERMANENT SECRETARY

CC:
Mr. Mathew Mdeme
PhD Candidate – University of Leeds, United Kingdom

Appendix C: Ethical approval certificate, University of Leeds



UNIVERSITY OF LEEDS

Faculty of Medicine and Health Research Office
School of Medicine Research Ethics Committee (SoMREC)

Room 10.111b, level 10
Worsley Building
Clarendon Way
Leeds, LS2 9NL
United Kingdom

☎ +44 (0) 113 343 1642

16 February 2016

Mr Mathew Mndeme
PhD Student
School of Medicine
Faculty of Medicine & Health
Yorkshire Centre for Health Informatics
G2 Charles Thackrah Building
101 Clarendon Road
LEEDS LS2 9LJ

Dear Mathew

Ref no: **MREC15-037**

Title: **Effectiveness of Health interventions for communicable-diseases surveillance in low-income setting: the case of Tanzania**

Your research application has been reviewed by the School of Medicine Ethics Committee (SoMREC) and we can confirm that ethics approval is granted based on the following documentation received from you and subject to the following condition:

- **The final version of the fieldwork medium risk assessment signed by your supervisor must be submitted prior to the research commencing**

| Document | Version | Date Submitted |
|---|---------|----------------|
| Ethical Review Application Form-Mathew Mndeme | 1.0 | 08/12/2015 |
| MREC15_037 Interview Guide for Participants from Regional and District levels-reviewer response | 1.0 | 09/02/2016 |
| MREC15_037 Interview Guide for Participants from Health Facilities -reviewer response | 1.0 | 09/02/2016 |
| MREC15_037 Interview Guide for Participants from National Level-reviewer response | 1.0 | 09/02/2016 |
| MREC15_037 PIS-Participants from national-region-districts levels_Reviewer comments response | 1.0 | 09/02/2016 |
| MREC15_037 PIS-Participants from health facilities level_Reviewer Comments_Response | 1.0 | 09/02/2016 |
| MREC15_037-Consent Form_Reviewer-response | 2.0 | 10/02/2016 |

Please notify the committee if you intend to make any amendments to the original research ethics application or documentation. All changes must receive ethics approval prior to implementation. Please contact the Faculty Research Ethics Administrator for further information (fmhuniethics@leeds.ac.uk)

Ethics approval does not infer you have the right of access to any member of staff or student or documents and the premises of the University of Leeds. Nor does it imply any right of access to the premises of any other organisation, including clinical areas. The committee takes no responsibility for you gaining access to staff, students and/or premises prior to, during or following your research activities.

Please note: You are expected to keep a record of all your approved documentation, as well as documents such as sample consent forms, and other documents relating to the study. This should be kept in your study file, which should be readily available for audit purposes. You will be given a two week notice period if your project is to be audited.

It is our policy to remind everyone that it is your responsibility to comply with Health and Safety, Data Protection and any other legal and/or professional guidelines there may be.

We wish you every success with the project.

Yours sincerely

Dr Roger Parslow
Co-Chair, SoMREC, University of Leeds


Dr Ruth Brooke
Co-Chair, SoMREC, University of Leeds

(Approval granted by Co-Chair Dr Ruth Brooke on behalf of committee)

Appendix D: Ethical clearance support letter from the local institution

UNIVERSITY OF DAR ES SALAAM
OFFICE OF THE DEPUTY VICE CHANCELLOR - RESEARCH
P. O. Box 35091 ■ DAR ES SALAAM ■ TANZANIA

General Line: 2410500-8 Ext. 2087
Direct Line: 2410743
Website: www.udsm.ac.tz



Fax: 255 022 2410743
255 022 2410078
E-mail: dvc-rke@admin.udsm.ac.tz


Our Ref. AB3/41 29th February 2016

Director General
National Institute for Medical Research (NIMR)
3 Barack Obama Drive
P. O. Box 9653
Dar es Salaam

RE: INTRODUCTION OF MR. MATHEW MNDEME

This is to introduce **Mr. Mathew Mndeme** who is an Assistant Lecturer at the University of Dar es Salaam and a PhD students at the University of Leeds. Mr. Mndeme is planning to conduct data collection in Tanzania as part of his PhD studies from 5th March to July 2016. The title of his research is "**Effectiveness of Health Interventions for Communicable Diseases Surveillance in Low-income Settings: The Case of Tanzania**". He intends to conduct the study at the Ministry of Health and Social Welfare Headquarters and Regional Health Management Teams (RHMTs) in Dar es Salaam and Mwanza through which four (4) districts health management teams and twelve (12) health facilities will be involved.

This is therefore to request your good office to grant the above- mentioned UD SM staff member research ethical approval so that he can be able to conduct data collection.



DEPUTY VICE CHANCELLOR - RESEARCH
UNIVERSITY OF DAR-ES-SALAAM
P.O. Box 35091
DAR-ES-SALAAM

Prof. C. Z. M. Kimambo
Deputy Vice Chancellor - Research

cc: Vice Chancellor
cc: Deputy Vice Chancellor - Academic
cc: Deputy Vice Chancellor - Administration
cc: Director - Research

Appendix E: Research ethical clearance certificate, NIMR Tanzania



THE UNITED REPUBLIC OF TANZANIA



National Institute for Medical Research
3 Barack Obama Drive
P.O. Box 965
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Tel: 255 22 2121400
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NIMR/HQ/R.8a/Vol. IX/2182

Mathew Mndeme
Department of Computer Science and Engineering
University of Dar es Salaam
P O Box 35062, DAR ES SALAAM

Ministry of Health, Community
Development Gender, Elderly & Children
6 Samora Machel Avenue
P.O. Box 9083
11478 Dar es Salaam
Tel: 255 22 2120262-7
Fax: 255 22 2110986

27th April 2016

CLEARANCE CERTIFICATE FOR CONDUCTING MEDICAL RESEARCH IN TANZANIA

This is to certify that the research entitled: Effectiveness of Health Interventions for Communicable-Diseases Surveillance in Low-Income Settings: The Case for Tanzania, (Mndeme *et al*), has been granted ethical clearance to be conducted in Tanzania.

The Principal Investigator of the study must ensure that the following conditions are fulfilled:

1. Progress report is submitted to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research, Regional and District Medical Officers after every six months.
2. Permission to publish the results is obtained from National Institute for Medical Research.
3. Copies of final publications are made available to the Ministry of Health, Community Development, Gender, Elderly & Children and the National Institute for Medical Research.
4. Any researcher, who contravenes or fails to comply with these conditions, shall be guilty of an offence and shall be liable on conviction to a fine. NIMR Act No. 23 of 1979, PART III Section 10(2).
5. Site: Ministry of Health, Community Development, Gender, Elderly & Children, Dar es Salaam, Dar es Salaam RHMT, Kinondoni MHMT, Temeke MHMT, Mwanza RHMT, Kwimba, CHMT, Misungwi CHMT.

Approval is for one year: 27th April 2016 to 26th April 2017.

Name: Dr Mwelecele N Malecela

Signature
CHAIRPERSON
MEDICAL RESEARCH
COORDINATING COMMITTEE

Name: Prof. Muhammad Bakari Kambi

Signature
CHIEF MEDICAL OFFICER
MINISTRY OF HEALTH, COMMUNITY
DEVELOPMENT, GENDER, ELDERLY
& CHILDREN

CC: RMO
DED
DMO



Participant Information Sheet

(For participants at the health facilities)

Version: Version 2.0 - Date: 9th February 2016
Principal Investigator: Mathew Mndeme
Study Title: Effectiveness of mHealth interventions for communicable-diseases surveillance in low-income setting: the case of Tanzania

Introduction

You are invited to participate in this study about the use of mobile-phones in Tanzania for reporting cases of diseases under surveillance from health facilities to the district and national levels. The study is conducted by Mathew Mndeme, who is an Assistant Lecturer at the University of Dar es Salaam and a fulltime PhD student at the University of Leeds in the United Kingdom, under the support of the Commonwealth Scholarship Commission in the UK.

Prior to your decision to participate in this study, you are provided with necessary information to help you understand the purpose of this study and the request for your participation. You are free to ask any question in case you need more clarification. If you agree to participate, you will be asked to sign a consent form and a copy will be given to you for your reference.

Why have you been chosen to participate?

You are requested to participate because of your role at the health facility on data management and reporting of cases of patients with communicable-diseases using mobile phones to higher levels through the eIDSR system.

What is the purpose of the study?

Communicable-diseases present a serious public-health challenge in Tanzania. They are the main cause of illness and deaths. This study aims at evaluating the use of an mHealth solution for improving reporting and notification of priority communicable-diseases from health facilities and timely response to diseases-outbreaks. The Ministry of Health and Social Welfare (MoHSW) introduced this intervention in 2013 and it has already been deployed in more than 35 districts, with further rollout in progress. The eIDSR is used to collect data of more than 20 infectious diseases, this study focusses on malaria, cholera, and bloody-diarrheal as tracer-diseases.

Using of mobile-phone technology to address health challenges is a new idea in low-income countries like Tanzania. Despite the expectations that this kind of technology might help in improving healthcare, there is not enough evidence on its potential to improve healthcare in our country. Therefore, there is a need to conduct scientific studies to establish usefulness of such solutions in our context, and the benefits to patients and healthcare.

Where will the interview be conducted?

The interview will be conducted at your health facility in a room/place of your choice without disruptions.

Do you have to participate?

Your participation is completely voluntary, and you are free to withdraw at any time: before, during and after the interview, without giving reasons for your decision. Your decision to withdraw will not affect you in anyway. If you withdraw after the interview, the information you provide will be discarded. However, withdraw is not possible after the principal investigator has left the premises in which the interview will be held since the analysis of the information you will provided will start shortly thereafter. But if you have any questions or concerns you can contact me or the lead supervisor on the telephone or emails provided at the end of this sheet.

What will happen if you agree to participate?

You will be interviewed regarding your involvement and experience in the implementation and scaling of eIDSR intervention in Tanzania together and the use of collected information. The interview will take duration of 1 to 3 hours depending on your role. The interview will be recorded to make sure no information is forgotten and the duration is shortened. The recording will not be used for any other purpose apart from this study and will be destroyed at the end of the study. The information you give will be anonymous and your personal details will not be disclosed. Quoted information in the final report, will neither make reference to your name nor other identifiable information.

In addition to interviewing you, the researcher will make observation at your health facility on how you process and transfer disease surveillance data from the patients' register to the mobile phone, then submit to the eIDSR system. The observation is meant to understand the process of how data is collected through mobile phones and not to assess/judge you or how you do your work. The study will focus at understanding the process and not you, hence no identification is needed as you will be observed working on the data and the mobile system.

How will the research results be used?

Results from this study will help to establish better ways of using mobile-phones technologies in fighting communicable-diseases and in controlling outbreaks. Summary of the findings will be shared with the MoHSW and other healthcare stakeholders in Tanzania to inform implementation and scaling of mHealth interventions and to operationalise the newly introduced national eHealth strategy. Also, results will be used to develop a PhD thesis to be submitted to the University of Leeds, and for academic publications and conferences presentations.

Ethical Approval

Ethical approval for conducting this study have been sought from the Medicine Research Ethics Committee (SoMREC/SHREC) in the University of Leeds with project number MREC15_037. Likewise, it has been ethically reviewed and approved by the National Institute of Medical Research (NIMR) in Tanzania.

Thank you for taking time to read this information.

Further Information and Contact details:

UK Contacts: Leeds Institute of Health Sciences, 101 Clarendon Rd, University of Leeds, Leeds, LS2 9LJ, UK. Tel: +441133434961 Mobile: +44-7432-08853, E-mail: ummjm@leeds.ac.uk

TZ Contacts: Department of Computer Science, University of Dar es Salaam, P.O. Box 35062, Dar es Salaam. Mobile: +255-713-5819, E-mail: ummjm@leeds.ac.uk

Lead Supervisor: Prof. Hamish Fraser, Leeds Institute of Health Sciences, University of Leeds, Telephone +44 (0)113 343 6940, E-mail: H.Fraser@leeds.ac.uk

Sponsor: The Commonwealth Scholarship Commission, in the UK. Woburn House, 20-24 Tavistock Square, London, WC1H 9HF, United Kingdom, Telephone: +44 0207 380 67512, E-mail: Shaheda.Khatun@cscuk.org.uk OR csc.secretariat@cscuk.org.uk

National Ethical Review Secretariat

Secretariat, National Health Research Ethics Review Committee, National Institute for Medical Research, 2448 Ocean Road, P.O. Box 9653, Dar es Salaam, Tanzania, Tel: +255 22 2121400 Fax: 255 22 2121360



Maelezo ya ufafanuzi wa utafiti kwa wahojiwa

(Kwa watakaohojiwa katika vituo vya afya)

| | |
|--------------------------|---|
| Toleo namba: | 1.0 - Tarehe: 09/02/2016 |
| Mtafiti kiongozi: | Mathew Mndeme |
| Jina la Utafiti: | Ufanisi wa mifumo ya taarifa za afya kwa njia ya simu za mkononi katika ufuatiliaji wa magonjwa ya kuambukiza kwenye nchi za kipato cha chini: Somo kutoka Tanzania |

Utangulizi

Umealikwa kushiriki kwenye utafiti huu juu ya matumizi ya simu za mkononi kwa ajili ya ukusanyaji na uwasilishaji wa taarifa za ufuatiliaji wa magonjwa ya kuambukiza kutoka vituo vya afya kwenda wilayani, mkoani, na wizarani. Utafiti huu unafanywa na Mathew Mndeme, ambaye ni Mhadhiri Msaidizi katika Chuo Kikuu cha Dar es Salaam, na mwanafunzi wa shahada ya uzamivu katika Chuo Kikuu cha Leeds nchini Uingereza chini ya ufadhili wa Kamisheni ya Jumuiya ya Madola.

Kabla ya hujaamua kushiriki au kutoshiriki utafiti huu, umepewa taarifa za kutosha kukusaidia kuelewa madhumuni ya utafiti huu na kwanini umeombwa kushiriki. Uko huru kuuliza swali lolote iwapo utahitaji ufafanuzi zaidi. Iwapo utakubali kushiriki katika utafiti huu utaombwa kusaini fomu ya kukubali ushiriki wako na utapewa nakala ya fomu hiyo kwa ajili ya kumbukumbu zako.

Kwanini umependekezwa kushiriki katika utafiti huu?

Unaombwa kushiriki katika utafiti huu kwa kuwa umeonekana mtu mwenye taarifa muhimu zitakazosaidia utafiti huu. Kubwa zaidi ni kuhusika kwako katika ukusanyaji na utumaji wa taarifa za ufuatiliaji wa magonjwa ya kuambukiza yaliyopewa kipaumbele kwa kutumia simu za mkononi kutoka vituo vya afya kwenda ngazi za juu kupitia mfumo wa eIDSR.

Madhumuni ya utafiti huu

Magonjwa ya kuambukiza ni moja ya changamoto kubwa za kiafya na ni chanzo kikuu cha maradhi na vifo nchini Tanzania. Wizarata ya Afya na Ustawi wa Jamii ilianzisha mfumo wa matumizi ya simu za mkononi kutoa taarifa za magonjwa ya kuambukiza (eIDSR) mwaka 2011 na hadi sasa umeshawekwa na unatumika kwenye wilaya zaidi ya 35 na uwekaji wa mfumo huu unaendelea kwenye wilaya zingine. Mfumo huu umelenga kuboresha utoaji wa taarifa za magonjwa ya kuambukiza kwa wakati kutoka vituo vya afya ili kurahisisha uchukuaji wa hatua za haraka za kukabiliana na milipuko ya magonjwa hayo. Magonjwa zaidi ya 20 yanaripotiwa kupitia mfumo wa eIDSR. Hata hivyo, utafiti huu umejikita katika taarifa za magonjwa matatu tu, ambayo yanatumika kama sampuli. Magonjwa hayo ni malaria-kali, kipindupindu, na kuhara damu. Utafiti huu unalenga kutathmini jinsi mfumo wa eIDSR ulivyoleta matokeo tarajiwa katika ufuatiliaji na kukabiliana na magonjwa ya kuambukiza.

Matumizi ya teknolojia ya simu za mkononi kwa malengo ya kukabiliana na changamoto zinazohusiana na utoaji wa huduma za afya na kupambana na magonjwa ya kuambukiza ni dhana mpya katika nchi za kipato cha chini kama Tanzania. Pamoja na matarajio makubwa juu ya uwezo wa teknolojia ya habari na mawasiliano (TEHAMA), hususani simu za mkononi katika kusaidia uboreshaji wa huduma za afya, hakuna ushahidi wa kitafiti wa kutosha juu ya uhalisia wa mfumo hii katika kuboresha huduma za afya katika nchini Tanzania. Hivyo, kuna kila sababu ya kufanya tafiti za kisayansi katika eneo hili ili kuweza kuona jinsi mifumo hii ilivyo na manufaa kakika mazingira husika na faida zake katika kufanikisha utoaji wa huduma bora za afya.

Mahojiano yatafanyika wapi?

Mahojiano yatafanyika katika kituo chako cha afya kwa siku na muda utaokubaliwa na wewe pamoja na mtafiti kiongozi. Zoezi litafanyika kwenye chumba au sehemu nyingine yoyote katika kituo chako cha kazi palipo na utulivu na bila usumbufu.

Je, unaalazimika kushiriki katika utafiti huu?

Ushiriki wako katika utafiti huu ni wa hiyari na uko huru kujitua wakati wowote. Unaweza kujitua kabla ya kuanza mahojiano, wakati wa mahojiano, au baada ya mahojiano bila kutoa sababu ya uamuzi wako wa kujitua. Uamuzi wowote utakaochukua hautakuwa na madhara yoyote kwako. Iwapo utaridhia kushiriki lakini baadaye ukaamua kujiondoa kushiriki, taarifa utakazokuwa umeshazitua hazitatumika katika utafiti huu na zitafutwa. Hata hivyo, hutaweza kufuta au kuondoa taarifa utakazokuwa umetoa baada ya mahojiano kukamilika na mtafiti kiongozi kuondoka kwenye kituo cha afya ambako mahojiano

yamemefanyika. Hali hii inatokana na ukweli kuwa uchambuzi wa taarifa unatarajiwa kuanza mara tu baada ya mahojiano kukamilika. Hata hivyo, iwapo utakuwa na swali au jambo lolote ambalo ungependa kupata ufafanuzi kuhusiana na utafiti huu au taarifa utakazokua umezitoa katika mahojiano, unaweza kuwasiliana na mtafiti kiongozi au msimamizi wake kupitia namba za simu na/au anuani za barua pepe zilizoorodheshwa mwishoni mwa ufafanuzi huu.

Nini kitatokea kama utakubali kushiriki utafiti huu?

Iwapo utakubali kushiriki, utahojiwa kuhusu uhusika na uzoefu wako katika uwekaji wa mfumo wa eIDSR katika kituo chako cha afya pamoja na matumizi yake na uwasilishaji wa taarifa zinazokusanywa. Mahojiano yatafanyika kwa saa moja hadi tatu kulingana na majukumu yako katika matumizi ya mfumo wa eIDSR. Mahojiano yatarekodiwa ili kutopoteza maelezo utakayoyotoa kwani itakua vigumu kwa mtafiti kusikiliza na kuandika kila kitu kwa wakati mmoja. Taarifa zitakazorekodiwa hazitatumika kwa madhumuni mengine yoyote zaidi ya utafiti huu. Taarifa husika zitafutwa mara tu baada ya utafiti huu kukamilika. Taarifa utakazotoa hazitaunganishwa na utambulisho wako kwa namna yeyote ile na itakapolazimu kunukuu sehemu ya maelezo hayo, utambulisho wako utafichwa katika nukuu hiyo.

Pamoja na mahojiano, mtafiti kiongozi atashuhudia namna mnavyokusanya taariza za magonjwa kutoka kwenye vitabu vya rejista za wagonjwa na kuingiza kwenye simu za mkononi na hatimaye kuzituma kwenye mfumo wa eIDSR. Lengo la ushuhudiaji wa mfumo wa utumaji taarifa unalenga kumpa mtafiti uelewa mpana wa jinsi utaratibu wa kuhamisha taarifa toka kwenye rejista kwenda kwenye mfumo wa eIDSR unavyofanyika. Hatua hii hailengi kuchunguza kwa lengo lakukosoa namna mnavyotekeleza majukumu yenu. Utafiti utajikita katika kuelewa mchakato wa uhamishaji na utumaji wa taarifa pekee na hivyo hakuhitajiki utambulisho wowote wa kuhusianisha kitakachoonekana na jina au taarifa za anayetazamwa.

Matokeo ya Utafiti huu yatatumikaje?

Matokeo ya utafiti huu yatasaidia kuonesha njia bora zaidi za matumizi ya teknolojia ya simu za mkononi katika mapambano dhizi ya magonjwa ya kuambukiza na namna ya kukabiliana na milipuko ya magonjwa hayo. Wizara ya Afya na Ustawi wa Jamii na wadau wengine wa sekta ya afya Tanzania watashirikishwa matokeo ya utafiti huu kwa lengo la kusaidia namna bora zaidi za uwekaji wa mfumo ya teknolojia ya simu za mkononi hasa katika utekelezaji wa mkakati mpya wa matumizi TEHAMA katika uboreshaji wa huduma za afya (eHealth Strategy). Hali kadhalika, matokeo ya utafiti huu yatatumika kuandaa andiko la kitaaluma litakalowasilishwa katika Chuo Kikuu cha Leeds na mtafiti kiongozi kwa ajili ya kupata shahada ya uzamivu. Hali kadhalika, matokeo ya utafiti yatatumika kuandika machapisho ya kitaaluma kwenye majarida na kuwasilishwa kwenye makongamano ya kitaaluma.

Idhini ya kimaadili ya utafiti huu:

Utafiti huu umezingatia maadili ya kitafiti unaohusisha taarifa za binadamu. Kibali cha kufanya utafiti huu kimeombwa kutoka katika Kamati ya Maadili ya Kitafiti ya Chuo Kikuu cha Leeds nchini Uingereza na kupewa namba ya usajili MREC15_037. Pia kibali kimeombwa kutoka Taasisi ya Taifa ya Utafiti wa Afya (NIMR) baada ya Wizara ya Afya ya Jamhuri ya Muungano wa Tanzania kuridhia.

Asante sana kwa muda wako na kwa kusoma ufafanuzi na maudhui ya utafiti huu.

Kwa maelezo zaidi na mawasiliano tumia anuani zifuatazo:

Anuani ya Uingereza: Leeds Institute of Health Sciences, 101 Clarendon Rd, University of Leeds, Leeds, LS2 9LJ, UK. Tel: +441133434961 Mobile: +44-7432-08853, E-mail: ummjm@leeds.ac.uk
Anuani Tanzania: Department of Computer Science, University of Dar es Salaam, P.O. Box 33335, Dar es Salaam. Mobile: +255-713-5819, E-mail: ummjm@leeds.ac.uk

Anuani ya Msimamizi mkuu: Prof. Hamish Fraser, Yorkshire Centre for Health Informatics, Leeds Institute of Health Sciences, University of Leeds, and Telephone 44 (0)113 343 6940, E-mail: H.Fraser@leeds.ac.uk

Mfadhili: The Commonwealth Scholarship Commission, in the UK, Woburn House, 20-24 Tavistock Square, London, WC1H 9HF, United Kingdom, Telephone: +44 0207 380 67512, E-mail: Shaheda.Khatun@cscuk.org.uk OR csc.secretariat@cscuk.org.uk

Wasiliana na Kamati ya taifa ya maadili ya tafiti za afya kupitia:

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Participant Consent Form

UNIVERSITY OF LEEDS

Version: 2.0 - Date: 09th February, 2016

Consent to take part in Effectiveness of mHealth interventions for communicable-diseases surveillance in low-income setting: the case of Tanzania

| | Add your initials next to the statement if you agree |
|--|--|
| I confirm that I have read and understand the information sheet dated 09/02/2016 explaining the above research project | |
| I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. I can withdraw the information during the interview or after the interview but before the investigator leaves the premise in which the interview was held. If I decide to withdraw my participation, the information given so far will be discarded. I cannot withdraw from the study after the investigator has left the premise since the analysis is expected to start soon thereafter. | |
| I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research. If quotations will be used, anonymity will be preserved | |
| I agree for the data collected from me to be stored and used in relevant future research in an anonymised form | |
| I understand that other genuine researchers may use my words in publications, reports, web pages, and other research outputs, only if they agree to preserve the confidentiality of the information as requested in this form. | |
| I understand that relevant sections of the data collected during the study, may be looked at by the University of Leeds where the principal investigator comes from or from regulatory authorities where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records. | |
| I understand that the interview will be audio recorded for the purpose of this study and the record will be destroyed soon after transcription | |
| I agree to take part in the above research project and will inform the principal researcher should my contact details change. | |

| | |
|----------------------------------|--|
| Name of Participant | |
| Participant's signature | |
| Date | |
| Name of a principal investigator | |
| Signature | |
| Date* | |

Contacts for Principal Invigilator

UK Contacts: Leeds Institute of Health Sciences, 101 Clarendon Rd, University of Leeds, Leeds, LS2 9LJ, UK. Tel: +441133434961 Mobile: +44-7432-08853, E-mail: ummjm@leeds.ac.uk

TZ Contacts: Department of Computer Science, University of Dar es Salaam, P.O. Box 35062, Dar es Salaam. Mobile: +255-713-581941, E-mail: ummjm@leeds.ac.uk

National Ethical Review Secretariat

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A Swahili translation of the participant consent form

Fomu ya kuridhia kushiriki katika utafiti

Namba ya toleo: 2.0
Tarehe: 09/02/2016



UNIVERSITY OF LEEDS

Ridhaa ya kushiriki katika utafiti kuhusu ufanisi wa mifumo ya taarifa za afya kwa njia ya simu za mkononi katika ufuatiliaji wa magonjwa ya kuambukiza kwenye nchi za kipato cha chini: Somo kutoka Tanzania

| | | Andika herufi za kwanza za majina yako kuonesha unakubaliana |
|--|--|--|
| Ninathibitisha kwamba nimesoma na nimeelewa taarifa zilizomo kwenye ufafanuzi wa tarehe 09/02/2016 kuhusu utafiti uliotajwa hapo juu | | |
| Ninaelewa kuwa kushiriki kwangu katika utafiti huu ni hiari na niko huru kujitoa muda wowote bila kutoa sababu za kujitoa kwangu. Ninatambua pia kuwa kujitoa huko hakutanisababishia matatizo yoyote. Ninaweza kufuta au kuondoa taarifa zangu wakati mahojiano yanaendelea au mara tu baada ya mahojiano kumalizika na kabla mtafiti hajaondoka eneo la mahojiano. Iwapo nitaamua kujiondoa kwenye ushiriki, taarifa nitakazokuwa nimetoea hazitatumika na zitafutwa. Hata hivyo sitaweza kuondoa ushiriki wangu baada ya mtafiti kuondoka eneo ambalo mahojiano yamefanyika kwani uchambuzi wa taarifa nitakazokuwa nimetoea utanza mara tu baada mtafiti kumaliza mahojiano na kuondoka eneo husika. | | |
| Hali kadhalika, kama sitapenda kujibu swali lolote au baadhi ya maswali nitakayoulizwa wakati wa mahojiano, nitakua na uhuru wa kufanya hivyo bila kutoa sababu. | | |
| Ninatoa ruhusa kwa timu ya utafiti huu kutumia taarifa nitakazotoa kwenye mahojiano ya utafiti huu pasipo kutaja jina langu au kuweka utambulisho wangu wowote. Ninaelewa kwamba jina langu halitahusishwa kwenye machapisho yoyote yatakayohusiana na matokeo ya utafiti huu. Nukuu yoyote ya maelezo nitakayotoa itafanyika bila utambulisho wangu. | | |
| Ninakubali kwamba taarifa nitakazotoa zinaweza kuhifadhiwa na kutumika kwa malengo ya kitafiti ya baadaye ila kwa namna ambayo haitakuwa na utambulisho wangu. | | |
| Ninaelewa kwamba watafiti wengine halisi wanaweza kutumia maneno yangu katika kuandika machapisho ya kitaaluma, ripoti, kurasa za tovuti, na maandishi mengine ya kitafiti iwapo tu wataridhia kuhifadhi usiri wa taarifa kama ilivyoainishwa katika fomu hii. | | |
| Ninaelewa kwamba vipengele stahiki vya data zinazokusanywa katika utafiti huu, vinaweza kuhakikiwa katika Chuo Kikuu cha Leeds anapotoka mtafiti kiongozi, au mamlaka zingine za udhibiti kadri itakavyoonekana inafaa kulingana na ushiriki wangu katika utafiti huu. Ninatoa idhini kwa wahusika hawa kuzitumia taarifa zangu. | | |
| Ninaelewa kwamba mahojiano ya sauti nitakayofanyiwa yatarekodiwa kwa madhumuni ya utafiti huu na sauti iliyorekodiwa itafutwa mara tu baada ya kunakiliwa kwenye maandishi. | | |
| Ninakubali kushiriki utafiti uliotajwa hapo juu na iwapo anuani yangu itabadilika nitamtaarifu mtafiti kiongozi. | | |
| Jina la Mshiriki | | |
| Sahihi ya Mshiriki | | |
| Tarehe | | |
| Jina la Mtafiti Kiongozi | | |
| Sahihi ya Mtafiti Kiongozi | | |
| Tarehe | | |

Wasiliana na Mtafiti Kiongozi kupitia:

Anuani ya nchini Uingereza: Mathew Mndeme, Leeds Institute of Health Sciences, 101 Clarendon Rd, University of Leeds, Leeds, LS2 9LJ, UK. Tel: +441133434961 Mobile: +44-7432-08853, E-mail: ummim@leeds.ac.uk

Anuani ya nchini Tanzania: Mathew Mndeme, Department of Computer Science, University of Dar es Salaam, P.O. Box 35062, Dar es Salaam. Mobile: +255-713-581941, E-mail: ummim@leeds.ac.uk

Wasiliana na Kamati ya taifa ya maadili ya tafiti za afya kupitia:

Secretariat, National Health Research Ethics Review Committee, National Institute for Medical Research, 2448 Ocean Road, P.O. Box 9653, Dar es Salaam, Tanzania, Tel: +255 22 2121400
Fax: 255 22 2121360



Interview Guide 1 - (participants at the Ministry of Health)

Version: Version 2.0

Date: 9th February 2016

Principal Investigator: Mathew Mndeme

Study Title: Effectiveness of mHealth interventions for communicable diseases surveillance in low-income setting: the case of Tanzania

Topic 1: Interview Introduction

- a) Introducing myself
- b) Introducing interview objectives
- c) Reminding the participant about confidentiality of the study
- d) Explaining the interview procedures and the use of tape recorder
- e) Signing of the participants' consent form

Topic 2: Understanding the implementation design and scaling approach of eIDSR intervention in connection to envisioned outcomes

1. Asking the participant to introduce him/herself and explain his/her knowledge about eIDSR (*to understand how much the participant understands the intervention and the roles he/she has played*)

Follow-up questions

- a) What does eIDSR intervention intends to achieve?
- b) What is/has been your role in the implementation process and use of eIDSR system?
- c) How many people at the national level have been involved in eIDSR implementation?
- d) What is the eIDSR implementation coverage (number of facilities/districts/regions)?

2. Asking the participant about their understanding of the design of eIDSR (*to understand how eIDSR design is linked to the attainment of the interventions objectives*)

Follow-up questions

- a) What were proposed plans and approach for implementation of eIDSR?
- e) Who were/are key stakeholders involved in designing the implementation process of eIDSR and what roles did they play?
- f) What guided the piloting and scaling of eIDSR?
- g) What were the process and activities involved in the scaling of eIDSR?
- h) Has there been any change of original plans on piloting and scaling of eIDSR?
- i) What were anticipated changes/outcomes from the intervention
- j) How were the implementation processes and scaling approach meant to achieve the envisioned changes/outcomes?

Topic 3: The effect of eIDSR intervention to reporting process of surveillance information (*to understand what has changed in reporting process of diseases surveillance information*)

1. To what extent is eIDSR used for the intended purposes?
2. How much has been achieved through the use of eIDSR system?
 - a) Do you have an evidence to support your position/view?
3. How does the reporting process of surveillance information differ after introducing eIDSR?
 - a) Do you have an evidence to support your position/view?
4. How can you describe the availability of surveillance information before and after the introducing of eIDSR?
5. How can you describe the quality of surveillance information reported through eIDSR?

Topic 4: Ways that the eIDSR intervention has influenced response to diseases outbreaks

1. What are your views regarding the use of information collected through eIDSR (*reference to severe malaria, cholera, and bloody diarrhoea*)

- a) Is there a change on information use to inform response activities during outbreaks?
 - b) Do you have examples of diseases surveillance reports with data generated from eIDSR?
2. Can you explain how disease outbreak notifications are triggered and made available to members of response team?
- a) Who gets the information first?
 - b) How is this information communicated?
 - c) What are processes/steps taken to get prepared to respond to outbreak?
 - d) In what ways do information from eIDSR used to assist response activities?
 - e) How do you compare outbreaks notification and response actions for districts with and those without eIDSR interventions?

Topic 5: Strategies for effective design, implementation and scale-up of the intervention

1. In what ways do you think eIDSR would have been better introduced? (adopted and upscaled)
2. What are challenges faced in introducing/implementing eIDSR?
3. What are challenges faced in using eIDSR system?
4. How can you explain users' participation in the process of adopting eIDSR?
5. How has eIDSR affected the interaction between source of surveillance information and management levels?
6. What are your general remarks about the use of eIDSR?
7. What improvement would you propose in the way eIDSR was introduced and used at all levels.

Topic 6: Conclusion

1. Ask whether the participant has any other relevant information would like to share
2. Ask for documents detailing eIDSR intervention and reports such as original proposals, implementation plan, scaling approach, progress reports, trainings reports, diseases surveillance reports, outbreaks response reports, etc. that they are permitted to share/show the researcher.
3. Thank the participant for the time spent and information provided.
4. Terminate the recording.



Interview Guide 2 - (participants at district and regional level)

Version: Version 2.0 - Date: 9th February 2016

Principal Investigator: Mathew Mndeme

Study Title: Effectiveness of mHealth interventions for communicable diseases surveillance in low-income setting: the case of Tanzania

Topic 1: Interview introduction

- a) Introducing myself
- b) Introducing interview objectives
- c) Reminding the participant about confidentiality of the study
- d) Explaining the interview procedures and the use of tape recorder
- e) Signing of the participants' consent form

Topic 2: Understanding the implementation design and scaling approach of eIDSR intervention in connection to envisioned outcomes

1. Asking the participant to introduce him/herself and explain his/her knowledge about eIDSR *(to understand how much the participant understands the intervention and the roles he/she played)*

Follow-up questions

- a) What does eIDSR intervention intends to achieve?
- b) What is/has been your role in the implementation process and use of eIDSR system
- c) How many people from your regional/district health management team were/are involved in eIDSR implementation?
- d) What is the eIDSR implementation coverage (number of facilities deployed with eIDSR) in your region/district?

2. Asking the participant about their understanding of eIDSR implementation design *(to understand how eIDSR design is linked to the attainment of the interventions objectives)*

Follow-up questions

- a) How was eIDSR introduced in your district?
- b) How was your district/region involved in deciding the eIDSR implementation approach?
- c) Who were/are key stakeholders involved in the eIDSR implementation process in your district/ region?
- d) What were the processes and activities involved in rolling out eIDSR in your district/region?
- e) What were anticipated changes/outcomes from the intervention?
- f) How were the implementation processes and scaling approach meant to achieve the envisioned changes/outcomes?

Topic 3: The effect of eIDSR intervention in reporting process of surveillance-information *(to understand what has changed in reporting process of diseases surveillance information)*

1. To what extent is eIDSR used for the intended purposes in your district/region?
2. How much has been achieved through the use of eIDSR system in your district/region?
3. How do you compare reporting process of surveillance information before and after the introduction of eIDSR?
4. How do you engage health facility workers in reporting surveillance information through the use of eIDSR system differently from the situation before/without eIDSR?
5. How can you describe the availability of surveillance information before and after the introducing of eIDSR in your district/ region?
6. How can you describe the quality of surveillance information reported through eIDSR?

Topic 4: Ways that eIDSR intervention has influenced response to diseases outbreaks

1. What are your views regarding the use of information collected through eIDSR system? (*reference to severe malaria, cholera and bloody diarrhoea*).
 - a) Is there a change on information use to inform response activities during diseases outbreaks in your district/region?
 - b) Do you have examples of diseases surveillance reports with data generated from eIDSR?
2. Can you explain how disease outbreak notifications are triggered and made available to members of response team?
 - a) Who receives information from health facilities first in the event of disease outbreak reports from health facilities? (*Like bloody diarrheal and cholera*)?
 - b) How is this information communicated and by what method?
 - c) How is this information used in responding to reported outbreaks?
 - d) How different are the response actions for weekly reported diseases (severe malaria) as compared to immediate notifiable diseases (cholera and bloody diarrheal)?
 - e) How do you compare the process of reporting diseases outbreaks before and after the adoption of eIDSR in your district/region?

Topic 5: Strategies for effective design, implementation and scale-up of mHealth interventions

1. In what ways do you think eIDSR would have been better introduced (designed and implemented) in your district/region? What improvement would you propose?
2. What were the challenges faced in introducing/implementing eIDSR in your district/region?
3. What are challenges faced in using eIDSR system?
4. How has eIDSR affected the interaction between health facilities and health management team in your district/region?

Topic 6: Conclusion

1. Ask whether the participant he/she any other information has they would like to share relating to the interview
2. Ask for documents about eIDSR intervention like implementation plan, scaling approach, trainings, progress reports, surveillance reports, outbreaks response reports, etc. that they are permitted to share/show interviewer.
3. Thank the participant for the time spent and information provided
4. Terminate the recording



Mwongozo wa mahojiano 2- (Kwa washiriki wa ngazi za wilaya na mkoa)

Namba ya toleo: 2.0 – Tarehe: 09/02/2016

Mtafiti kiongozi: Mathew Mndeme

Mada ya Utafiti: Ufanisi wa mifumo ya taarifa za afya kwa njia ya simu za mkononi katika ufuatiliaji wa magonjwa ya kuambukiza kwenye nchi za kipato cha chini: Somo kutoka Tanzania

Mada 1: Utanguzi wa mahojiano (mtafiti kujitambulisha, na kutambulisha mada na utaratibu wa mahojiano)

- a) Kujitambulisha
- b) Kutambulisha malengo ya mahojiano
- c) Kumkumbusha mhojiwa kuhusu umuhimu wa usiri wa utafiti
- d) Kuelezea utaratibu wa mahojiano na matumizi ya kifaa cha kurekodia sauti
- e) Kusaini fomu ya kuridhia ushiriki kwenye utafiti

Mada 2: Kuelewa muundo wa utekelezaji na upimaji wa mkakati wa mfumo wa eIDSR kuhusiana na matokeo tarajiwa

1. Kuwomba mshiriki ajitambulishe na kuelezea uelewa wake kuhusu mfumo wa eIDSR (lengo ni kuelewa jinsi mshiriki anavyoelewa mfumo wa eIDSR na nafasi yake katika utekelezaji wa mfumo)

1) **Maswali ya nyongeza**

- a) Mfumo wa eIDSR unalenga kufanikisha nini?
 - a) Ipi ni nafasi yako katika mchakato mzima wa uwekaji wa mfumo wa eIDSR?
 - b) Kwa ujumla ni watu wangapi katika ngazi wilaya/mkoa wako wamehusika katika mchakato wa uwekaji wa mfumo wa eIDSR?
 - c) Hadi sasa, mfumo wa eIDSR umesambazwa kwa kiasi gani? (idadi ya vituo vya afya katika wilaya/mkoa wako)
2. Kumuuliza mshiriki kuhusu uelewa wake juu ya mtindo uliotumika kuweka mfumo wa eIDSR (*kuelewa ni kwa kiasi gani mtindo wa uwekaji wa mfumo wa eIDSR uliendamba sambamba na ufanikishaji wa malengo tarajiwa ya mfumo*)

Maswali ya nyongeza

- a) Ni mipango na taratibu gani zilitumika kama mwongozo wa uwekaji mfumo wa eIDSR kwenye eneo lako?
- b) Watumishi wangapi wa wilaya/mkoa wako walihusika katika maamuzi ya muundo wa uwekaji wa eIDSR?
- c) Ni wadau gani nje ya wilaya/mkoa wako walihusika kubuni mchakato wa utekelezaji wa mfumo wa eIDSR? Nini yalikuwa majukumu ya wadau wengine waliohusika?
- d) Ni mchakato na shughuli gani zilizohusika katika zoezi la upanuzi wa mfumo wa eIDSR?
- e) Je, kulikuwa na mabadiliko/matarajio gani yatokanayo na makakati wa mfumo wa eIDSR?
- f) Ni kwa jinsi gani uwekaji na usambazaji wa mfumo wa eIDSR ulianishwa na ufanikishaji wa malengo yaliyotarajiwa?

Mada 3: Mchango wa mkakati wa mfumo wa eIDSR kwenye mchakato wa utoaji taarifa za ufuatiliaji wa magonjwa ya kuambukiza (*kuelewa nini kimebadilika au kufanikiwa kutokana na mchakato wa ukusanyaji na uwasilishaji wa taarifa za magonjwa ya kuambukiza*)

Maswali ya nyongeza

1. Ni kwa kiwango gani mfumo wa eIDSR unatumika kama ilivyokusudiwa katika mkoa/wilaya yako?
2. Kwa uelewa wako, nini kimebadilika au kufanikiwa katika mkoa/wilaya yako kutokana na mfumo wa eIDSR?
3. Unalinganishaje mchakato wa uwasilishaji wa taarifa za ufuatiliaji wa magonjwa kabla na baada ya uwekaji wa mfumo wa eIDSR?
4. Je kuna utofauti wowote wa jinsi unavyowashirikisha watumishi wa vituo vya afya katika ukusanyaji wa taarifa za ufuatiliaji wa magonjwa kwa kutumia mfumo wa eIDSR tofauti na ilivyokua kabla ya mfumo?
5. Unaelezeaje upatikanaji wa taarifa za ufuatiliaji wa magonjwa katika mkoa/wilaya yako ikilinganishwa na hali ilivyokuwa kabla ya kuanza kutumia mfumo wa eIDSR?

6. Unaelezeaje ubora wa taarifa za ufuatiliaji wa magonjwa zinazopatika kupitia mfumo wa eIDSR?

Mada 4: Jinsi ambavyo mfumo wa eIDSR umeathiri mwikio wa milipuko ya magonjwa ya kuambukiza

1. Una mtazamo gani kuhusu utumiaji wa taarifa zinazokusanywa kupitia mfumo wa eIDSR? (*kwa magonjwa ya malaria kali, kuhara damu na kipindupindu*)
 - a) Je, kuna mabadiliko ya matumizi ya taarifa za ufuatiliaji wa magonjwa wakati wa kukabiliana na milipuko?
 - b) Je, una mfano wa taarifa zilizoandaliwa zikijumuisha data zitokanazo na mfumo wa eIDSR?
2. Unaweza kuelezea jinsi taarifa za awali za milipuko ya magonjwa ya kuambukiza zinavyowafikia wanakikosi wanaohusika na uchukuaji wa hatua baada ya kugundulika milipuko katika vituo vya afya?
 - c) Kunapotokea mlipuko wa magonjwa yanahohitaji mwikio wa haraka kutoka ngazi za juu, ni nani anakuwa wa kwanza kuarifiwa (kama kipindupindu na kuhara damu)
 - d) Taarifa ya milipuko zinapatikanaje au zinawasilishwa kwa njia gani?
 - e) Taarifa zipatikanazo kupitia mfumo wa eIDSR zinatumikaje kusaidia majukumu ya kukabiliana na milipuko
 - f) Kuna tofauti gani ya hatua zinazochukuliwa kwa magonjwa ya mlipuko yanayotolewa taarifa kwa wiki (kama malaria) ukilinganisha na magonjwa yanayohitaji mwikio na hatua za haraka (kama kipindupindu na kuhara damu)
 - g) Unalinganishaje upatikanaji wa taarifa za uwepo wa milipuko kwa wilaya/vituo vya afya vinavyotumia mfumo wa eIDSR tofauti na vile zisizotumia?

Mada5: Mikakati ya njia bora zaidi za uundaji, uwekaji, na usambazaji wa matumizi ya mfumo wa mHealth

1. Unadhani ni njia gani bora zaidi zingeweza kutumika wakati wa kuweka mfumo wa eIDSR (uwekaji na usambazaji) katika mkoa/wilaya yako?
2. Je, kulikuwa na changamoto gani zilijitokeza wakati wa uwekaji wa mfumo wa eIDSR mkoa/wilaya yako?
3. Ni changamoto gani mumeabiliana nazo katika utumiaji wa mfumo wa eIDSR mkoa/wilaya yako?
4. Mfumo wa eIDSR umeathiri kwa kiasi gani namna kamati ya wilaya/mkoa inavyoshirikiana na vituo vya afya katika utoaji wa taarifa za magonjwa?

Hitimisho

1. Muulize mhojiwa iwapo ana taarifa nyingine inayohusiana na mahojiano haya ambayo angependa kueleza
2. Muulize mshiriki iwapo ana nyaraka (taarifa iliyoandaliwa) kuhusu mfumo wa eIDSR kama vile andiko la mradi, mpango wa uwekaji mfumo, utaratibu wa usambazaji mfumo, taarifa za maendeleo ya uwekaji, taarifa za mafunzo ya mfumo, mrejesho wa taarifa za ufuatiliaji kwenda ngazi za chini, taarifa za tathmini ya mfumo, taarifa za kukabiliana na milipuko ya magonjwa, taarifa za milipuko, nk,
3. Mshukuru mshiriki kwa muda wake aliotumia kushiriki mahojiano na kwa taarifa alizotoa.
4. Zima kifaa cha kurekodia mahojiano.



Version: Version 2.0 - Date: 9th February 2016

Principal Investigator: Mathew Mndeme

Study Title: Effectiveness of mHealth interventions for communicable diseases surveillance in low-income setting: the case of Tanzania

Introduction

Topic 1: Introduction (*introducing the interviewer, the topic and the approach*):

- a) Introducing myself
- b) Introducing the objective of the interview
- c) Reminding the interviewee about confidentiality of the study
- d) Explaining the interview procedures and the use of tape recorder
- e) Signing the consent form

Topic 2: Understanding the implementation design and scaling approach of eIDSR intervention in connection to envisioned intervention's outcomes

1. Asking a participant to introduce his/herself and explain his/her knowledge about eIDSR (*to understand how much the interviewee understands the intervention and the roles he/she has played*)

Follow-up questions

- a) What does eIDSR intervention intends to achieve?
- b) How is eIDSR system used in your health facility?
- c) What is/ has been your role in using eIDSR system at your facility?

2. Asking the participant about their understanding of eIDSR design (*to understand how eIDSR design is linked to the attainment of the intervention's objectives*)

Follow-up questions

- a) How was eIDSR introduced in your health facility?
- b) How were you involved in designing and implementing eIDSR?
- c) Apart from you, who else uses eIDSR to report diseases surveillance data from your facility?
- d) What processes are involved in recording a case from when it was observed to when data is submitted to the higher levels through the eIDSR?
- e) What changes/outcomes have you anticipated from the intervention?

Topic 3: The effect of eIDSR intervention on reporting process of surveillance information (*to understand what has been changed in the reporting process of diseases surveillance information*)

Follow-up questions

1. How much has been achieved from the eIDSR intervention?
 - a) Can you give more details and evidence to justify your view?
2. How do you compare reporting process of surveillance information before and after the introduction of eIDSR? (*reporting time, work simplification, record submission*)
 - a) Do you get feedback from high levels after reporting surveillance information?
 - b) Does the system ever fail/not work when you need to submit information? If yes, how frequently and how does it affect reporting process?
 - c) What has changed in terms of smoothness in reporting?
3. How can you explain reporting frequencies before and after the introducing of eIDSR?
 - a) Do you think eIDSR has changed information availability at higher levels in the health system compared to the situation before you adopted it?

Topic 4: Ways has the eIDSR system influenced response to diseases outbreaks

1. What are your views about usage of information collected through eIDSR system? (*reference to severe malaria, bloody diarrheal and cholera*)

- a) Has there been a change in information usage for surveillance activities after the introduction of eIDSR?
- b) Do you have any evidence supporting your view?
- c) Do you have examples of diseases surveillance reports with data generated from the eIDSR?

2. Can you explain how disease outbreak notifications are triggered and made available to members of response team?
 - a) Who do you communicate first and how for cases of disease outbreaks categorized for immediate response? (such as bloody diarrhoea and cholera)
 - b) How are you involved in activities related to outbreaks response?
 - c) In what ways is information from eIDSR used to assist response activities?
 - d) How do you compare reporting of diseases outbreaks to higher levels before and after the adaptation of eIDSR?

Topic 5: Strategies on how to effectively design, implement and scale-up mHealth interventions

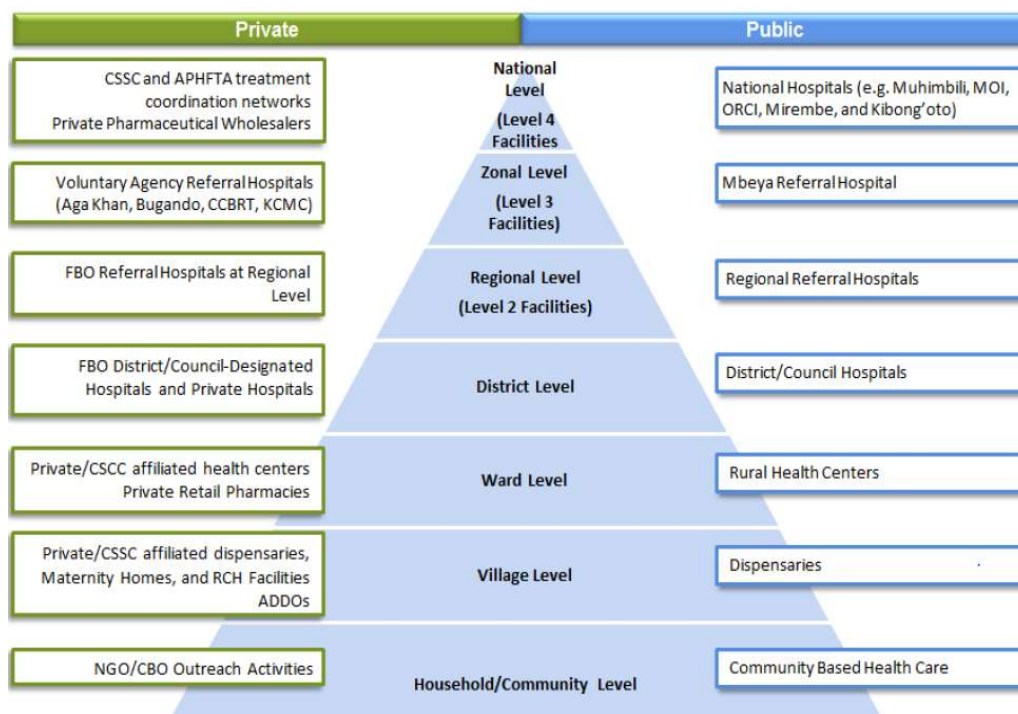
1. How did you familiarise yourself on the use of eIDSR after been introduced in your facility?
2. In what ways do you think eIDSR would have been better introduced in your facility?
3. What are the challenges faced in using eIDSR system?
4. How has eIDSR affected the interaction on diseases surveillance reporting between your facility and higher levels?
5. What are your views regarding the use of eIDSR in your health facility?
6. If some is to be improved in the way eIDSR was introduced and used in your facility, what would you propose?

Topic 6: Conclusion

1. Ask the participant if he/she has any other information would like to share relating to the interview
2. Ask if the participant has any document about eIDSR reports, feedback from higher levels, evaluation reports, outbreaks response reports, etc.
3. Thank the participant for the time spent and information provided
4. Terminate the recording

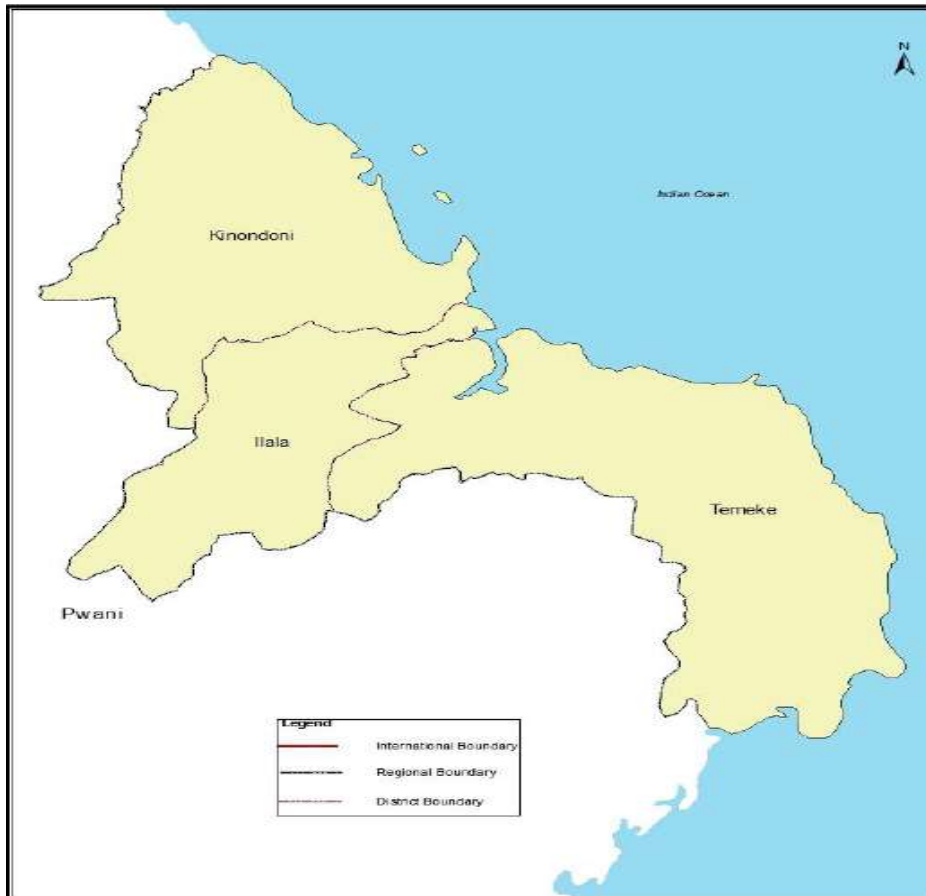
Appendix G: Study setting and location

Figure 47: Tanzania healthcare pyramid



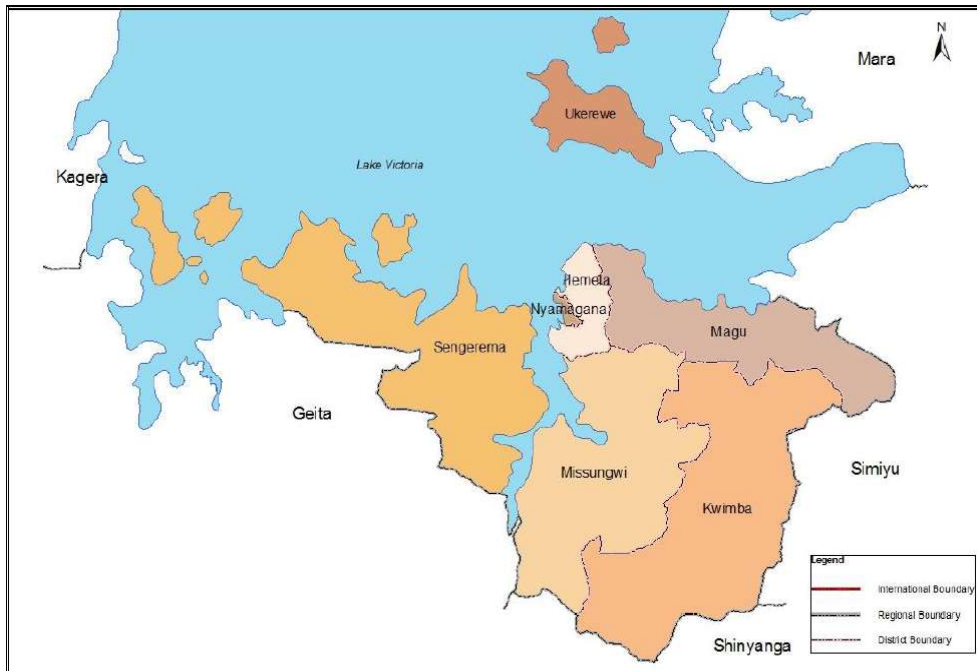
Source: (MoH-Tanzania, 2015d)

Figure 48: Dar es Salaam region, administrative districts, and boundaries



Source: Tanzania National Bureau of Statistics(2016)

Figure 49: Mwanza region, administrative districts, and boundaries



Source: Tanzania National Bureau of Statistics(2016)

Appendix H: Lists of priority diseases and conditions under surveillance

Table 62: Priority diseases in the first edition of the IDSR strategy

| Disease categorie | List of diseases |
|---|---|
| Epidemic Prone Diseases | Cholera; bloody diarrhoea/ bacillary dysentery; plague; measles; yellow fever; cerebral spinal meningitis |
| Disease targeted for elimination/ eradication | Acute Flaccid paralysis / Polio; Neonatal Tetanus |
| Diseases of public health importance | Diarrhoea in children <5 years; Pneumonia in children < 5 years; malaria; typhoid |

Source: Ministry of Health Tanzania (2001)

Table 63: Priority diseases and conditions in the second edition of the IDSR strategy

| Disease categories | List of diseases |
|---|---|
| Epidemic-prone Diseases | Cholera; bloody diarrhoea/ bacillary dysentery; plague; measles; yellow fever; cerebral spinal meningitis; Anthrax; Rabies/ animal bite; Viral haemorrhagic fevers (<i>Rift valley fever, Ebola, Marburg, dengue, Lassa fever, etc</i>); Human influenza caused by new subtypes (<i>Avian influenza, SARs, Influenza A (H1N1) 2009, SARI, etc</i>); Smallpox; Epidemic viral keratoconjunctivitis |
| Disease targeted for elimination/ eradication | Acute Flaccid paralysis / Polio; Neonatal Tetanus; Trachoma; Onchocerciasis |
| Diseases of public health importance | Diarrhoea in children <5 years; Pneumonia in children < 5 years; malaria; typhoid; Trypanosomiasis; Tick-borne relapsing fever; Tuberculosis (MDR/ XDR); HIV/AIDS (New cases); STI; Leprosy; Lymphatic Filariasis; Schistosomiasis; Soil-transmitted helminths |
| Non-communicable diseases (NCDs) | Diabetes mellitus; High blood pressure; Cataract; Maternal deaths; Road traffic accidents; Cancers; Malnutrition |

Source: Ministry of Health Tanzania (2011)

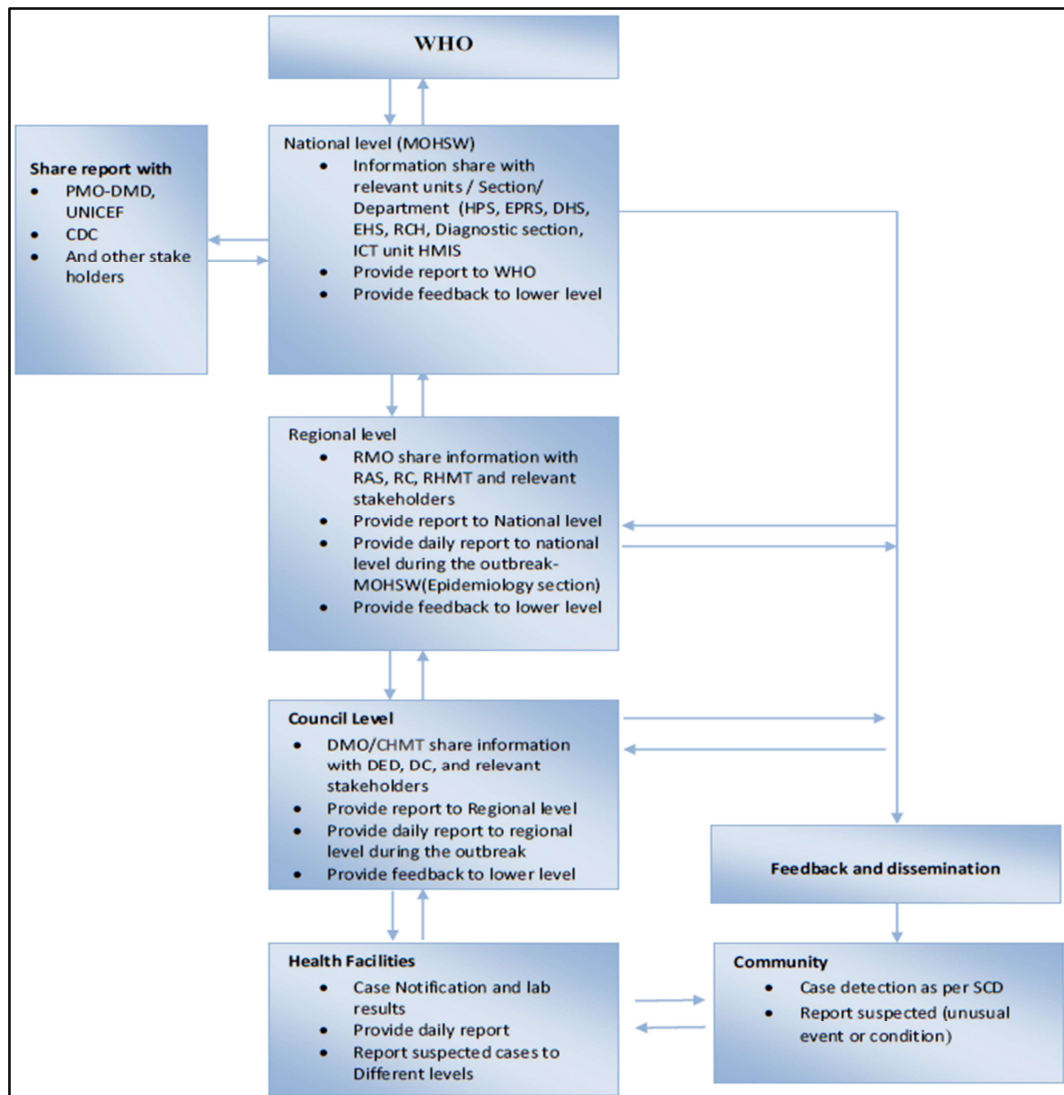
Appendix I: Protocol for reporting disease outbreaks and data flow

Table 64: Standard procedures in responding to cholera and malaria

| | Cholera outbreaks | Malaria outbreaks |
|--|--|---|
| Type of response | Daily – immediate notifiable | weekly report |
| Threshold for reporting | Death of at least 1 case reported in a week | When there is an unusual increase in incidence or fatality rate by 50% as compared to the same period in previous non-epidemic years |
| Respond to alert threshold | Report the detection of an increased number of cases to the next level of the health system | Report suspected epidemic to the next level. |
| | Treat the suspect cases | Treat with appropriate anti-malarial drugs according to program recommendations. |
| | Obtain a stool or rectal swab specimen for confirming | Investigate the cause of the increase in new cases. |
| | Investigate the case to determine risk factors contributing to transmission | New cases are managed according to malaria guidelines. Conduct community education for prompt detection of cases and access to health facilities |
| Respond to action threshold | Report to next-level | Report suspected epidemic to the next level. |
| | Search for additional cases in the locality of confirmed cases. | Evaluate and improve as needed prevention strategies such as the use of Insecticide Treated Nets (ITNs) and Indoor Residual Spreading (IRS) for all areas at risk of malaria. |
| | Strengthen case management and treatment. | |
| | Mobilize community to enable rapid case detection and treatment. | |
| | Identify high-risk populations using person, place, and time data. | |
| | Reduce sporadic and outbreak-related cases by promoting hygienic behaviour like hand-washing with soap, handling food, use of latrines and safe disposal of human waste. | |
| Strengthening access to safe water supply and storage, | | |

Source: IDSR technical guidelines (2011)

Figure 50: Flow of surveillance information during epidemic outbreaks



Source: IDSR technical guidelines (MoH-Tanzania, 2011)

Appendix J: Disease surveillance information system tools

Table 65: Reporting form for individual cholera death records at health facilities

| | | | |
|--|--|---|------------------|
| Region | | District: | |
| Locality (Village/Street): | | Health facility: | |
| Name of the Deceased | | | |
| Age (years) | | | |
| Sex (Male/Female) | | | |
| Occupation | | | |
| Date and time of admission (If admitted) | | Date: Time | |
| Date of onset of illness | | | |
| Symptoms & signs (Tick after the appropriate response) | | | |
| | | Diarrhea: | |
| | | Vomiting: | |
| | | Dehydration: | status : Severe: |
| | | Others (mention)..... | |
| Specimen taken for laboratory investigation (Tick the appropriate response) | | | |
| | | Yes: Investigation Results (mention) | |
| | | No | |
| Treatment given (Tick the appropriate response) | | | |
| | | Intravenous Fluids: | |
| | | Antibiotics: | |
| | | Oral Rehydration Solutions: | |
| Place Death Occurred (Tick the appropriate response) | | | |
| | | Home: | |
| | | On the way to Cholera Treatment Centre or Health Facility | |
| | | At Cholera Treatment Centre or Health Facility: | |
| Date and time of death | | Date: Time : | |
| Burial Process (Tick the appropriate response) | | | |
| | | Buried by relatives, unsupervised by environmental health personnel | |
| | | Supervised by environmental health personnel: | |
| Burial place (Tick the appropriate response) | | | |
| | | Home grave yard | |
| | | Public cemetery: | |
| | | Special area for Cholera: | |

Source: Individual cholera records from one district IDSR coordinator

Table 66: Report form for capturing cholera individual records at health facilities

| Cholera Case Investigation Form | | |
|---|---|---------|
| Area : Patient and clinical laboratory related information | | |
| | Variables/Questions | Answers |
| 1 | Detection day (ddmm/yyyy) | |
| 2 | Detection place (Health facility or Community) | |
| 3 | Patient identification number (yyyy-week-CCC-PPP-DDD-Reporting site-nnn) | |
| 4 | Patient surname or last name | |
| 5 | Patient first name(s) | |
| 6 | Age (years) | |
| 7 | Sex (F/M) | |
| 8 | Number of people in same household | |
| 9 | Patient's residential Address | |
| 10 | Village/Town | |
| 11 | Neighborhood | |
| 12 | District | |
| 13 | Region | |
| 14 | Country | |
| 15 | Date of onset (first symptoms) (ddmm/yyyy) | |
| 16 | Clinical signs and Symptoms | |
| 17 | Was patient exposed to any known risk factor for this disease? (Yes/No) | |
| 18 | If yes, specify risk factor(s): Water used by the patient for drinking : (list by type, e.g. tap water, Borehole, unprotected well, protected well, River, dum, lake, pond) | |
| 19 | Number of doses of cholera Vaccine | |
| 20 | Date last dose was administered | |
| 21 | Laboratory related information: at least first and last cases | |
| 22 | <i>Vibrio cholerae</i> identified in stools? | |
| 23 | Drugs to which the vibrio strain is sensitive | |
| 24 | Drugs to which the vibrio strain is resistant | |
| 25 | Outcome (Died, Survived, Unknown) | |
| 26 | Final Classification (Not a case, Suspect, Probable, Confirmed by Lab, Confirmed by epidemiological link, Pending) | |
| 27 | Other Notes and Observations | |
| 28 | Date latest update of this record (dd/mm/yyyy) | |
| Area: Risk factor search (Information to be obtained from the water and sanitation group of the investigation team) | | |
| | Variables/Questions | Answers |
| Mapping Potential Hazards | | |
| 1 | Potential vibrio vehicles: drinking water | |
| 2 | Drinking water source 1 | |
| 3 | Drinking water source 2 | |
| 4 | Drinking water source 3 | |
| 5 | Drinking water source 4 | |

| | | |
|----|--|--|
| 6 | Potential vibrio vehicles: non drinking water | |
| 7 | Non drinking water source 1 | |
| 8 | Non drinking water source 2 | |
| 9 | Non drinking water source 3 | |
| 10 | Non drinking water source 4 | |
| 11 | Potential vibrio vehicles: Food items | |
| 12 | Food items 1 | |
| 13 | Food items 2 | |
| 14 | Food items 3 | |
| 15 | Food items 4 | |
| | Food items 5 | |
| 17 | Food items 6 | |
| 18 | Food items 7 | |
| 19 | Food items 8 | |
| 20 | Bacteriology lab findings | |
| 21 | Drinking water found infected by vibrio | |
| 22 | Non drinking water found infected by vibrio | |
| 23 | Food items found infected by vibrio | |
| 24 | Looking out for Exposure to the identified hazards | |
| 25 | Water used by the patient for drinking : (list by type, e.g. tap water, Borehole, unprotected well, protected well, River, dum, lake, pond): | |
| 26 | Within 3 days prior to the onset of the disease did the patient drink from | |
| 27 | Water source 2 (Yes/No) | |
| 28 | Water source 3 (Yes/No) | |
| 29 | Water source 4 (Yes/No) | |
| 30 | Water source 5 (Yes/No) | |
| 31 | Within 3 days prior to the onset of the disease did the patient eat | |
| 32 | Food item 1 (Yes/No) | |
| 33 | Food item 2 (Yes/No) | |
| 34 | Food item 3 (Yes/No) | |
| 35 | Food item 4 (Yes/No) | |
| 36 | Food item 5 (Yes/No) | |
| 37 | Within 3 days prior to the onset of the disease did the patient attend any | |
| 38 | funerals (Yes/No) | |
| 39 | other social event (Yes/No) | |

Source: The national IDSR technical guidelines (MoH-Tanzania, 2011)

Table 67: Epidemic-prone diseases weekly surveillance report from health facilities

FORM 3 B: WEEKLY REPORTED NEW CASES / DEATHS DURING AN EPIDEMIC AT HEALTH FACILITY AND DISTRICT LEVELS

District _____ Health Facility _____ Week beginning _____ Week ending _____ Month _____

| S/N | DISEASES | < 5 CASES | | | | > 5 CASES | | | | TOTAL | | | | Cumulative Totals (From 1st January) | | | |
|-----------------------------|----------------------|-----------|---|---|---|-----------|---|---|---|-------|---|---|---|---|---|---|---|
| | | C | | D | | C | | D | | C | | D | | C | | D | |
| | | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| 1 | AFP | | | | | | | | | | | | | | | | |
| 2 | Anthrax | | | | | | | | | | | | | | | | |
| 3 | Blood Diarrhea | | | | | | | | | | | | | | | | |
| 4 | Cholera | | | | | | | | | | | | | | | | |
| 5 | CSM | | | | | | | | | | | | | | | | |
| 6 | Human Influenza | | | | | | | | | | | | | | | | |
| 7 | Keratoconjunctivitis | | | | | | | | | | | | | | | | |
| 8 | Measles | | | | | | | | | | | | | | | | |
| 9 | NNT | | | | | | | | | | | | | | | | |
| 10 | Plague | | | | | | | | | | | | | | | | |
| 11 | Rabies/Animal Bites | | | | | | | | | | | | | | | | |
| 12 | Small Pox | | | | | | | | | | | | | | | | |
| 13 | Trypanosomiasis | | | | | | | | | | | | | | | | |
| 14 | VHF | | | | | | | | | | | | | | | | |
| 15 | Yellow Fever | | | | | | | | | | | | | | | | |
| 16 | Malnutrition | | | | | | | | | | | | | | | | |
| Total No. Of HFTs | | | | | | | | | | | | | | | | | |
| No. Of HFTs Reported | | | | | | | | | | | | | | | | | |
| No. Of HFTs Reported Timely | | | | | | | | | | | | | | | | | |

Reported by: _____ Designation: _____ Sign: _____ Date: _____

Reporting Instructions

Health Facility Level: Send a copy to DMO/DHO and retain a copy by Wednesday 03:30 P.M

District Level: Summarize then, send copies to the RMO/RHO and the RHO retain a copy by Thursday 09:30 P.M

Table 68: The old IDSR weekly report from health facility prior to eIDSR initiative

FORM 3 B: WEEKLY REPORTED NEW CASES / DEATHS DURING AN EPIDEMIC AT HEALTH FACILITY AND DISTRICT LEVELS

District: _____ Health Facility _____ Week beginning 21/5 Week ending 27/5 Month MAY 2015

| S/N | DISEASES | < 5 CASES | | | | > 5 CASES | | | | TOTAL | | | | Cumulative (From 1st) | | | |
|-----------------------------|---|-----------|---|---|---|-----------|---|---|---|-----------|---|---|---|--------------------------|---|---|---|
| | | C | | D | | C | | D | | C | | D | | C | | D | |
| | | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| 1 | AFP | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | Anthrax | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | Blood Diarrhea | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | Cholera | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | CSM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | Human Influenza | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | Keratoconjunctivitis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | Measles | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | NNT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | Plague | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | Rabies | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | Animal Bites | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | Small Pox | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | Trypanosomiasis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | VHF | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | Yellow Fever | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | Malnutrition | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | Confirmed Malaria | < 5 Cases | | | | | | | | > 5 Cases | | | | | | | |
| | Total number tested with RDT/Microscope | 1145 | | | | | | | | 790 | | | | | | | |
| | Total tested positive with RDT/Microscope | 460 | | | | | | | | 232 | | | | | | | |
| | Total Clinical malaria Case | 277 | | | | | | | | 102 | | | | | | | |
| Total No. Of HFTs | | 43 | | | | | | | | | | | | | | | |
| No. Of HFTs Reported | | 43 | | | | | | | | | | | | | | | |
| No. Of HFTs Reported Timely | | 43 | | | | | | | | | | | | | | | |

Table 69: An example of a district monthly summary report in an excel spreadsheet

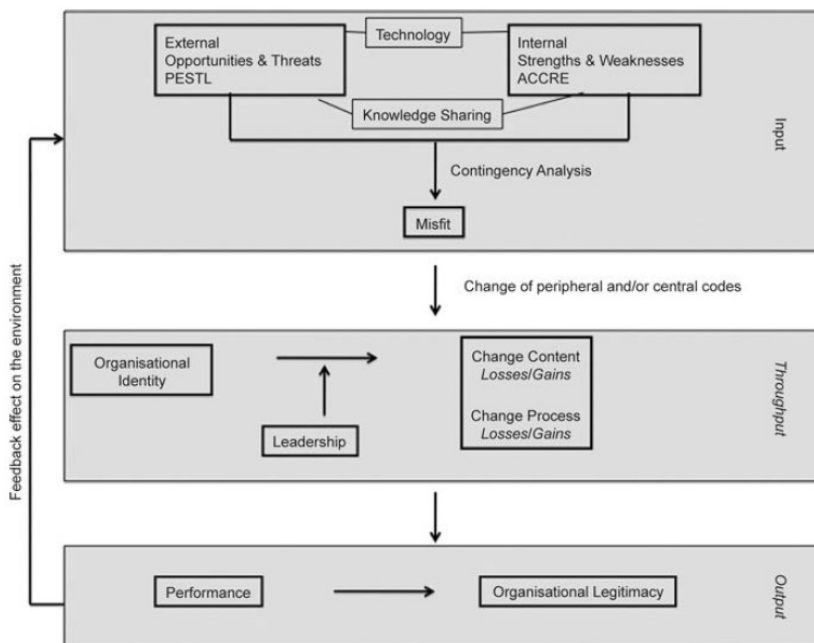
| FORM 2B: HEALTH FACILITY MONTHLY DATA FOR INPATIENT AND OUTPATIENT | | | | | | | | | | | | | | | | | |
|--|----------------------------|-----------|------|---|---|-----------|------|---|---|-------|------|---|---|--|--------|----|----|
| District: XXXXX DISTRICT SUMMMARY. Month: XXX, 201X | | | | | | | | | | | | | | | | | |
| S/N | DISEASES | < 5 CASES | | | | > 5 CASES | | | | TOTAL | | | | Cumulative Totals (From 1 st January) | | | |
| | | C | | D | | C | | D | | C | | D | | C | | D | |
| | | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| 1 | AFP (Suspects) | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | Anthrax | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | Bloody Diarrhea | 36 | 30 | 0 | 0 | 20 | 16 | 0 | 0 | 56 | 46 | 0 | 0 | 543 | 632 | 0 | 0 |
| 4 | Cholera | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | CSM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | Diarrhea < 5 years | 633 | 1076 | 0 | 0 | | | | | 633 | 1076 | 0 | 0 | 2,383 | 2,591 | 6 | 5 |
| 7 | Human influenza (SARI) | 39 | 29 | 5 | 2 | 31 | 36 | 5 | 3 | 70 | 65 | 1 | 5 | 433 | 424 | 58 | 77 |
| 8 | Keratoconjunctivitis | 6 | 5 | 0 | 0 | 20 | 20 | 0 | 0 | 26 | 25 | 0 | 0 | 204 | 169 | 0 | 0 |
| 9 | Malaria | 1131 | 1599 | 0 | 0 | 2362 | 2953 | 0 | 0 | 3493 | 4552 | 0 | 0 | 30,381 | 33,248 | 56 | 77 |
| 10 | Measles | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 4 | 0 | 0 |
| 11 | NNT | 0 | 0 | 0 | 0 | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | Onchocerciasis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | Plague | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | Pneumonia < 5 years | 416 | 713 | 0 | 0 | | | | | 416 | 713 | 0 | 0 | 2,875 | 2,863 | 27 | 17 |
| 15 | Rabies/Animal Bites | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 2 | 4 | 0 | 0 | 305 | 263 | 0 | 0 |
| 16 | Small Pox | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | Tick borne relapsing fever | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | Trachoma | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | Trypanosomiasis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | Typhoid | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 369 | 403 | 5 | 4 |
| 21 | VHF (Dengue Fever) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 290 | 246 | 0 | 0 |
| 22 | Malnutrition | 57 | 61 | 0 | 0 | 0 | 3 | 0 | 0 | 57 | 64 | 0 | 0 | 473 | 548 | 0 | 0 |
| 23 | Yellow Fever | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Total Facilities: 245 Reported: 67 Reported Timely 45
Prepared by: XXXXXX, | Designation: Surveillance Officer, Signature: xxxx, Date: xxxxxx, Contacts: xxxxx

Source: Excel files in a computer of one district IDSR coordinator

Appendix K: Theoretical framework


Figure 51: A unified framework of organisations change



Source: Jacobs et al (2013, p. 777).

Appendix L: eIDSR implementation

Figure 52: eIDSR user quick start guide



Ministry of Health and Social Welfare

eIDSR! TANZANIA: Quick Start Guide

***149*18#**

- Before you start reporting, make sure the report form is completely filled in. This way, submitting your report will be much easier and quicker.
- eIDSR uses USSD technology, which has time limit (**maximum 2 minutes**), in case a session times out while you are reporting, call the number again within two minutes and you will continue from where you ended.
- For weekly reporting, make sure you report number of cases and deaths for all diseases before you submit your weekly report.
- When you complete your report, make sure you receive Confirmation SMS with Case ID or Report ID. **Be sure you record the ID on IDSR paper form.** ID serves as proof of submission and will help in the future locate your data/report.
- Epidemiological week for reporting starts from Monday to Sunday every week.

Accessing eIDSR through Phone

- Make sure you are registered to be able to send reporting
- Dial eIDSR code number ***149*18#**
- Enter PIN number shared to you during registration
- Upon successful login, **eIDSR** main menu will be displayed.

What to report and why.

| Report | Purpose |
|---------------------|--|
| IDSR Weekly Report | Number of cases and death for weekly reportable diseases to monitor trends. |
| Immediate Reporting | Data about cases of immediately notifiable diseases to describe a person. The information will be used to identify outbreak, initiate case investigation, define action to be taken etc. |

Using the main menu

| | |
|----------|-------------------------------|
| Enter 1: | For immediate reporting |
| Enter 2: | For Weekly reporting |
| Enter 3: | To submit your weekly report. |

When to report?

| Report | Deadline |
|---------------------|------------------------------------|
| IDSR Weekly | Monday 3:30 PM |
| Immediate Reporting | Same day a case has been observed. |

Frequently Asked Questions (FAQs)

Q: What if I forget my password?
A: ~~Contact~~ **Contact** district IDSR focal person for your password to be reset and a new password will be sent back to you.

Q: What if I make mistake while submitting a weekly report?
A: You must resubmit your report and eIDSR will override your old report with the new one sent.

Q: What if I don't have credit on my phone?
A: ~~eIDSR~~ **eIDSR** is a toll-free number, no credit from your phone will be required to send report.

Q: What if application timeouts before I complete reporting?
A: If its connection timeouts before you complete reporting, just redial the code again within two minutes and application will start from where you ended initially. If you call after two minutes, you will have start over afresh.

Q: What if I submit weekly report late?
A: **eIDSR** will accept your report but it will be marked as late.

Q: What if I don't have any case to report this week?
A: **You must submit a zero report so that district, region and national level will know that you have reported.**

Q: What if my phone is not working?
A: ~~As long as~~ **As long as** you use your same registered phone number, you will be able to access eIDSR for reporting.

Q: What if I change my mobile phone number?
A: You must contact district IDSR focal person for your old number to be removed and your new one to be registered.

Q: What if I do not submit a report at all?
A: Your role in disease surveillance is very important, if you don't send your report, IDSR information will be inaccurate and might lead to bad decisions.