DYNAMIC AMBIDEXTERITY FOR BALANCING STANDARDIZATION AND EVOLVE-ABILITY IN INFORMATION SYSTEM IMPLEMENTATION IN THE RESOURCE-CONSTRAINED SETTING: THE CASE OF DHIS2 IMPLEMENTATION IN PUBLIC HEALTH CARE IN ETHIOPIA

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This is to certify that the thesis prepared by Birkinesh W/Yohannes, entitled: Dynamic Ambidexterity for Balancing Standardization and Evolve-ability in Resource-Constrained Setting: the case of DHIS2 Implementation in Public Health Care of Ethiopia and submitted in fulfillment of the requirements for the Degree of Doctor of Philosophy (with specialization in Information Systems) complies with the regularities of the University and meets the accepted standards concerning originality and quality.

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DEDICATION

To:

Heni, Yoni and Dani;

For Your Unconditional Love!!!

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ABSTRACT

Health Information System (HIS) implementation involves inherently contradictory issues, standardization, and evolve-ability, that require different sets of information technology solutions and governance mechanisms (i.e. centralized/decentralized structure, controlled/autonomous process, top-down/bottom-up communication) which is difficult to materialize in practice. Contemporary studies indicate that organizations are shifting away from either/or strategies toward balancing that favors simultaneously achieving contradictory activities. However, theoretical and empirical research guiding how to organize and implement a balancing of standardization and evolve-ability is lacking. Furthermore, research has paid little attention to resource-constrained settings where sources of contradiction are immense due to a lack of technical and financial resources needed for HIS implementation. To address this shortcoming, this study seeks to study HIS implementation in the public healthcare sector of Ethiopia aiming to contribute to the development of an IT governance framework for understanding and addressing contradictory issues in the resource-constraining setting.

Following an interpretive approach, the implementation of DHIS2, an open-source software developed at the University of Oslo, in the Ethiopian public health care setting was used as a case to explore the underlying logic of IT governance and IS implementation and its impacts. Managers, health, and IT professionals who were involved in the implementation were chosen as informants for this study to provide a deeper understanding of the IT governance mechanisms and their impact on the implementation. Institutional logic served as the primary analytical tool for this study and was used to identify common themes for stakeholders. Dynamic ambidexterity and boundary resource concepts became parts of analytical tools to explore the process of IS implementation at organizational and project levels as the study progressed from data collection, analysis, and the development of theoretical inferences.

This study proposed an integrated ambidextrous implementation governance framework, drawn from institutional logics; dynamic ambidexterity, and boundary resource model; to complement the resource-chasing collaboration with major logics-collaboration, uncontrolled and controlled processes. This framework can be considered a major

theoretical contribution that requires the central actor's institutional distance to accommodate major collaboration with diverse underlying logic. This required enabling common visions, strategies, and mechanisms for sensing, seizing, and reconfiguring the emergent heterogeneous system implementation initiatives that lead to continuously and simultaneously achieving standardization and evolve-ability.

This study is limited by data from one region and a specific system which might not adequately describe the complexity of a national HIS implementation. Furthermore, the researcher's role as an external participant would miss important events such as internal meetings where technical decision and discussion was made which should have been ideal to get rich information. Furthermore, the research indicates the importance of technological features to shape governance mechanisms. Hence further research can investigate the interrelationship between IT governance and the technology feature. Further research is needed to extend the scope of this study to multiple regions, and systems for a longer time to highlight new insights and to highlight the differences across regions and systems. These are limitations and potential areas for further research.

Keywords: Standardization, Evolve-ability, Health Information System, Implementation, Institutional Logic, Ambidexterity

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Acronyms

ANC	Antenatal Care
BNA	Bottle Neck Analysis
CCT	Core Customization Team
CDC	Centers for Disease Control and Prevention
CSA	Central Statistical Authority
DATIM	Data for Accountability, Transparency and Impact Monitoring
DHA	Digital Health Activity
DHBP	Digital Health Blue Print
DHIS2	District Health Information System version 2
DUP	Data Use Partnership
EA	Enterprise Architecture
EC	Executive Committee
ECHIS	Electronic Community Health Information System
e-HMIS	Electronic Health Management Information System
ENEAF	E-government Interoperability Framework
EPHI	Ethiopian Public Health Institute
EPI	Expanded Program on Immunization
FDRE	Federal Democratic Republic of Ethiopia
GAVI	Global Alliance for Vaccines and Immunization
GDP	Gross Domestic Product
GTP	Growth Transformation Plan
HC	Health Center
HEP	Health Extension Program
HIS	Health Information System
HISP	Health Information System Program
HIT	Health Information Technology
HITD	Health Information Technology Directorate
HIV	Human Immunodeficiency Virus
HMIS	Health Management Information System
HMN	Health Metric Network
HP	Health Post
HPMTCT	HIV AIDS performance and monitoring tool
HRS	Human Resource Information System
HSDP	Health Sector Development Plan
HSTP	Health Sector Transformation Plan
ICAP	International Compliance Assurance Program
ICD	International Classification Disease
IPD	Inpatient Disease
IR	Information Revolution
IRNAG	Information National Advisory Group
IS	Information System

ISO	International Standardization Organization
IT	Information Technology
JC	Joint Consultative Forum
JCCC	Joint Core Coordinating Committee
JSC	Joint Steering Committee
JSI	John Snow Inc.
JSI-DUP	John Snow Institute-Data Use Partnership
M&E	Monitoring and Evaluation
MCH	Mother and Children Health
MFR	Master Facility Registry
MINT	Ministry of Innovation and Technology
MOH	Ministry of Health
MTOT	Master of Training of Trainers
NASA	National Aeronautics and Space Administration
NIRSC	National Information Revolution Steering Committee
NIT	National Implementation Team
OPD	Outpatient Disease
ORHB	Oromia Regional Health Bureau
PHCU	Public Health Care Unit
PHEM	Public Health Emergency and Monitoring
PPMD	Policy Plan Monitoring and Evaluation Directorate
PPME	Policy Plan Monitoring and Evaluation
RHB	Regional Health Bureau
SNNPR	Southern Nation Nationalities and Peoples Region
TB	Tuberculosis
TWG	Technical Working Group
UN	United Nations
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
VPN	Virtual Private Network
WHO	World Health Organization
WorHO	Woreda Health Office

CHAPTER 1: **Introduction**

Information Technology (IT) governance is key to the success of Information System (IS) implementation, involving inseparable and contradictory activities, such as standardization and evolve-ability. For the purposes of this study, standardization is defined as a process of creating a new standard or system and maintaining a standard to coordinate and communicate over multiple heterogeneous actors (Hanseth & Bygstad, 2015). Evolve-ability is defined as the activity or process focused on innovation to produce products, services, or components in response to the unprompted change in IS implementation driven by large, varied, and uncoordinated actors (Zittrain, 2006). These implementation activities can be both complementary and contradictory; standards facilitate evolvability, yet technically complex standards can halt evolvability (Hanseth et al., 1996a). When evolve-ability does not rely on standards, communication among systems and coordination between departments and other actors is impeded (Poppe, 2021). Balancing these contradictory issues requires both architectural design (Hanseth & Bygstad, 2015) and IT governance solutions (Constantinides & Barrett, 2015). Various technology design solutions, such as IS artifact design architecture, principles, and features, are available to help practitioners simultaneously address standardization and evolvability (Braa et al., 2007; Gaynor & Bradner, 2001; Hanseth & Bygstad, 2015). However, these design solutions should be complemented by appropriate IT governance to leverage the architectural solutions for enabling IS implementation (Constantinides & Barrett, 2015; Msiska et al., 2019; Poppe, 2021).

Despite the prescriptive IT governance frameworks and models focused on centralized and decentralized strategies, organizational and digital ambidexterity research based on the paradox perspective, provides separation, integration, contextual, and dynamic principles to achieve conflicting activities simultaneously (Banker et al., 2011; Gregory et al., 2015; Liang & Wu, 2011; Raisch & Birkinshaw, 2008). However, this research rarely addresses the contemporary organizations are a nexus of multiple entities collaborating and competing with different institutional backgrounds and perspectives on IT (Berente & Yoo, 2012; Boonstra et al., 2017; Kauppila, 2010). Particularly, the health sector in a resource-constrained setting and is shaped by a mix of governmental and international organizations working together to overcome infrastructure, technical and financial resource limitations (Gebre-mariam & Bygstad, 2019). This study argues that

existing strategies are inadequate to address such conflicting activities of IS implementation in resource-constrained settings. Further, this study aims to explore IT governance approach and its mechanisms for handling contradictory issues in the course of implementation.

This chapter introduces the study by first discussing the background and context, followed by the research problem, the research aims, objectives, questions, significance, and limitations.

1.1 Study Background

IS implementation is considered as a process of organizational implementation including phases of initiation, adoption, configuration, contextualization, installation, and integration of the IS product in an implementation setting while dealing with multiple social and organizational matters (Koskinen, 2006). Health Information system (HIS) implementation is characterized by dynamic and complex situations (Bernardi et al., 2017; Smith & Lewis, 2011), including diverse user interests, multiple applications, heterogeneous data, and data types requiring special efforts and strategies on standardization (Boonstra et al., 2017; Constantinides & Barrett, 2015). The health sector dynamicity includes frequent changes in health data due to health facilities construction, upgrading to other levels, merging health facilities, the introduction of new cases, new services, and products. Successful IS implementation in this dynamic and complex situation, therefore, demands two inseparable activities of standardization to minimize the complexity and evolvability of the implementation process (Hanseth & Bygstad, 2015; Montealegre et al., 2019; Smith & Lewis, 2011).

Standardization and evolve-ability inhibit and enable each other during IS implementation. Evolve-ability uses standard tools to produce new systems, tools, products, and services, which allow smooth communication amongst systems and heterogeneous actors. However, extreme standardization makes the evolve-ability of systems challenging, which magnifies fragmented systems that are unable to communicate with each other (Hanseth et al., 2006; Hanseth & Bygstad, 2015). Focusing more on evolve-ability in addressing local or emergent needs halts coordination and communication amongst heterogeneous actors and impedes standardization efforts. In general, without standardization, communication and coordination amongst heterogeneous actors, systems, and departments are impossible, and similarly, without

evolve-ability, the emergent needs of heterogeneous actors cannot be adequately addressed (Constantinides & Barrett, 2015).

HIS implementation struggles with such contradictory issues (Gregory et al., 2015), which is magnified in resource-constrained settings struggling with accessing infrastructural, technical, and resource support (Boonstra et al., 2017; Braa et al., 2004). Sustainability will fail if such inseparable and conflicting implementation activities are not properly addressed during HIS implementation, often experienced in developing countries (Heeks, 2002). Sustainability failure can be described as a system that initially works well but fails to keep working overtime (Heeks, 2002). Thus, an organization's response to such contradictions may determine the success of the implementation process (Hanseth et al., 2006; Smith & Lewis, 2011).

Sustainability in the industry requires a balance with the precise mix of short-term and long-term goals (Gregory et al., 2015), and the process of exploration and exploitation (Raisch & Birkinshaw, 2008). To strike this balance, IS designers have provided and applied various system architectural and design solutions (Bygstad, 2010; Gizaw et al., 2017; Hanseth & Lyytinen, 2010) and emphasized the importance of IT governance to balance conflicting activities, standardization, and evolve-ability (Constantinides & Barrett, 2014). This requires the development of novel empirical and theoretical insights for handling emerging contradictory issues, particularly in the context of public sector settings (Mergel et al., 2018). This research focuses on developing a novel IT governance framework and outlining its underlying institutional logic for handling complex challenges of standardization and evolve-ability.

1.2 Motivation

This research is motivated by the theoretical and personal motivation to contribute toward practice. This study was initially motivated by witnessing recurrent system failure in HIS implementation in Ethiopia. About ten years ago, the researcher had the privilege to participate in HIS implementation activities which enabled me to experience the underlying challenges of HIS implementation in the Ethiopian public health care sector. It was noticed the government's commitment and immense investment to implement harmonized standardized health information system to overcome system fragmentation since 2005. However, the government expectations were not realized in practice, which led to new initiatives repeatedly, which did not address the root problems of an inadequate

governance framework. Ten years after this initial experience, the researcher conducted a preliminary study for my PhD work and observed how training programs were being conducted interviewed the participants about the previous system they used, and how the current approach was different, it was observed the existence of a lack of trust towards system developers, and implementers, which motivated this study to come up with how successful IS implementation can be conducted.

Theoretically, significant IS research has been conducted in outlining the decentralized versus centralized model of IT governance (Constantinides & Barrett, 2015; Hanseth & Lyytinen, 2010) and their relation to IS implementation success. These contradictory IT governance approaches have been challenged by constraining innovation (Hanseth et al., 2006) and standardization processes (S. Mekonnen & Sahay, 2009). Recently, ambidexterity research has promoted different mechanisms for balancing the two activities for long-term success in IS implementation (Gregory et al., 2015; Montealegre et al., 2019). However, these researches have typically not been situated in resource-constrained settings, which come with unique challenges and particularities. To address this research gap, this study kept its empirical focus in the Ethiopian public health care context.

1.3 Statement of the Problem

IT governance matters for IS implementation (Weill, 2014), which includes adoption, development, and deployment (Kallinikos, 2006). Effective IT governance supported by clear structure, process, and communication is crucial for successful IS implementation (Weill & Ross, 2005). However, the traditional centralized-decentralized IT governance approach is inadequate to achieve balance in the inherently contradictory issues of IS implementation, standardization, and evolvability. Managers are left with generic strategies, such as centralized and decentralized governance, to determine IS adoption, contextualization, and deployment in such conflicting contexts (Pache & Santos, 2010).

Despite the range of existing IT governance frameworks and standards (Brown & Grant, 2005; Weill & Ross, 2005) focused on form and structure (Smith & Lewis, 2011) based on an either-or strategy, contemporary IS approaches have advocated the paradox perspective to discuss the inherent contradictions in IT governance (Gregory et al. 2015; Smith, 2011; Constantinides & Barrett, 2014). The paradox perspective stresses that overall organizational success depends on meeting competing demands simultaneously,

such as standardizing while ensuring change through evolve-ability (Luger et al., 2018; Stettner & Lavie, 2014a).

Of these paradox perspectives, organizational and digital ambidexterity literature reveals how IT governance practices are inclined for balancing the contradictory issues based on separation, integration, contextual, and dynamic principles (Banker et al., 2011; Gregory et al., 2015; Liang & Wu, 2011; Raisch & Birkinshaw, 2008). The separation and integration principles emphasize using the structure for addressing conflicting issues whereas the contextual approach emphasizes having processes and systems that allow individuals to analyze the context of the dilemma when making local-level decisions. The dynamic principle depicts how dynamism at the environment level determines the optimal balance (Stieglitz et al., 2016), stressing the organization's ability to rebalance the contradiction over time as changes occur (Luger et al., 2018).

However, this literature rarely addresses the contemporary organization as a nexus of multiple entities collaborating and competing with different institutional backgrounds and perspectives on IT (Berente & Yoo, 2012; Boonstra et al., 2017; Kauppila, 2010). For instance, the health sector in developing countries is a mix of government and international organizations which tend to use centralized governance strategies to address different and potentially diverging beliefs, values, and norms, which is also rarely addressed in IS research (Boonstra, Eseryel, and Offenbeek, 2017; Kizito and Kahiigi, 2018).

Often, IT governance mechanisms can be affected by dominant stakeholders' beliefs, values, and norms (Boonstra et al., 2017; Reay & Hinings, 2009; Xue et al., 2012). Such influence is of immense relevance in developing countries where multiple donor organizations render system implementation technical and financial support (Bernardi et al., 2017). This research seeks to analyze the influence of multiple stakeholders on IT governance, within a resource-constrained context.

Recent research advocates for loose coupling and collaborative strategies instead of dominant centralized models (Berente & Yoo, 2012; Boonstra et al., 2017; Jones et al., 2015). To do so, senior managers are advised to distance themselves from prevailing institutional logic to employ collaborative and loose coupling strategies (Berente & Yoo, 2012; Reay & Hinings, 2009). Some researchers have advocated for the boundary resource model in digital platform governance which facilitates involvement and

coordination between heterogeneous actors in system development (Ghazawneh & Henfridsson, 2013). The boundary resource model is a tool to analyze two contradictory activities in platform governance which are resourcing and securing (Ghazawneh & Henfridsson, 2013), which is a topic currently under-researched (Heeks & Stanforth, 2014; Masiero, 2020). This study extends the boundary resource model used for platform technology governance by including concepts of institutional logic and dynamic ambidexterity.

1.4 The research aims, objectives, and questions

The study aims to explore and propose appropriate IT governance approaches and mechanisms for balancing conflicting activities within a resource-constrained setting of the public health care sector of Ethiopia. To understand how IT governance and its mechanisms balance standardization and evolve-ability while implementing HIS in a resource-constrained context, three interlinked research questions were devised:

1. What are the underlying institutional logics in HIS implementation that influence managers when devising IT governance approaches and mechanisms?
2. How do IT governance approaches and mechanisms influence contradictory issues of standardization and evolve-ability implementation?
3. What are possible alternative IT governance approaches and mechanisms that can address the contradictory issues in the resource-constrained setting?

1.5 Theoretical focus and expected contribution

This research draws upon concepts from institutional theory, ambidexterity, and platform governance literature to unpack the underlying logic of the IT governance approach, mechanisms, and its impact on handling conflicting activities during IS implementation. Institutional logic is never homogeneous; within an organization, multiple logic may be simultaneously in play (Friedland & Alford, 1991). Competitive logic creates a dominant logic that influences the implementation. Conversely, recent research indicates that competitive logic can co-exist for lengthy periods of time in loose coupling and collaborative strategies (Reay & Hinings, 2009), which contribute to maintaining a form of relative balance. Thus, identifying the underlying institutional logic in IS implementation enables managers to design IT governance mechanisms that lead to a balancing of standardization and evolve-ability during the implementation. Failing to understand key actors' institutional logic might bias the approach leading to sub-optimal

implementation (Boonstra et al., 2017). Therefore, this study explores multiple institutional logics (integrated, innovative, centralized, systemic, and IT) underpinning a national HIS implementation and their implications on IT governance.

Despite the range of existing IT governance frameworks and standards (Brown & Grant, 2005; Weill & Ross, 2005), from those focused on form and structure (Smith & Lewis, 2011) to either-or strategy (i.e centralized or decentralized), contemporary IS researchers have advocated for a paradox perspective to discuss the inherent contradictions in IT governance (Gregory et al. 2015; Smith, 2011; Constantinides & Barrett, 2014). This study proposes an implementation governance framework based on the paradox perspective, by focussing on dynamic ambidexterity and platform governance, (Boonstra et al., 2017; Gregory et al., 2015; Tilson et al., 2010; Wareham, 2014). Dynamic ambidexterity and platform governance based on the boundary-resource model is identified and analyzed as means to understand the approach for innovation. The new insights and concepts developed in this study for a complex public health care organization in a resource-constrained setting enhance the understanding of concepts and methods for studying and explaining IT governance in health care settings.
Based on this understanding, policies can be developed that are capable of guiding IT managers when designing appropriate IT governance mechanisms to address conflicting activities in HIS implementation, with a focus on standardization and evolve-ability.

1.6 Overview of empirical basis and research strategy

A case study approach was used to undertake this study of DHIS2 implementation in the Ethiopian public health context for three major reasons. First, a healthcare organization setting presents a motivating context for IT governance due to its varied stakeholders and diverse disciplines such as health, IT, administration, government, and international organizations (Kizito & Kahiigi, 2018). Second, the need for balancing conflicting approaches surpasses the professionals' interest due to the huge role of donor organizations in the resource-constrained setting of public health care. Third, DHIS2 is a web-based open-source architectural solution that can be leveraged to address both standardization and evolve-ability (Adu-Gyamfi et al., 2019). The scope of this study is limited to one region and its specific system, DHIS2 implementation in Ethiopia. ,

An interpretive case study was used to unpack the complexity of IT governance when heterogeneous stakeholders are involved. Document analysis, interviews, and

observation were used as data collection techniques to collect primary and secondary data related to DHIS2 implementation and its governance. Institutional logic, dynamic ambidexterity, and the boundary resource model concepts have been used as a lens to explore and understand the interplay of different actors with varied socio-cultural backgrounds, emerging issues, and differences on how to improve the IT governance in such a resource-constrained setting. The research flow diagram describes how the research was conducted in figure 1.

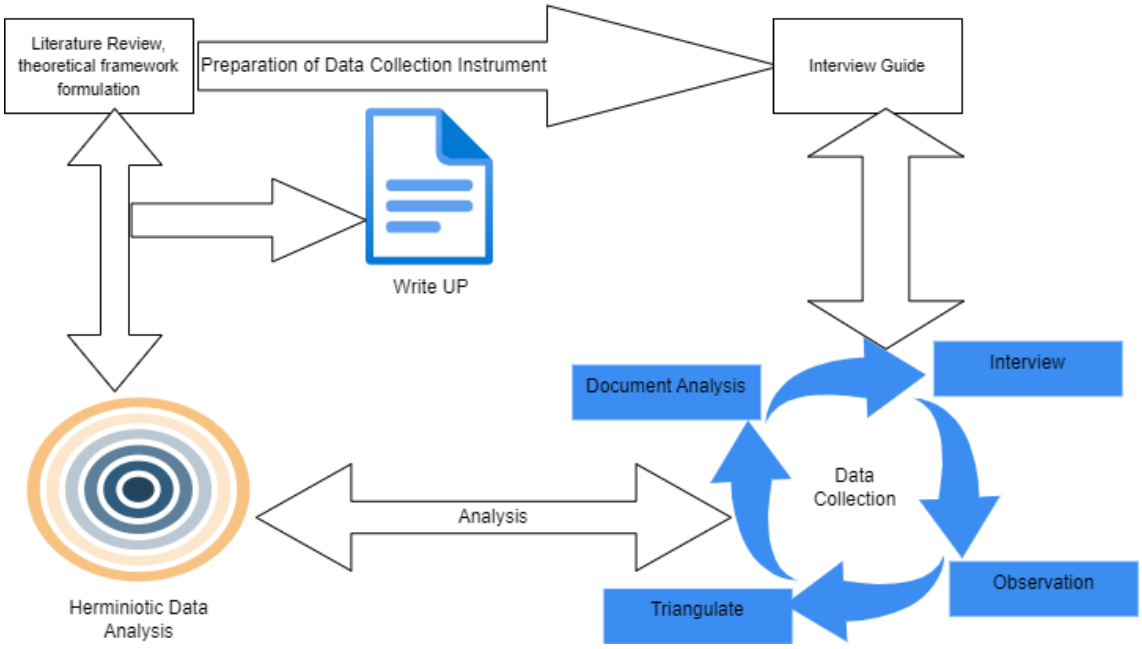


Figure 1 Research Flow Diagram

1.7 Ethical Considerations

The study was approved by multiple institutions including Addis Ababa University, the Ministry of Health and the Oromia Regional Health Bureau. First, the research proposal was initially approved by the PhD Board of the IT Doctoral program in the College of Natural and Computational Science, Addis Ababa University, Ethiopia. Next, the research proposal received ethical approval from the MOH of Ethiopia and the Oromia Region Health Bureau, who then directed me to the appropriate experts to get information pertinent to this study. The Oromia Regional Health Bureau research ethics committee also delivered research permission letters to the health institutions' study sites and programs to conduct interviews, observations, and access documents in the study sites to conduct interviews, observations, and access documents. Appendices 1 and 2 depict the

initial approval letter gained from the university and the data collection permission letter given from the regional health bureau, respectively. Each study participant gave written and oral permission to participate in this study and be audio recorded. Verbal consent was also given by participants to allow photography at study sites for use in this thesis. Identities of individuals who participated in the study were kept confidential and reported anonymously. Furthermore, appropriate acknowledgment and citation have been made for concepts and ideas taken from the literature.

1.8 Structure Outline

In this chapter, the context of the study has been introduced, the research objectives and questions have been identified and the value of such research argued. The scope of the study has also been discussed. The rest of the thesis is organized as follows. Chapter 2 presents an overview of the literature review on standardization and evolve-ability to highlight the challenges of IS implementation in contradictory issues and discuss digital ambidexterity literature as resolving mechanisms. Chapter 3 discuses theoretical backgrounds drawn from institutional, ambidexterity theories, and boundary resource models. Research methods are presented in chapter 4 which includes philosophical assumption, research design, data collection and analysis techniques, ethical considerations, and reflections on the methodology which is followed by a case description in chapter 5. Chapter 5 presents an overview of the research context, including demography, socio-economic, ICT, and the health care status of the country which is followed by the history of health information systems implementation concerning HIS governance and digital health strategy in the context is presented. The findings of this study are provided in chapters 6 and 7 in the Case description and Case analysis respectively. Chapter 8 discusses the findings to the research questions and related works of literature. Chapter 9 provides a conclusion and contributions of the study.

CHAPTER 2: Literature Review

In this chapter, HIS implementation literature with IT governance for balancing standardization and evolve-ability is presented. Section 2.1 presents HIS literature highlighting implementation challenges related to contradictory issues, i.e. standardization, and evolve-ability. Section 2.2 presents a discussion on design solutions for paradox activity in IS implementation, followed by the lack of IT governance with a paradox perspective for resolving the challenges in section 2.3. Finally, 2.4 describes the ambidexterity literature as a mechanism for addressing conflicting issues.

2.1 HIS implementation Challenge in Health Care

Information system (IS) implementation includes system adoption, development, and deployment (Koskinen, 2006). IS implementation can lead to a range of contradictory issues (i.e stability and change, local and global, control and generativity, innovation, and standardization) in varied contexts and with multiple diversified actors (Gizaw et al., 2017; Montealegre et al., 2019; Nielsen & Hanseth, 2010; Smith & Lewis, 2011). This study uses standardization and evolvability with a process perspective to encompass all tensions (Birkinesh et al., 2022). The health care sector, in particular, is characterized by dynamic and complex situations that demand simultaneous standardization and evolve-ability, inherently contradictory activities for success (Bernardi et al., 2017; Hanseth & Bygstad, 2015; Montealegre et al., 2019). However, failing either of these leads to sustainability failure (Werder & Heckmann, 2019). Despite the importance of these contradictory issues in IS implementation, handling both is a challenge due to their dueling nature, with one sometime inhibiting the other, while at other times they enable each other (Hanseth & Bygstad, 2015). This study highlights the importance of implementation context and dependency on international organization as an additional challenge to achieve the contradictory issues in HIS implementation in resource-constrained context (Lankhorst, 2017; Neema et al., 2022).

2.1.1 Standardization

Standardization in health care is defined as a process of creating and maintaining a new standard to coordinate and communicate between multiple heterogeneous actors such as hospitals, doctors, labs, pharmacies, and authorities (Hanseth & Bygstad, 2015) and has been described as part of practice for coordinating work globally (Bowker & Star, 1999)

through technical and non-technical standards which emphasize voluntary standard process to follow (Brunsson et al., 2012). According to Timmermans and Berg (2003), standards, protocols, or guidelines are sets of instructions guiding the implementer's activities in specific situations. Scholars categorized standards as three major types: product (what we have), document for minimum quality; and compatibility standards (what we do) (Timmermans & Berg, 2003). Product standards refer to what people or organizations have or should have (i.e. Constitutions); Document standards include information codes used to classify things such as the International Classification of Diseases (ICD) used by the WHO to coordinate information about morbidity and mortality data (Timmermans & Berg, 2003). Standards need to be in play so that data can be collected in uniform formats and time intervals, which allows comparison across facilities and geographical regions to monitor health care service as well as to allocate scarce resources (Mavimbe, 2007). Compatibility standards refer to how individuals or organizations should behave and, processes within an organization that includes procedures and presentation in both production and consumption such as the Health Metric Network (HMN) framework for strengthening HIS in developing countries (Besen, 1990; Brunsson et al., 2012; David & Greenstein, 1990) which is the focus of this study.

Standards can be created by formal standardization bodies such as International Standardization Organization (ISO), individuals (experts, scientists), large corporations, international NGOs, and so on. Standards can be classified as de jure, formal, and de facto, based on the standardization process they follow (Schmidt & Werle, 1998). A de jure standard is developed by authorized bodies that enforce the adoption of standards by rules and regulations. A formal standard is set by a standardization body, such as the International Organization for Standardization (ISO). A de facto standard is a process imposed by the market instead of standardization organizations and authorized bodies.

This study focuses on the compatibility standard related to HIS implementation in the Ethiopian public health care context by MOH using the case of DHIS2 implementation. MOH aimed to overcome the existing fragmented systems and standardize routine data collection, processing, and disseminating of data throughout the country, where data clerks use DHIS2 to collect and process data and managers and experts at different levels of administration and from different programs can share and use data for their day-to-day activities. DHIS2 is an open source web-based freely available software with data warehousing functionalities and customizable modules for integrated health data

capturing and analysis which is designed and implemented by a health information system program (HISP) (Adu-Gyamfi et al., 2019). HISP is the Oslo university project engaged in researching, designing, and implementing DHIS2 in more than a hundred low and middle-income countries for more than two decades through local HISP teams in each country such as HISP-Ethiopia, HISP-Tanzania, HISP-Uganda, etc.

However, since standards set precise criteria, which are uniform for all settings: they may not fit with the realities in a given community. Thus, the use of standards may overlook significant aspects of implementation and lead to the loss of important information and interventions that are difficult to quantify (Timmermans & Berg, 1997). Research reveals how an overemphasizing of the standardization process for maintaining alignment, efficiency, and control leads to reflexive standardization (Hanseth et al., 2006). In a large study of e-health implementation at a national level, Hanseth and Bygstad (2015) found that the integration standardization strategy to overcome fragmentation often leads to increased complexity that hinders innovation or evolvability.

Standardization produces tensions between universal and local solutions (Timmermans & Berg, 2003). Universal solutions require standardization, whereas locality requires adaptation or innovation according to the local context to achieve evolve-ability. Universality or pure standardization is often characterized by top-down, centralized, procedures, more actors, efficiency, and control whereas locality is characterized by a bottom-up, decentralized structure, autonomy, change, and few users triggering evolve-ability (O'Reilly & Tushman, 2008). Most of the IS implementation is carried out in a software-centric fashion, challenging the standardization activities (Avgerou, 2016; Yoo et al., 2012).

For example, DHIS2 is a global public good available for low and middle-income countries as a solution for health information systems but requires adaptation to the local context. For instance, the Ethiopian local context required various levels of innovation to localize the standard. The global DHIS2 was initially adapted to the Ethiopian context by developing a local calendar, data entry, and disease reporting applications to handle aggregated data collection, processing, and reporting. Further, the initial DHIS2 routine system which focused on aggregated data was extended to include disaggregated data, enhance data quality and simplify the data entry. To deploy the system, the necessary IT and network-related infrastructures were established in the country's health institutions. In return, the establishment of these IT infrastructures for deploying and using DHIS2

motivated potential actors to further configure, develop, and deploy various modules, components, and applications at different levels of health care administration to respond to heterogeneous actors' emergent requirements. Thus implementation of global standards has been contested by the local context including work practices, routines and existing infrastructural resources (Rolland & Monteiro, 2002). Therefore, global standards, data, procedures, or tools such as ISs need to be adapted to the local context to reap their full implementation benefits using various levels of innovation in the setting that leads to evolve-ability.

2.1.2 Evolve-ability

Evolve-ability in this study is the activity or process focused on innovation to produce products, services, or components in response to an unprompted change in IS implementation driven by large, varied, and uncoordinated audiences. IS research uses various terms for evolve-ability, such as innovation (Hanseth & Bygstad, 2015), generativity (Pollock et al., 2007), and flexibility (Hanseth & Lyytinen, 2010), to depict the trajectories, mechanisms causes and strategic approach of information system development, implementation, and use (Wareham, 2014). Flexibility refers to using technology for different contexts without changing the technology and being able to easily change the technology when needed. Generativity is defined as "a technology's overall capacity to produce unprompted change driven by large, varied, and uncoordinated audiences" (Zittrain, 2006, p. 180). This study uses evolve-ability as a strategic approach to IS implementation. Evolve-ability focuses on change that addresses the current and emergent needs of multiple actors who are situated in different contexts and the continuous change of technology (Zittrain, 2006).

A longitudinal study of IS infrastructure development and implementation identified evolve-ability mechanisms, and macro-micro and micro-macro service innovation, in the airline industry (Bygstad, 2010). The macro-micro innovation mechanisms depict how information infrastructure provides space for generating new services, whereas the micro-macro innovation mechanisms describe how the created services generate several new actors into the system, such as new users, and vendors, who also develop new components and applications that extend the infrastructure (ibid…). In other words, Grisot, et, al. (2013) identified three evolve-ability mechanisms in health care information infrastructure development as "**in, on, and of"**. Innovation "**on"** refers to extending the

existing infrastructure by adding new modules on top of what exists, Innovation "**in"** refers to replacing or modifying existing components of infrastructure without architectural change, innovation "**of"** infrastructures denotes conceptualization and implementation of new infrastructures including re-conceptualizing and re-engineering existing infrastructures.

Concerning the system, evolve-ability is enhanced by the system's evocative, adaptive, open-ended (Avital & Te'Eni, 2009), leverage, mastery of use, and accessibility features (Msiska & Nielsen, 2018; Zittrain, 2008). These evolve-able system features support users' inherent innovative capacity and leads the system to evolve. Research revealed how My Health Rec, a secure online summary of patients' health information system in the Norwegian health system, with evocative, adaptable, and open features allowed evolve-ability and led to success in the Norwegian public health care system (Grisot & Vassilakopoulou, 2013). Another study in the same context revealed how the lack of evolve-ability in technology hindered the success of Norwegian ambulant health service systems development and implementation (Hardy & Maguire, 2008). However, although evolve-ability is important in system implementation, uncontrolled evolve-ability is not always positive and can lead to complexity that triggers fragmentation (Hagiu & Halaburda, 2010).

Regarding governance, evolve-ability is facilitated by autonomous, decentralized, and collaborative situations, while also being limited by centralized governance and controlled process. On the other hand, the evolve-ability of IS in general and in particular in developing countries is challenged by the existing IT infrastructure, technical capacity, standards, and institutions (Avgerou, 2000).

In general, uncontrolled evolve-ability leads to fragmentation and overemphasized standardization processes to maintain alignment, efficiency, and control lead to reflexive standardization that can lead to increased complexity and ultimately hinder innovation or evolve-ability (Hanseth et al., 2006).

2.1.3 Balancing as HIS Implementation Challenge

Standardization and evolve-ability are tensions across IS implementation that needs to be addressed properly. In one aspect, IS research described how standardization enhances evolve-ability and vice versa. On the other hand, standardization and evolve-ability

activities in IS implementation can halt innovation and standardization respectively (Hanseth, Bygstad, Ellingsen, & Johannesen, 2012). Thus, failing to address one of these tensions in IS implementation leads either to stability or to fragmentation, which in turn leads to sustainability failure (Hanseth, Bygstad, Ellingsen, Johannesen, et al., 2012; Heeks, 2002). This is a common occurrence in developing countries, a system that works well initially but fails to keep working over time (Heeks, 2002).

Successful HIS requires having simultaneous standardization and evolve-ability efforts in the implementation process. Without standardization, communication and coordination amongst varying stakeholders is impossible, and without evolve-ability, local and emergent needs will not be addressed during IS implementation. HIS implementation should properly address both standardization and evolvability to prevent sustainability failure (Gaynor & Bradner, 2001; Gregory et al., 2015; Smith & Lewis, 2011).

However, addressing both is a challenge that requires different system and organizational design solutions, structures, routines, and culture (Avital & Te'Eni, 2009; Msiska and Nielsen 2018;Zittrain, 2008). For instance, standardization requires centralized structure, standards, protocols, or guidelines to instruct the implementer on how activities in specific situations should be performed. On the other hand, evolve-ability is often triggered by changes enhanced by decentralized structure, actors' autonomy, and the system's flexibility features, such as evocative, adaptive, open-ended, leverage, mastery of use, and accessibility features (Avital & Te'Eni, 2009; Msiska and Nielsen 2018;Zittrain, 2008). The problem concerns how an organization addresses this paradoxical tension between, standardization and evolve-ability, in IS implementation simultaneously (Dea Rocha & Pollock, 2019; Gregory et al., 2015; Tiwana et al., 2010). To address this paradoxical challenge, IS researchers argue that addressing contradictory issues should begin with a design solution (Hanseth & Lyytinen, 2010) and complement by appropriate IT governance mechanisms (Constantinides & Barrett, 2015; Yoo et al., 2010).

2.2 Digital Innovative Platform as a design solution

Scholars provide various design solutions, including design principles using dynamic complexity theory (Hanseth & Lyytinen, 2010), guidelines (Lars et al., 2017) and Enterprise architecture (EA), modular, layered architecture (Gaynor & Bradner, 2001),

digital platform (Tiwana et al., 2010) to strike the balance. Five design principles such as design for usefulness, based on the installed base, extending the installed base through convincing, simplifying IT capability, and modularization were suggested to address conflicting issues simultaneously (Hanseth & Lyytinen, 2010). This digital platform allows standardization and evolve-ability through its stable and module components (Baldwin & Woodard, 2008).

The digital platform is defined as an extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate (Tiwana, 2014). A digital platform enables value-creating interactions between external producers and consumers (Constantinides et al., 2018a; Sarker et al., 2012). Consumers can be application developers using the core functionality provided by the platform owner or an end user who uses the platform. There are two types of digital platforms, the transaction with market logic and innovation, that provide boundary resources for others to innovate apps (Msiska et al., 2019; Poppe, 2021). This study focuses on the innovation platform which enables the co-creation of value in the platform ecosystem by complementors. The advantage of an innovation platform is reducing the complex technical materiality app developers face by providing ready-to-consume boundary resources (Ghazawneh & Henfridsson, 2013). The software in this case study, DHIS2, is one example of an innovation platform that allows users to freely access, modify as they want, and distribute either the original or their own modified version (Nicholson et al., 2019).

The ubiquity of innovation platforms has led to increased attention to digital platform governance models in the IS field (Schreieck & Wiesche, 2016) as innovation platform does not work well in the conventional managerial hierarchy (Constantinides et al., 2018b; Yoo et al., 2012).

2.3 Lack of Paradox Perspective in IT Governance

Currently, scholars emphasize the importance of information technology (IT) governance to complement the system design solution (Constantinides & Barrett, 2014) which does not get adequate attention in IS implementation (Msiska & Nielsen, 2018). IT governance is an integral part of an enterprise or corporate governance that ensures the enterprise's IT sustains and extends the organization's strategy and objectives (Weill, 2004). IT governance is institutionalized decision-making structure, process, and communication

mechanisms that specify decision rights and accountability (Peterson, 2004; Weill & Ross, 2005).

Effective IT governance is determined by the way the IT function is organized and where the IT decision-making authority is located within the organization that is specified in the structure. The structure represents the tangible planning and organizational elements outlined by the high-level governance strategy, including IT organizational structure, committees, and boards (De & Grembergen, 2004; Weill & Ross, 2005). The dominant organizational structure approaches are centralized and decentralized. Public sector organizations have been criticized for having centralized, highly bureaucrats and controlled governance (Mergel et al., 2018) which is criticized for inertia and missed opportunities due to its resistance to changes. A decentralized structure promotes innovative activity which is often initiated locally and organized by a few members.

IT structure should be complemented with the process to monitor activities. Process refers to strategic decision-making, strategic information systems planning (SISP), and monitoring, control, and process frameworks to provide ongoing control and evaluation of the IT design, implementation, and use. The process tools include scorecards (De & Grembergen, 2004), Control Objectives for Information and Related Technology (COBIT) (Damianides, 2005), decision rights matrix (Korhonen & Pirttila, 2003), and the IT alignment maturity model (Weill & Ross, 2005).

Having well established IT governance structure and process does not lead to success unless it is supported by transparent communication between IT and business (Weill & Ross, 2005). Transparent communication overcomes the problem of domain awareness in both IT and the business field. Well-designed, well-understood, and transparent mechanisms promote desirable IT behaviors and individual accountability. Relational mechanisms include business/IT participation, strategic dialogue, training, shared learning, and proper communication.

However, others criticize such structured and centralized IT governance for leading to reflexive standardization and inhibiting innovation (Ciborra et al., 2000; Hanseth & Lyytinen, 2010; Sahay et al., 2009). This group promotes a flexible approach through bottom-up design using dynamic adaptive theory (Hanseth & Lyytinen, 2010) and polycentric governance (Constantinides & Barrett, 2015).

Regardless of these two extremes, centralized and decentralized governance, addressing both standardization and evolveability requires different IT governance mechanisms (structure, process, and communication). Decentralized or organic structure and autonomous process promotes evolve-ability, whereas centralized or mechanistic structure and controlled process promotes standardization (Hanseth & Bygstad, 2015; O'Reilly & Tushman, 2008). The range of existing IT governance frameworks and standards (Brown & Grant, 2005; Ross & Weill, 2005) focused on form and structure (Smith & Lewis, 2011) are inadequate for discussing the inherent contradictions in IT governance (Gregory et al. 2015; Smith, 2011; Constantinides & Barrett, 2014). The organization's response to such contradiction may determine its fate, success, or failure (Smith & Lewis, 2011). Thus appropriating the context with decentralized IT governance for evolve-ability without control or standard leads to fragmentation and can trap companies in an endless cycle of evolve-ability (Volberda & Lewin, 2003). On the other hand, putting more acts on control or standardization with centralized governance limits the firm's innovation and hinders their response to changes or evolve-ability (Hanseth & Bygstad, 2015). Thus organizations must meet the balance.

Scholars stress the paradox perspective for organizational success depends on meeting competing demands simultaneously, such as standardizing at the same time as ensuring successful change through evolve-ability (Constantinides & Barrett, 2015; Gregory et al., 2015; Smith & Lewis, 2011). Recently, ambidexterity literature reveals how IT governance practices aim to balance the contradictory issues by rearranging the governance mechanisms such as structural, contextual, and temporal (Banker et al., 2011; Gibson & Birkinshaw, 2004; Gregory et al., 2015; Liang & Wu, 2011; Luger et al., 2018).

2.4 Ambidexterity

The word ambidexterity is derived from the Latin ambos (both) and dexter (right). In biology, ambidexterity is the ability of humans to use both hands with equal proficiency. Ambidexterity can also be used to define an organizational capability for addressing conflicting issues at the same time (Simsek, 2009). The ambidextrous organization is defined as being efficient for meeting current needs, while also being responsive enough to future environmental changes (Gibson & Birkinshaw, 2004). Firms with greater technological capabilities and large organizations benefitted more from ambidexterity (Lars et al., 2017). Furthermore, ambidexterity is especially valuable in uncertain

environments (Hornnes et al., 2010). Scholars use the ambidexterity concept as an analysis lens for balancing conflicting activities such as efficiency and innovation (Kizito & Kahiigi, 2018); exploration and exploitation (Stettner & Lavie, 2014b); alignment and adaptability (Raisch et al., 2009); control and generativity (Blaschke & Brosius, 2018).

Although balance is necessary for success, it is hard to define. Some scholars emphasize finding an equal position to balance conflicts, while others focus on relative balance. Those emphasizing finding equal position stated that a precise mix of conflicting activities is required for an organization to survive, such as standardization and evolve-ability (Gregory et al., 2015; Tilson et al., 2010), exploration and exploitation (Raisch & Birkinshaw, 2008), and stability and variety (Wareham, 2014). He and Wong (2004) demonstrate how equally proportionate tendencies are needed for superior performance to be achieved. Different from finding the middle point to balance, others describe how environmental dynamism and organizational issues such as mission, dominant logic, and industry conditions, determine the proportions of the conflicting issues (Auh & T, 2005; Sidhu et al., 2004). Other scholars with process perspectives emphasize an organization's efforts to balance instead of finding the actual proportions of contradictory issues that shifted to balancing (Gibson & Birkinshaw, 2004; Lavie et al., 2010). Although there is consensus on the importance of balancing, it is little known about the means to get the balance (Ghazawneh & Henfridsson, 2013). This study focuses on how to get on such balance through IT governance mechanisms.

Various ambidexterity mechanisms such as temporal, structural, and contextual mechanisms are advocated for handling conflicting issues (O'Reilly & Tushman, 2013). Temporal ambidexterity refers to conducting two contradictory activities at different points in time and switching between them periodically (Gibson & Birkinshaw, 2004; Turner et al., 2013). However, the temporal solution is criticized in a rapid change environment in relation to short stability time.

Structural ambidexterity promotes organizing two different units for each activity and integrating them at the top management level later (Andriopoulos & Lewis, 2009; Gibson & Birkinshaw, 2004; O'Reilly & Tushman, 2008). Contextual ambidexterity highlights the inadequacy of these separating activities by time and structure due to the coordination and transition problems with the isolated activities. This contextual ambidexterity scholars emphasize appropriating the process and systems to pursue both activities in one unit by giving individuals the autonomy to alternate between the two (Gibson & Birkinshaw, 2004; Hornnes et al., 2010). Appropriating the organizational contexts with

stretch, discipline, support, and trust provide the capabilities for members of the organization to achieve the two activities simultaneously (Gibson & Birkinshaw, 2004). This is supported by empirical evidence in Singapore Airlines (Heracleous & Wirtz, 2014). Furthermore, given the contemporary organization is engaged in various relations with other organizations, ambidexterity helps achieve balance by promoting boundary-spanning activities across organizations through alliance (Rosenkopf, 2011).

Recently, dynamic ambidexterity research acknowledges the importance of structural, contextual, and temporal solutions but criticizes its static perspective because the choice to alternate evolve-ability and standardization depends on the organization's size and resource availability because small and resource-constrained organizations inclined to efficiency or standardization and the big one focuses on evolve-ability (Luger et al., 2018). Thus, dynamic ambidexterity advocates the dynamic capability of the organization as a driver of performance and a necessary prerequisite for success in changing environments, and contexts (Birkinshaw et al., 2016). In congruence with dynamic ambidexterity, this study employs the dynamic ambidexterity concept to analyze how to address the conflicting issues in the health sector in which changes occur frequently. Table 1 details the characteristics of IS implementation concerning governance mechanisms

Table 1 Characterizing IS Implementation with Governance Mechanisms

Governance Mechanisms	Implementation		
	Standardization	Evolve-ability	Balancing
Structure	Large, Centralized(Constantinides et al., 2018a; Constantinides & Barrett, 2015; Hanseth, 2016; Hanseth & Bygstad, 2015; O'Reilly & Tushman, 2013, 2008)	Small, Decentralized(O'Reilly & Tushman, 2013), Organic systems with a lack of formally defined tasks, more lateral coordination mechanisms, and less reliance on formalization and specialization(Lars et al., 2017)	Structural separation(O'Reilly & Tushman, 2008); integration(Smith & Lewis, 2011); Architecture based governance Decoupling or separating (O'Reilly & Tushman, 2013), collaboration (Hornnes et al., 2010; Battilana et al., 2009); synthesis(Papachroni et al., 2015)
Process	Anticipated efficiency, control, and incremental(Hanseth &	Flexibility (Ciborra et al., 2000; Hanseth & Lyytinen, 2010)	compromising(Oliver, 1991); Contextual balancing (Gibson &

Governance Mechanisms	Implementation		
	Standardization	Evolve-ability	Balancing
	Bygstad, 2015; Lars et al., 2017); Scorecards(Grembergen, 2004), COBIT(Damianides, 2005), Decision right matrix(Korhonen & Pirttila, 2003), IT alignment maturity model(Weill & Ross, 2005)	(Ciborra et al., 2000; Hanseth & Lyytinen, 2010), autonomy, and experimentation(Lars et al., 2017) end-to-end architecture (Saltzer et al. 1984)	Birkinshaw, 2004); flexible standardization(Braa et al., 2004; Hanseth & Bygstad, 2015), flexible generification (Hanseth & Bygstad, 2015);Generic(Zittrain, 2008);open generification(Gizaw et al., 2017) ; Dynamic ambidixterity(Luger et al., 2018);(Ghazawneh & Henfridsson, 2013)
Communication	Hierarchical(Hanseth & Monteiro, 1997)	Bottom up(Zittrain, 2008)	Network (Braa et al., 2004)

CHAPTER 3: **Theoretical Background**

This chapter presents a discussion on the core concepts used to build the conceptual framework of the thesis (institutional logic, dynamic ambidexterity, boundary resource built from institutional theory, platform governance, and ambidexterity) and a summary of the conceptual framework used to inform the study's research questions and methodology.

3.1 Institutional Theory

The institutional theory offers institutional logic concept to unpack the socio-cultural elements of IT governance and the management paradox (Jacobson, 2009; Kizito & Kahiigi, 2018). Given HIS complexity which generates contradictory issues; the study adopts the institutional theory contemporary concept, institutional logic, to describe and analyze actors' logic, tensions, and management in HIS implementation.

Institutions constitute stable routines, practices, and norms that are resistant to change and transmitted across generations through cultures, social structures, routines, and artifacts (Jepperson, 1991; Scott, 2001). The institutional theory asserts that information technology implementation should be congruent to the recipient organization's normative, cognitive, and regulative institutions for success which is often called isomorphism. However, isomorphism has been difficult to achieve in complex environments that also disregard the role of IT, agency, and macro issues. Despite its stability, the existing institutions can be changed downward or eroded through the process of deinstitutionalization and replaced by new institutions incrementally through the process of institutionalization (Jepperson, 1991; Scott, 2001). Institutionalization can be facilitated or occurs through different mechanisms such as structural overlap, event or temporal sequencing, institutional entrepreneurs, and competing institutional logic (Jepperson, 1991; Thornton & Ocasio, 2012). This study emphasizes the institutional logic concept to describe how tensions guide the institutionalization of the decision-making for governing IS implementation at the field level which are described as follows.

3.1.1 Institutional Logic

Institutional logic is defined as a socially constructed, historical pattern of material practices, assumptions, values, beliefs, and rules used by individuals to produce and reproduce their material subsistence, organize time, and space, and provide meaning to

their social reality (Thornton & Ocasio, 2012). When diversified actors with different institutional and social backgrounds are involved in IS implementation at the field level, which is, they often employ different information technology (IT) perspectives, which can impact IT governance and, in turn, affect IS implementation. IS implementation, particularly in a health setting, can lead to stakeholder contradiction due to the multiple perspectives of the heterogeneous actors involved (Gutierrez & Friedman, 2005). Institutional logic is characterized by principles, assumptions, identities, and domain dimensions (Berente & Yoo, 2012). The principles dimension guides stakeholders' actions and embodies the goals and values of the institutions. The assumption dimension refers to the means to reach a certain goal. Identities are formed based on the enactment of selected scripts of certain institutional logic. Finally, the domain dimension relates to the application area. These dimensions are used to characterize institutional logic in a different context (Berente & Yoo, 2012; Tumbas & Schmiedel, 2015). Institutional logic concept value lies in tying local action to society's broader institutional structures (Friedland & Alford, 1991).

Institutional logics is never homogeneous; within an organization, multiple logics may be simultaneously in play (Friedland & Alford, 1991). Heterogeneous actors may draw on different logic and exercise their power to influence decision-making (Xue et al., 2012). For instance, actors use institutional logic as the organizing principle to select technologies, authorize actors, and specify criteria for effectiveness and efficiency (Greenwood et al., 2011; Lounsbury, 2002). For instance, scientists at NASA delegate administration workers to do procedural activities to focus on their scientific work (Berente & Yoo, 2012). Platform owners in the case of ERP software implementation set criteria for third-party developers to select the system development level (Wareham, 2014). Multiple logics in the organization field can complement and compete with each other (Goodrick & Reay, 2011).

3.1.2 Competitive Logics and Collaboration

Cooperative logic supports each other through facilitative or additive mechanisms (Goodrick & Reay, 2011). Competitive logic contributes to institutional contradictions, which results in the change or new activities in the organization field (Thornton & Ocasio, 2012). Competitive logics creates dominant logic that influences implementation.

Organizational field change is often related to dominant logic (Thornton & Ocasio, 2012). Dominant logic is conceptualized as organizing and guiding the behavior of social actors in the organization field whereas other competing logics will continue challenging the dominant actor to advance their dominance (Goodrick & Reay, 2011). The dominant logic-led IT governance might lead implementation to one extreme, either to standardization or evolve-ability, which is not suitable for long-term sustainable system implementation (Montealegre et al., 2019; Smith & Lewis, 2011). Furthermore, it is not optional for contemporary organizations where multiple stakeholders are involved in a dynamic world (Luger et al., 2018). In such dominant actor, lead IS implementation, incumbent actors will continue challenging the dominant actors to advance their dominance. The dominant-led IS implementation characterized by competition then often results in sustainability failures (Werder & Heckmann, 2019).

Regardless of the competitive logic, recent research suggests employing a collaborative approach will allow all logic to co-exist through understanding multiple IS implementation stakeholders and their logic (Asangansi, 2012; Berente & Yoo, 2012; Boonstra et al., 2017). Collaboration is defined as a group of autonomous stakeholders of a problem domain engaging in an interactive process that uses shared rules, norms, and structures to act or decide on issues related to that domain (Baldwin & Woodard, 2008) yet collaborators might hold different interests, identities, and intentions. Some sustain collaboration while maintaining their own identity and others enact a new identity by partially diverting from their former identity (Maguire et al., 2004; Reay & Hinings, 2009). Literature reveals how collaboration supports the co-existence of competing logics which requires senior managers' distance from prevailing institutional logic to employ collaborative strategies for successful IS implementation in complex settings (Berente & Yoo, 2012; Boonstra et al., 2017; Jones et al., 2015; Lepoutre & Valente, 2012). Collaborative strategies allow stakeholder entities to maintain their own identity using separation, informal communication, cooperation, and establishing experimental site techniques (Reay & Hinings, 2009), while others show stakeholders adopting and enacting others' identity over time (Boonstra et al., 2017). For example, NASA used alliance, joint experimenting, interpreting, and delegating mechanisms in their IS implementation (Goodrick & Reay, 2011; Reay & Hinings, 2009). Furthermore, these strategies proved successful in Nigeria, with a changeover and dialectical resolution for successful HMIS implementation in the face of conflicting logic (Asangansi, 2012).

Thus, explicating different stakeholders' logics in IS implementation, particularly in resource-constrained settings, is crucial to enable managers to devise appropriate ambidexterity mechanisms to balance conflicting activities. However, failing to understand key actors' institutional logic might lead managers to use the dominant actor's logic, which can lead IS implementation to an either-or strategy, standardization, and evolve-ability (Boonstra et al., 2017; Sahay et al., 2009, 2010). Scholars stress the paradox perspective of organizational success depends on meeting competing demands simultaneously, such as standardizing at the same time as ensuring change through evolve-ability (Constantinides & Barrett, 2015; Gregory et al., 2015; Smith & Lewis, 2011). Thus, research recommends managers employ problem-solving and creative thinking abilities to solve how opposing elements can logically or meaningfully co-exist (Berente & Yoo, 2012; Reay & Hinings, 2009) that enables to address both conflicting activities simultaneously which is described in the next section.

3.2 Dynamic Ambidexterity

Organizational ambidexterity is a construct that refers to a firm capability to handle contradictory issues i.e. exploration and exploitation; flexibility and standardization (O'Reilly & Tushman, 2013). The former ambidexterity literature focuses on static perspective whereas the more recent organizational ambidexterity has been conceptualized as a dynamic ambidexterity based on the insight that achieving organizational ambidexterity may involve sensing environmental threats, seizing opportunities, and dynamically reconfiguring resources accordingly (Birkinshaw, Zimmermann, & Raisch, 2016; O'Reilly & Tushman, 2008). Dynamic ambidexterity emphasizes balancing the conflicting activities continuously (Luger et al., 2018; Magnusson et al., 2021) rather than optimal balancing based on context (O'Reilly & Tushman, 2008; Raisch et al., 2009). Optimal balancing is rearranging organization to standardization or evolve-ability depending on context. Dynamic capability with distinct skills, competencies, systems, incentives, processes, procedures, organizational structures, decision rules, and disciplines for conflicting activities enable the senior managers to identify threats and opportunities which help them to reconfigure assets to meet the conflicting activities (Luger et al., 2018; O'Reilly & Tushman, 2008). The different organizational units with distinct characteristics are held together by developing common strategies, shared values, and targeted structural linking mechanisms to leverage shared assets (Rotemberg & Saloner, 2000).

To happen this senior management should articulate a common vision and strategic intent, shared values, and meaning that provides a common identity to standardize and evolve simultaneously (Rotemberg & Saloner, 2000). Senior managers are key in establishing organization ambidexterity through sensing, seizing, and reconfiguring the resource (Luger et al., 2018). Sensing opportunities and threats requires scanning, searching, and exploration of their context and environment. Seizing opportunities is about making the right decisions, crafting a vision and strategy, and deciding on resource allocation and timing, and execution (Harreld et al., 2007; O'Reilly & Tushman, 2013). Finally, reconfiguring the existing assets, and organizational structures based on markets and technologies change to sustain both which is referred to as asset orchestration (Teece, 2007). Regardless of universal dynamic capability, scholars suggested various adoption strategies for different implementation context include structural separation, behavioral integration, or sequential alternation (Birkinshaw et al., 2016).

This study found dynamic ambidexterity as an appropriate strategy to achieve standardization and evolve-ability in a continuously changing health care setting particularly in resource-constrained settings where IT computerization is at an infant stage. However, we argue that dynamic ambidexterity in particular, and ambidexterity, in general, is challenging for resource-constrained settings as it requires adequate resource and technological capability which is absent in the setting. Furthermore, the organizational ambidexterity literature scantly addresses the contemporary organization as a nexus of multiple organizations collaborating with different institutional backgrounds and perspectives on IT. In such organizations, how IT managers are involved in governance is affected by different and potentially diverging beliefs, values, and norms which is rarely addressed in IS research (Boonstra et al., 2017; Kizito & Kahiigi, 2018). Such influence is immense in developing countries where multiple donor organizations render system implementation technical and financial support (Sanner & Manda, 2014). It is worth noting the need for balancing surpasses the stakeholders' interest due to the lack of technical and financial capacity in the resource-constrained setting of public health care where there is a lack of empirical and theoretical evidence (Asangansi, 2012; Masiero, 2020).

Thus, unless ambidexterity is consciously managed, senior leaders can easily make invalid inferences from their organizational learning (Denrell, 2003). For instance,

senior managers' decision in resource-constrained countries is often driven by donor organizations (Asangansi, 2012; Gebre-mariam & Bygstad, 2019; Sanner & Moyo, 2013). Therefore, we argue that dynamic ambidexterity should be configured according to the resource-constrained context. Dynamic ambidexterity in the resource-constrained setting should begin with navigating and enacting major logics of the sector at the scanning stage that enables addressing standardization and evolvability simultaneously. Enacting other logic requires seizing and reconfiguring the IT governance mechanisms based on the implementation context including socio-technical elements. Thus we argue that it is important to discern the heterogeneous actors' logic, and contradictions behind the implementation to enact other logics and seize and reconfigure IT governance mechanisms. Accordingly, the dynamic implementation governance framework is adapted to suite for resource constrained setting as shown in figure 2.

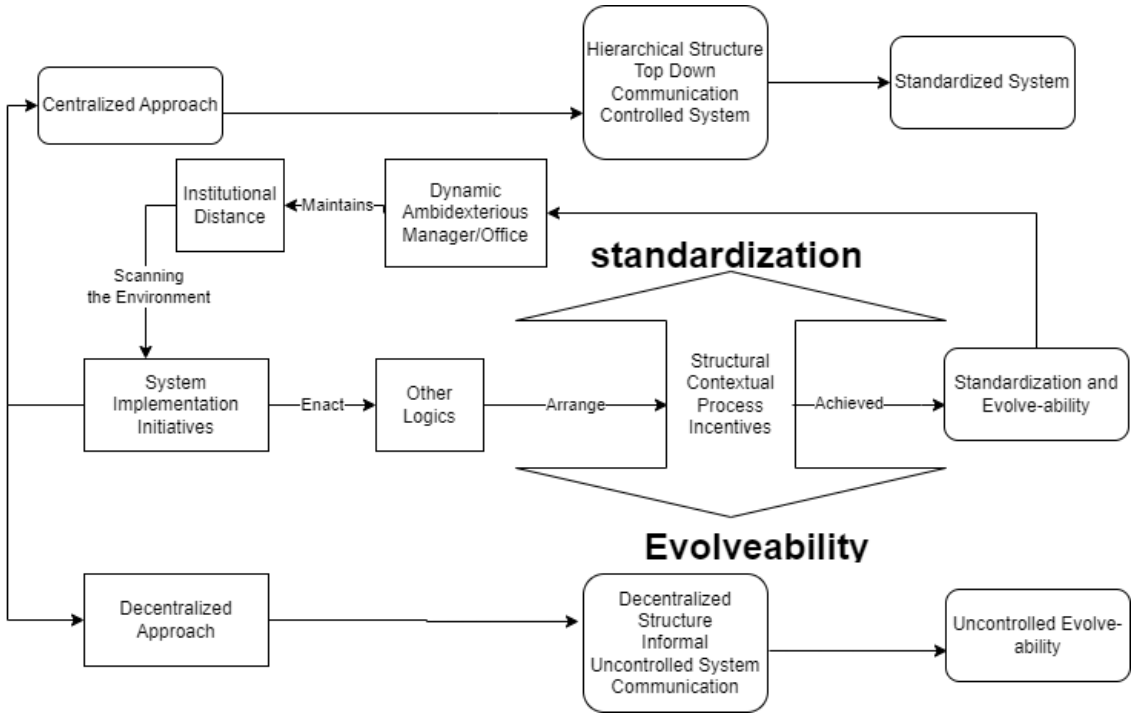


Figure 2 Dynamic Implementation Governance Framework Adapted from (Lavie et al., 2010; O'Reilly & Tushman, 2008)

The implementation framework begins with dynamic organization/managers' dynamic capability to be complemented with maintaining institutional distance from the prevailing institutional logics which enabled to encourage searching, identifying, and enacting the existing/unprecedented institutional logics in the organization field. Enacting other logic require reconfiguring the IT governance mechanisms (structure, process, communication). Dynamic ambidexterity describes the importance of structuring,

context, and process for resource configuration. However, it does not specify which mechanisms for what context, this study employs platform governance and the boundary resource model to specify the mechanisms for resource re-configuration. The suitability of platform governance and this model to the case is described as follows.

3.3 Platform Governance

Platform technology implementation in the resource-constrained setting is often guided by the established hierarchical IT governance based on dominant institutional logic (Gawer, 2014; Sahay et al., 2010; Woldeyohannes et al., 2022), resulting in either a fragmented (Woldeyohannes et al., 2022) or rigid (Sahay et al., 2010) system that leads to sustainability failure. This indicates how the innovation platform does not work well in the conventional managerial hierarchy, it is demanding a new governance model (Tiwana et al., 2010; Woldeyohannes et al., 2022).

Platform governance is the partitioning of decision-making authority between platform owners and app developers, control mechanisms, and pricing and pie-sharing structures that impact the platform ecosystem (Tiwana, 2014). A platform's governance model divides the organizations into two parts, core, and periphery, which allows platforms of half-realized, not-yet-made solutions and visions to emerge (Baldwin & Woodard, 2008; Tiwana et al., 2010). Such governance overcomes the key challenge that face platform owners is to maintain tight integration at the platform level, while allowing loose couplings horizontally to cater to the needs across different knowledge communities (Baldwin & Clark, 2000; Yoo et al., 2010). For instance, an integrative approach was employed at Apple to maintain balance by involving heterogeneous actors who leverage innovations and powerful platform owners to control third-party developers without constraining their innovation (De Reuver et al., 2018; Eaton et al., 2015).

This study proposes that platform governance for resource-constrained settings is beyond its technical suitability. First, the implementation context of a resource-constrained setting heavily relies on multiple international organizations' financial and technical capacity based on a decentralized governance strategy. Second, there is no adequate system and capability in government to address continuous emergent data needs. Third, The health institution and staff are craving to receive new systems not only for system needs but also for the material and financial resources that come in association with a new

system (Lars et al., 2017). Thus this implementation context is appropriate to categorize the system development and implementation stakeholders into two as platform owner and third-party developers.

Public health institutions like MOH can be regarded as a platform owners for the modified version of DHIS2 at a national level where as diverse health programs and partner organizations who engaged in specific program system implementation can be considered as third-party developers for the sector. Furthermore, this study categorized partner organizations in IS implementation into two based on their technical capability as partner organizations with core system knowledge and technical capability and partner organizations with periphery system technical capability. Partner organizations with core system knowledge and technical capability can be assigned to work with the platform owner i.e. MOH in standardizing the system where as partner organizations with periphery system knowledge and technical capability work with health programs as third-party developers for specific health programs systems, modules, or app development. However, platform governance did not detail the means to achieve the tensions. Others claim the process theory perspective emphasizes the importance of an ecosystem-wide controlling system to navigate tensions between co-created value and cost control (Huber et al., 2017). Accordingly, the boundary resource model is provided to use it as a means to address the tensions.

3.4 Boundary Resource Model

The boundary resource model is a securing-resourcing model which is developed based on boundary resources to maintain balance in digital platform technology (Ghazawneh & Henfridsson, 2010). Boundary resources can be tools, regulations, or other resources that are often provided by platform owners to govern the co-creation of value in platform ecosystems (Eaton et al., 2015). A boundary resource that is gaining importance in practice is data that is provided by the users of a platform and can be made accessible to third-party developers (Gawer, 2014). The platform resources facilitate a shift of design capability to external actors who, typically make a business on developing applications for the platform (Von Hippel & Katz, 2002). On the other hand, it enables the platform owner to secure platform control and maintain its integrity by providing data standards, appropriate rules and regulations to maintain quality and achieve its goal (Boudreau, 2010). For example, application programming interfaces (APIs) and software

development kits (SDKs) facilitate the development of the application whereas rigid regulations for the approval of complementary products or services on a platform may decrease the complementor's motivation (Eaton et al., 2015). The platform owner may then reap the benefits of distributing, brokering, and operating the developed applications, transforming the owner from a software producer into a distribution channel (Meyer & Seliger, 1998).

Similarly, MOH as a platform owner for the modified version of DHIS2 at a national level in cooperation with core system partner organizations and research development institutions like universities can design national boundary resources, to enhance the design capability of government and international organizations' IT work-forces while controlling fragmented systems implementation. Thus, this study argues that in addition to technical boundary resources supplied by the global platform owner, national-level boundary resources (i.e capacity building, national-level standard data, rules, and regulations) can be designed and supplied by the MOH at the periphery to facilitate and control third-party or international organizations uncontrolled system implementation. International organizations in cooperation with health programs can use this boundary resource to program specific systems, modules, and app development which are also useful for maintaining standardization.

In general, health institutions with core system knowledge and skill partner organizations in cooperation with research development institutions, such as universities can work on standardizing the evolved, evolving, planned to evolve, and emerged systems, modules, and applications by designing boundary resources. Health programs with periphery system knowledge and skill partner organizations can work on system, module, and application development and implementation based on the boundary resources supplied by the central actors by which standardization and evolve-ability can be balanced. Public health institutions at various levels should scan their respective implementation context to identify and enact emergent institutional logic to seize and reconfigure the IT governance mechanisms continuously for balancing standardization and evolve-ability.

Although the boundary resource concept has been widely used in IS literature to analyze the relationships of actors to enhance and sustain the platform (Gawer, 2014; Ghazawneh & Henfridsson, 2013), most digital platform IS research has been conducted in the

developed context. The developing countries' context is scantly addressed and requires more research in digital platform technology and governance (Masiero, 2020).

To address this gap, the boundary resource model was modified to make it useful for digital platform implementation in resource-constrained setting which is largely dependent on various international organizations' financial and technical capacity but use a decentralized governance strategy. The concept is used to explicate the relationship of major stakeholders, including health institutions at various administration levels, international organizations who have huge roles in HIS implementation in Ethiopia, managers, health programs, and ICT professionals, for maintaining standardization and evolve-ability in DHIS2 implementation in the public health care of the resource-constrained setting.

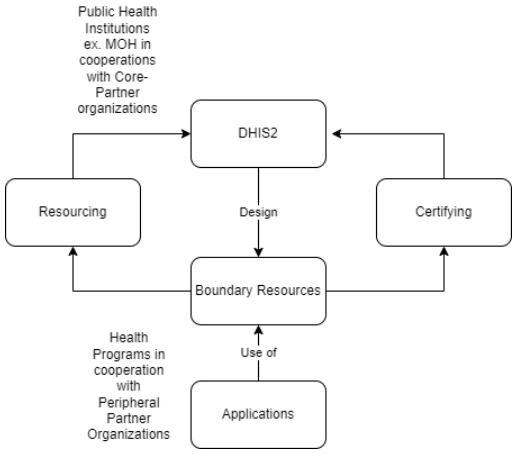


Figure 3 Boundary Resource Model For DHIS2 at National level

Platform: Country specific DHIS2 platform adapted from the global DHIS2 ex. DHIS2-Ethiopia

Boundary Resources: The software tools and regulations that serve as the interface for the arm's- length relationship between health institution and international organizations as a developer. Ex. Indicator reference document, organizational data migrated from previous e-hmis, system development agreement

Third-Party Applications: Executable pieces of software that are offered as applications, services, or systems to end-users of the platform ex. DHIS2-routine, COVID19, EPHEM, data quality, data entry

Boundary Resources Design: The platform owner's and the health institution act of developing new, or modified, boundary resources as a response to perceived external contribution opportunities and control concerns. Ex. MFR and TERMINOLOGY designing, national indicator reference document preparation to standardize health data, agreement

Boundary Resources Use: The internal organizations act of developing end-user applications drawing on boundary resources offered by the MOH or by the levels of health care administration(MOH, RHB, ZHO, WHO, HF)

Resourcing: The process by which the scope and diversity of a platform or a system is enhanced

Certifying: The process by which the control of a platform or a system and its related services is increased

3.5 Summary of the conceptual framework

Using DHIS2 implementation in Ethiopia as a case study setting, this thesis aims to understand and promote balancing inherently contradictory activities in HIS implementation, standardization, and evolve-ability, given that research shows that either-or strategies result in sustainable failure. Furthermore, despite, the developing countries' context being characterized by extensive scarcity, change, and multiplicity

which is a source of paradox, it is scantly researched with a paradox perspective. This study seeks to link the inherently contradictory IS implementation activities with IT governance using a paradox perspective. Thus, IS implementation in this study is conceptualized as a continuously balancing activity between standardization and evolve-ability and should be supported by paradox perspective IT governance.

To do so, relevant literature has been reviewed and presented in this chapter. First, the chapter highlighted the problem of HIS implementation challenges related to standardization and evolve-ability to highlight the need for balance during HIS implementation. Second, based on the paradox perspective, HIS implementation is conceptualized as a dynamic balancing act that requires continuous scanning of the implementation context to formulate IT governance mechanisms that simultaneously address standardization and evolve-ability. Thirdly, the chapter presents important concepts that are used to analyze and discuss the HIS implementation and IT governance mechanisms that enable the balancing of standardization and evolve-ability. Using these concepts independently did not reveal the holistic process of IS implementation, thus integrative frame work was formulated to unpack the structure, process and communication of IS implementation with contradictory issues.

Viewing IS implementation as a dynamic balancing activity of the contradictory issues, institutional logic from contemporary institutional theory (Thornton & Ocasio, 2012), boundary resource (Ghazawneh & Henfridsson, 2013) from platform governance, and dynamic ambidexterity (Luger et al., 2018) from organization science were used to build an integrated implementation governance framework as shown in figure 4.

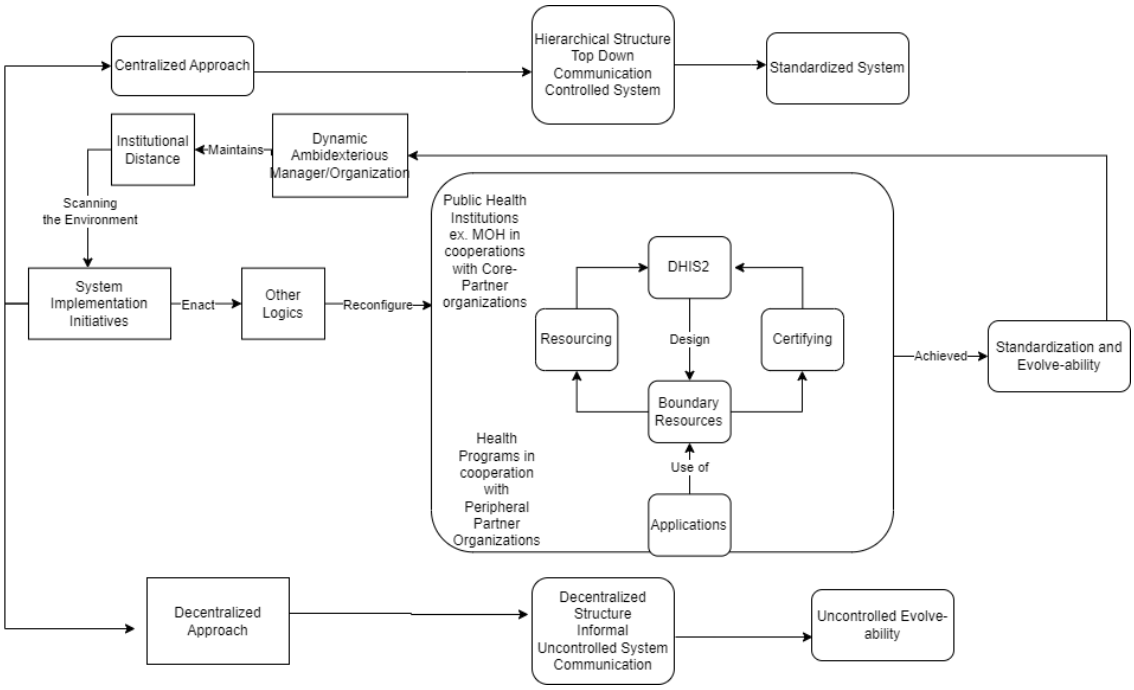


Figure 4 Integrated Implementation Governance Framework for DHIS2 at national level adapted from (Ghazawneh & Henfridsson, 2013; O'Reilly & Tushman, 2008; Stettner & Lavie, 2014b)

This framework is used to study how the HIS implementation process is perceived and results are realized in line with IT governance, contributing to both theory and practice. Institutional logic is used as an analysis lens to identify stakeholders' perspectives and contradictions underlying IS implementation. Based on the process theory perspective, the study adopts the dynamic ambidexterity and boundary resource concepts to unpack the HIS implementation process and governance mechanisms that enable balancing.

Institutional logic is used to explore the tensions within IS implementation and the competing and cooperative logic is used to understand the managers' response to multiple institutional logics. The contradiction of multiple institutional logics around system ownership, technical capacity, the type of data collected, and actor selection in DHIS2 configuration, reveal how and why IT governance mechanisms were designed in a particular way that led the IS implementation towards standardization and/or evolve-ability.

Given the continuous change in the health sector, the IS implementation should embody continual processes that lean to use the dynamic ambidexterity theory. Dynamic ambidexterity paves the way for an organization to establish a common vision for multiple stakeholders with diverse logic, and set dynamic processes to identify and seize emergent actors with their logic to achieve both standardization and evolve-ability. The

boundary resource model unpacks the IT governance mechanisms of the implementation context, which adopts platform technology's open-source feature, and decentralized governance strategy to provide access to donor organizations that support health care at lower levels by implementing systems.

In this thesis, however, the framework is used as a guiding framework to study the HIS implementation process. The integrated framework explains the relationship between major IS implementation stakeholders in the organization field the government health institutions as the platform owner for the modified version, and non-government institutions with IT and financial capacity as third-party developers to the sector. Furthermore, health, IT, and managerial professionals with diverse institutional logics can be categorized in these organizations to balance standardization and evolve-ability. Health institutions with core system partner organizations can engage in boundary resource design to control and enhance the health programs and partner organizations with system periphery system technical capability system development and implementation.

The conceptual framework underpinning this study that uses, institutional theory, ambidexterity, and platform governance enables me to uncover the heterogeneity and complexity of HIS implementation that shape the IT governance mechanisms for balancing standardization and evolve-ability. The study unpacks the health information implementation context and the institutional complexity of HIS to understand how the heterogeneity and institutional logics shape the balance of standardization and evolve-ability in IS implementation with IT governance focus. This integrated framework suitable to context is used as a framework to study and analyze the DHIS2 implementation. Institutional logic is used to uncover the heterogeneous actors of DHIS2 implementation and their logic, dynamic ambidexterity is used to explore the organizational process of the implementation including how system implementation was initiated, actors were selected or disregarded, and how they addressed their needs, and boundary resource model is used to identify the enabling a controlling activities of DHIS2 implementation.

CHAPTER 4: **Research Methodology**

This chapter describes the research approach and methods used in this study and is divided into four sections. In the first section, the ontological and epistemological assumption is described and followed by the adopted research paradigm of this study. Section two describes the research design, detailing the appropriateness of a case study for this context, researcher involvement, and the research setting. This is followed by a description of multiple data collection techniques in section three. Next data analysis using a hermeneutics approach, its suitability for this study, and how it was used are discussed in section four. Finally, a summary of the chapter in diagrams is presented.

4.1 Research Approach: Interpretive

Ontological, and epistemological philosophical assumptions and methodological choices in IS research are categorized as positivist, interpretive, and critical realities (Myers & Avison, 2002; Walsham, 1995b). Ontological assumption refers to what reality, is whereas epistemological assumption concerns how knowledge is constructed about reality. The specific ways of studying and understanding the specific phenomenon are regarded as methodological choices. These philosophical assumptions and methodological choices are related to each other. The researcher's ontological knowledge informs the epistemological assumptions or how that knowledge is constructed which determines the research methodology. The research methodological choice specified how to study and understand the research phenomenon. These fundamental philosophical assumptions related to IS research are presented as follows to position my study with in IS research field.

Positivist research assumes reality as objective and independent of humans that can be understood through specific variables, hypotheses, and measurement (Myers & Avison, 2002; Orlikowski & Baroudi, 1991). The researcher's role in the positivist tradition is to formulate hypotheses, not influenced by the researchers' prior knowledge, to test theories, and discover generalizable knowledge (principles or laws) about the natural and social world (Walsham, 1995a).

Different from the positivist tradition, critical researchers consider reality as constructed by humans (Myers & Avison, 2002). Critical realists claim that humans are influenced by their culture, structure, and political situations while shaping their reality. Thus,

critical research focuses on oppositions, conflicts, and contradictions in society and how to eliminate such influence. Critical research challenges the existing beliefs, values, and assumptions that might be taken for granted by researchers, study subjects, or society under consideration (Orlikowski & Baroudi, 1991). Critical research aims to highlight the constraining political, cultural, and structural issues human beings face when attempting to achieve desired goals (Klein & Myers, 1999).

The interpretive approach similar to critical realities assumes reality and knowledge are a product of social construction. Knowledge cannot be accessed independently of human actors. Rather, it is shaped by the researchers' prior information and interactions with the informants, which opposes the positivist stance for considering knowledge as objective and measured by dependent and independent variables (Myers & Avison, 2002; Walsham, 1995a). This research focuses on understanding the complexity of the human understanding process in a situated context and explores the participants' cultural and historical context to understand their meaning and produce a deep understanding of phenomena in a context (Walsham, 1995b; Walsham & Sahay, 2005). Thus, knowledge is considered relativistic and can be accessed by revealing the meanings and interpretations of people attached to the research phenomenon and their understanding of the social and organizational context (Orlikowski & Baroudi, 1991).

IS research emphasizes the importance of context to understand and shape IS design, development, and implementation (Avgerou, 2000) and an interpretive approach to IS research can help unpack the organizational and social context of IS in contemporary organizations where there is dynamic change (Chen & Hirschheim, 2004; Klein & Myers, 1999; Walsham, 1995b). The interpretive approach helps researchers answer how and why the ISs are designed, developed, and implemented by examining human thought and action in social and organizational contexts (Klein & Myers, 1999). Research using an interpretive approach often reveals how IS influences and is influenced by its context (Walsham & Sahay, 2005). Therefore, the interpretive researcher's role is not to come up with a generalized prediction, like the positivist stance. Rather, the focus is on understanding a phenomenon within its specific context. Generalizations in interpretive research could be concept development, theory development, drawing specific implications, and rich insight contributions, all of which can apply to other similar contexts (Walsham, 1995a).

Therefore, this research is positioned under the interpretive tradition. Ontologically, IS implementation and its governance is assumed as paradoxical activities in which diverse stakeholders and their context play a critical role influencing and being influenced in the process. Thus, reality is considered the product of the diverse stakeholders' interpretations. Epistemologically, knowledge about (IS implementation and governance) reality is assumed to be only gained through the researcher's and stakeholders' interactions in the implementation context.

This study falls under the interpretive tradition for three major reasons. First, the study focuses on IS implementation process in a resource-constrained context that has critical value to influence and is influenced IS implementation. Second, the study emphasizes on contradiction and its management in IS implementation from the perspectives of stakeholders' institutional logics, which requires the understanding of stakeholders' principles, assumptions, values and beliefs regarding IS implementation. Finally, the study unpacks the organizational, social, and technological roles of managing contradiction in IS implementation. Thus, this research is guided by an interpretive approach for studying IS implementation process in its context.

An interpretive case study research design is adopted (Klein & Myers, 1999; Walsham, 1995b; Walsham & Sahay, 2005) to describe and analyze the case. Interpretive research focuses on understanding the complexity of human sense-making processes in situated contexts. This approach helps deepen the understanding of the complex problems in HIS implementation, which involves heterogeneous actors' principles, values, and assumptions, influencing managers' IT governance mechanism design (i.e, authorization, process, and communication). Actors can give various justifications for similar activities according to their context (Marvasti, 2018; Walsham, 1995a; Walsham & Sahay, 2005) that lead the IS implementation to standardization and/or evolve-ability. Thus, understanding these heterogeneous actors' logics is critical to understand and shape the implementation direction towards standardization and/or evolve-ability. Understanding actors' logic requires interpreting their principles, values, and assumptions of their activities. Thus, an interpretive approach is found to be suitable to this study to explore and understand heterogeneous actors' logics and their impact on IS implementation overtime and space. The interpretive perspective helped me gain an in-depth understanding of the various stakeholders' institutional logic, which is related to the

context that shaped IT governance mechanisms to facilitate IS implementation from the system implementation initiative until its deployment. This approach also helped me understand the social and organizational context of managers concerning IS implementation. A qualitative research approach, which focuses on the point of view of the participants to understand one phenomenon, was employed for this study to investigate the social, organizational, political, and cultural phenomena of the context (Walsham, 1995a).

4.2 Research Method: Case Study

Based on the underlying ontological and epistemological assumption, IS research can use different types of research methods, including case study, ethnography, and action research to design a research project and guide data collection and analysis (Myers & Avison, 2002). Action research requires the direct involvement of the researcher in the research phenomenon to bring change, whereas case studies and ethnography do not. Case study and ethnography research methods differ on the amount of time horizon the researcher spends in the field, with ethnographic research requiring a longer time immersed in the social group being studied (Yin, 2002). Researchers should select the appropriate research method based on the goals of the researcher, the time horizon of the study, complexity, and access to the research phenomenon (Klein & Myers, 1999; Walsham, 1995a).

Therefore, a case study was found to be appropriate for this study of balancing standardization and evolve-ability in IS implementation in a dynamic and complex organizational context that involves multiple and heterogeneous interests (Benbasat, 2002). Case study research is the most common qualitative method used in IS research (Orlikowski & Baroudi, 1991) to answer the 'how' and 'why' questions (Walsham, 1995a) and is useful for explaining the processes, actions, and/or interactions (Easton, 2010). It focuses on understanding the dynamics present within a single setting with multiple sources of evidence, such as documents, interviews, observation, and physical artifacts from the setting (Benbasat, 2002) to address contextual and complex conditions and not just isolated variables (Yin, 2002). Case studies can be used in positivist, interpretive, and critical research approaches (Myers & Avison, 2002). The interpretive case study focus is on developing concepts, generating theory, and drawing specific implications from practice to contribute rich insight (Walsham, 1995b) to the IS field where researchers often lag behind practitioners in discovering and explaining new

methods and techniques (Neuman, 2014). Further, a case study methodology has been adopted for most paradox studies (Andriopoulos & Lewis, 2009), similar to the case represented in this study.

Based on the interpretive ontological and epistemological tradition, an interpretive case study has been adopted as it concerns a contemporary phenomenon of DHIS2 implementation with in a real-life context. Furthermore, the study deals with explaining how and why IT governance mechanisms handle contrasting needs to shape the DHIS2 implementation towards standardization and/or evolve-ability in the course of IS implementation. Last, this study does not concern certain variables rather the study concerns the contextual and complex conditions of HIS implementation based on multiple sources of evidence to arrive at the required understanding of HIS implementation. It explores unpacking HIS implementation process including routines, practice, technological features, and the stakeholders' thoughts and actions to understand the underlying IT governance mechanisms; the organizational structure, process, and communication.

A research design is the fundamental basis of interpretive research, which requires a conscious decision for case selection, the type of researcher involvement in the research setting, and access to the research setting (Walsham, 2006). This research was designed to study DHIS2 implementation in the public health care context of Ethiopia from January 2019-2022 as an outside researcher who does not have direct relations to the phenomena explored in this study. This research was designed as a single case study with multiple levels of analysis ranging from national to health facility level. The case allowed examining relationships at different levels of analysis within the DHIS2 implementation context; national level, regional health bureau, zone health office, wereda health office, and health facility level and organization field level analysis that provided a rich understanding of the case. Institutional logic allows for multiple levels of analysis from the macro-micro level of analysis (Avgerou, 2000). Accordingly, this study employed multiple levels of data collection and analysis (Gilson, 2012). Thus, the fieldwork involved engaging actors within the different levels of the HIS, national, regional, zonal, woreda, and health facilities and partner organizations engage in these different levels.

Understanding the social and technological issues enables me to generate interpretive knowledge regarding IT governance by studying IS implementation contradictions and

management in its natural organizational setting using multiple methods of data collection (Myers & Avison, 2002).

The health sector complexity involves heterogeneous actors, including government and non-government institutions functionally organized in several distinct programs (Tuberculosis (TB), Human Immunodeficiency Virus (HIV), Mother and Children Health (MCH), Malaria) where different professionals (health, management, and IT) work at different hierarchical levels of an organization (national, regional, zonal, wereda (district), and health facility level). In addition to health sector complexity, health care in a resource-constrained setting is intensified by multiple organizations that have key roles in supplying technical and financial resources for IS implementation. Thus, HIS implementation in the public health care context of Ethiopia is a suitable case to investigate heterogeneous actors' institutional backgrounds, and their conflict to understand and design IT governance mechanisms behind IS implementation.

4.2.1 Case Selection

Case selection was made based on purposive and judgmental methods to ease access to the research setting (Walsham, 2006; Yin, 2002). The case selection was made for three major reasons; familiarity with and ease of accessing to the research setting, suitability for the research phenomenon, and an interest to contributing to solving IS implementation problems in the health sector. The case focuses on DHIS2 implementation in the Ethiopia public health care system, with a special focus on the East Shoa Zone of the Oromia Regional Health Bureau. First, my research experience in my post-graduate thesis was related to standardization in the region. Learning about the new system implementation initiative in the public health care sector interested me to pursue my PhD in balancing standardization and evolve-ability and contributing to the field of study and to the sector. The good personal relationship established during my prior study enabled me to learn first-hand about the DHIS2 implementation initiative and to get easy access to the research setting. Second, a health care setting is a suitable case to study contradictory issues in IS implementation around standardization and evolve-ability due to its complexity. East Shoa zone is found in the Oromia region, which is the largest in the country. This zone is known by both remote and urban health institutions, which is good for representing the big differences between health institutions in terms of resources and infrastructure that play such a huge role in HIS implementation (Braa et al., 2007).

4.2.2 DHIS2 implementation in Ethiopia

MOH adopted DHIS2 as a national platform in April 2017 to standardize routine data collection, processing, and disseminating of data nation-wide, where data clerks use DHIS2 to collect and process at the health facility level; Managers and experts at different levels of administration and programs can share and use the data for their day-to-day activities. DHIS2 is an open-source, web-based, freely available software with data warehousing functionalities and customizable modules for integrated health data capturing and analysis, which is designed and implemented by a health information system program (HISP) (Adu-Gyamfi et al., 2019). DHIS2 has been implemented through local HISP teams in each country such as HISP-Ethiopia, HISP-Tanzania, HISP-Uganda, etc.

DHIS2 has been configured for aggregated and disaggregated data for various health programs at national, regional, and health program levels in different periods since May 2017 based on the benefits of the system gained in the implementation. The study follows the DHIS2 implementation from a national level to the health facilities level by selecting four weredas/districts (two urban and two rural) of the Eastern Shoa Zone of Oromia Regional Health Bureau to get representative health institutions with well-equipped IT infrastructure and poorly-equipped IT infrastructure.

4.2.3 Oromia Regional Health Bureau

Oromia is one of the largest and the most populous of the 12 regions in Ethiopia, with 38,170,034 people living in an area of 284,537.87 square kilometers (MOH, 2013). The Oromia Regional Health Bureau is organized in 20 zones and 333 weredas to regulate and administer all health and health-related activities in the region. The region has 104 hospitals, 1,405 health centers, and 7,090 health posts to deliver curative and preventive health services to the communities (MOH, 2013). The region works closely with all stakeholders to deliver appropriate health services to the community. The region's health institutions are known to have stark differences in IT infrastructure and resources which are crucial for IS implementation. According to the CSA projection in 2021, 77.3% of the population is estimated to be rural inhabitants (CSA, 2018).

The East Shoa Zone is one of the twenty Zones in Oromia Regional State and is situated in the south-eastern part of the region. It has 12 weredas (districts), 1 town administration

Figure 6 Ethiopia with Oromia Region Map

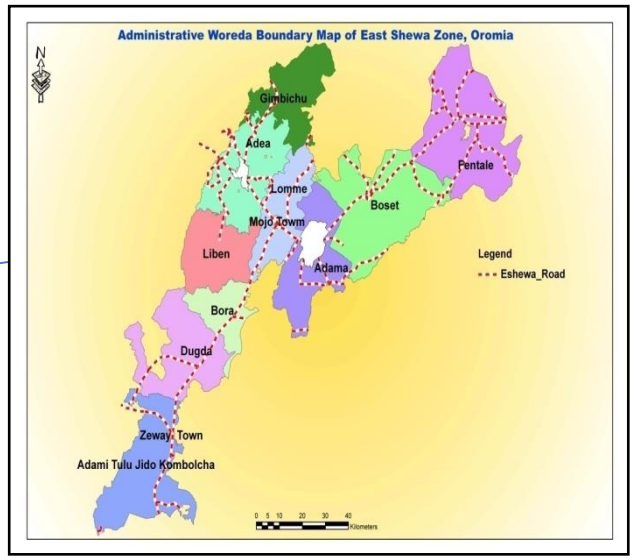


Figure 5 East Shoa Zone of Oromia region

, and 545 kebeles (lowest administrative units) of which 515 are rural and 30 are urban (Health Office, 2019). The Zone has a total of 736 health professionals who work in 343 health facilities consisting of 1 hospital, 58 health centers, and 284 health posts. Based on the 2019 East Shoa Zone report regarding the use of DHIS2, 12% of the health facilities did not have electricity. DHIS2 has been implemented in 87% of the health facilities, of which 32 were online and 27 were offline users of DHIS2. Health facilities with internet connection are regarded as online users which directly access the MOH DHIS2 system for data entry, processing, and use. Health facilities without an internet connection use electronic devices and e-mail to transmit data to the next level where there is an internet connection. Managers and IT professionals from MOH, RHB, Eastern Shoa Zone, and the two rural and urban weredas (districts) named (Adaami Tulu and Dugda - rural, Adama and Adaa- urban) and their respective health facilities were the source population for the study. Informants with DHIS2 implementation experience as a manager, and health and IT professions were considered from these health institutions.

4.2.4 Researcher Involvement

Being an outside researcher helps one maintain distance from the participants in the field and allows the researcher to get the participants' views openly to generate a relatively bias-free result despite the researcher's prior conceptions shaping the data collection and analysis (Walsham, 2006). However, being an outside researcher might force one to miss

important occasions and events with pertinent direct information because they lack information about the events and participants' concerns about confidentiality. Despite an outside researcher, I have been involved in various DHIS2 implementation events such as training, workshops, and annual review meetings because of a good personal relationship established in my prior involvement in the implementation in this context. Thus, the research findings of this study are based on interviewing and observing many DHIS2 events as an outside researcher.

4.3 Data Collection Technique

Sources of data in a case study include interviews, documents, physical artifacts, and observation (Yin, 2002). Related data collection was conducted in January 2018 when the 1st DHIS2 training was conducted in the Addis Ababa region before deploying DHIS2 nation-wide, as part of a course work, laying the foundation for establishing my case around DHIS2. I then followed the process informally through my personal network until my thesis proposal was approved in March 2020.

Following the guidance in Walsham (1995, 2006), empirical data for this study were collected using different instruments, including interviews, observation, and document analysis. A multilevel data collection and analysis approach was adopted and aligned with advice that institutional analysis should consider both the local organizational context and the broader national context (macro), as well as at micro-individual levels (Avgerou, 2001).

4.3.1 Interview

An interview is the primary source of data in the case of interpretive case studies because they are ideal for collecting data as an outsider observer (Walsham, 2006). This technique allows outside observers to get the participants' interpretations and views of events and their actions that are taking place in the study field (Walsham, 2006). Thus interview was considered a primary source of this research. Purposive sampling was used to select informants engaged in DHIS2 implementation by considering their experience and managerial positions, including key health and IT managers, developers, and planners within the different levels of the health structure ranging from National to health facilities and partner organizations' staff. In addition, former informants were asked to identify potential key informants in their context.

The interview was conducted at different times between January – July 2019 while preparing the research proposal; from April to June 2020 and from June to July 2021 following the guidelines in Myers and Newman (2007). An interview guide with objectives of the research and research ethics documents received from their health institutions were forwarded to informants ahead of time, as well as a process to select the times and places of the interviews. The interview place and time were set based on the participants' convenience. The interview questions asked how and when they joined DHIS2 implementation activities, why and how DHIS2 implementation was initiated and deployed, specifically asking about organizational structure, process, communication, challenges they faced that hindered implementation, and their general comments about the implementation.

In addition to the interview guide, the interview was often initiated by describing the research purpose, the researcher's qualification and role, and the relation to the study phenomenon to establish trust. The researcher facilitated the interview by raising a question or giving comments based on the interviewee's response and sharing limited professional ideas regarding the raised issues which helped developed trust in the research and prompted interviewees to express their views openly. Key informants who had a large role in managing and developing the software were interviewed more than once, some for clarification and others to follow the IS implementation progress and change in IT governance mechanisms. A total of fifty-one in-depth, semi-structured interviews with open-ended questions were conducted, with forty-five informants representing IT, managerial, and health professionals of government and partner organizations at all levels of the organization, ranging from MOH to health facility level as shown in Table 2. These informants are selected due to their level of involvement in DHIS2 implementation particularly in managing, coordinating, and developing the DHIS2 implementation activities. DHIS2 users who did not have much experience regarding DHIS2 implementation, and who were not in a decision-making position regarding DHIS2 implementation are excluded.

Table 2 Data Collection Details

Levels	Departments	No of informants	No of Interviews
MOH	Information Technology Department(ITD)	5	18
	Policy Plan Monitoring and Evaluation Department (PPMED)	7	
	Health Program experts	4	
Regional Health Bureau	ITD	3	11
	PPMED	2	
	Health Program experts	5	
Partner organization	HISP	3	9
	JSI-DUP	2	
	JSI-DHA	1	
Zonal(Zonal, wereda)	IT	1	3
	Policy Plan	1	
	Health Programs	1	
Wereda	IT, policy plan, and health programs	4	4
Health facilities	IT, policy plan, and health programs	6	6
Total		45	51

The initial interviews were conducted online via Zoom meetings due to COVID-19 protocol during the data collection period. The subsequent interviews were conducted face-to-face. The length of the interviews ranged from 30 to 90 minutes depending on the level of involvement in the case. Data collection under each informant's category (i.e health experts at a national level) was ceased when similar views, data, and observations were repeated from different informants of each group (IT, health, manager, partner organization) (Orlikowski & Baroudi, 1991).

Figure 7 HMIS Unit Office in East Shoa Zone (Picture taken by Birkinesh Sept 2020)

All interview data were electronically recorded, and field notes were converted to electronic format and entered in NVIVO for analysis. To triangulate the data gathered through documents and interviews, system observations were made at the informant's workplace to determine how they were challenged by or benefited from the system. Attempts

were made to observe the different system implementations in terms of data type, access, ease to use and modify, simplicity, flexibility, controlling mechanisms, and the level of implementation concerning the resources and infrastructure available in the setting to learn the level of standardization and evolveability.

4.3.2 Observation

Observation is one of the data collection techniques in interpretative case studies to ask relevant questions and gain a better understanding of the case in its natural setting (Walsham, 2006). An observation checklist was prepared while reading and re-reading the interviews' transcripts which required clarification and verification from the system at the health facility level. For instance, data variation and duplication issues which were raised by HIV and TB experts during the interview were confirmed during system observation at the health facility level. The observation checklist was attached in Appendix 4. Researcher can act as an external observer without direct interference or as a participant observer with aims to change the context (Walsham, 1995b). My role in the study was as an external observer or attendee on various occasions, such as training, workshops, and international conferences focused on DHIS2 implementation. For instance, I attended the online annual review meeting of the MOH in October 2021 and the DHIS2 annual conference in June 2021, with a special focus on DHIS2 implementation in Ethiopia. The face-to-face workshops and training enabled me to access the diverse study informants in one place, including managers, IT, and health professionals from the national MOH, regional and zonal health offices, and partner organizations. These channels gave me the opportunity to talk with various informants during breaks, which helped me to grasp their perspectives on DHIS2 implementation. Some of these talks were extended to a formal interview based on the analysis of the participants' importance concerning their position and experience in the research.

Furthermore, the implemented systems were observed at the work-place to examine their

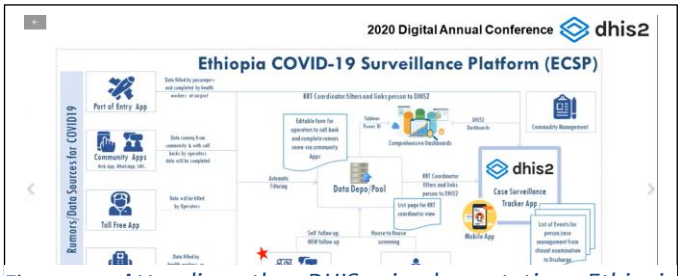


Figure 9 Attending the DHIS2 implementation Ethiopia presentation in international Conference in Nov. 2020

Figure 8 DHIS-2 interface for routine health system(Pictures taken by Birkinesh, Sept. 2020

features and relationships with standardization and evolve-ability, such as how they communicate, and coordinate with each other, their ease of flexibility to innovate new modules, and components or apps to respond to the emergent requirements. For instance, how routine DHIS2 implementation by MOH and DHIS2 for HIV implemented by the regional health bureau was observed in Oromia Regional Health Bureau and in the Ministry. Such system analysis also helped me understand the level of communication and coordination between systems and the importance of system flexibility to innovate or restrict innovation, the challenges they faced to use the system. An attempt was made to understand why they came up with such different systems. The analysis of the data gained from the document was used to triangulate with interview transcripts. The analysis of the interview transcript was used to prepare an observation check list and triangulated with the field notes of observation.

4.3.3 Document Analysis

Data gained from interviews and observation were complemented by data collected from documents. Document analysis began with key actors' organization's websites, including the MOH, HISP, John Snow Company (JSC), and the Oromia Regional Health Bureau (ORHB) to gather the organizations' mission, vision, strategies, and policy documents. Furthermore, ICT policy, and strategy documents of the country and the sector such as Digital Ethiopia-2020, Interoperable Framework, Information Revolution Road Map, and digital health-related documents were collected and analyzed. The document analysis focused on how the structure, process, and communications of the organization is arranged in relation to IS implementation.

The document analysis focused on how the structure, process, and communications of the organization is arranged with IS implementation data gained from interview and observation. The analysis of the data gained from the document was used to triangulate with interview transcripts. The analysis of the interview transcripts was also used to triangulate with the field notes of observation. For instance, the centralized structure theme generated from the document analysis was triangulated with the systemic logic decentralized IT governance structure. The "zero tolerance for system duplication and fragmentation" from the interview transcript which was themed as centralization and "we have an agreement with regional health bureaus to use One Plan, One Policy, One Report principle" themed as standardization were triangulated with observation field notes states

multiple program specific DHIS2 customization and deployment at health programs and regional level as shown in figure 10.

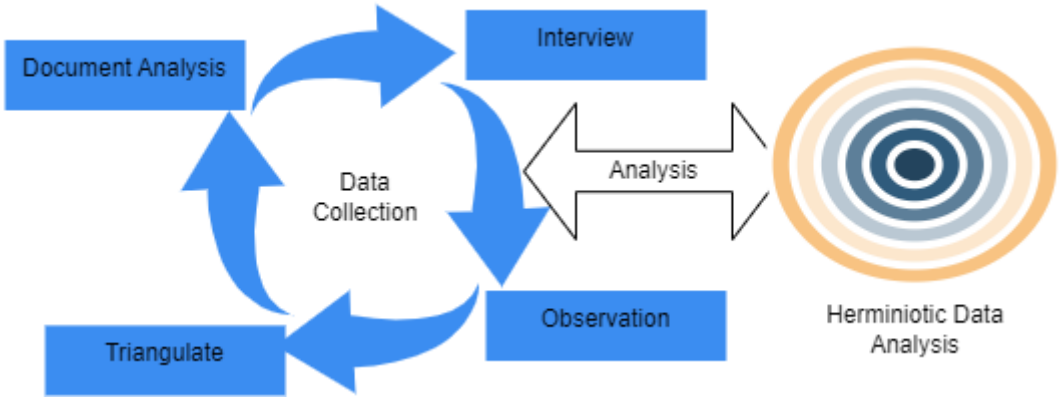


Figure 10 Multiple Data Collection Techniques and Triangulation

4.4 Data Analysis: Hermeneutics

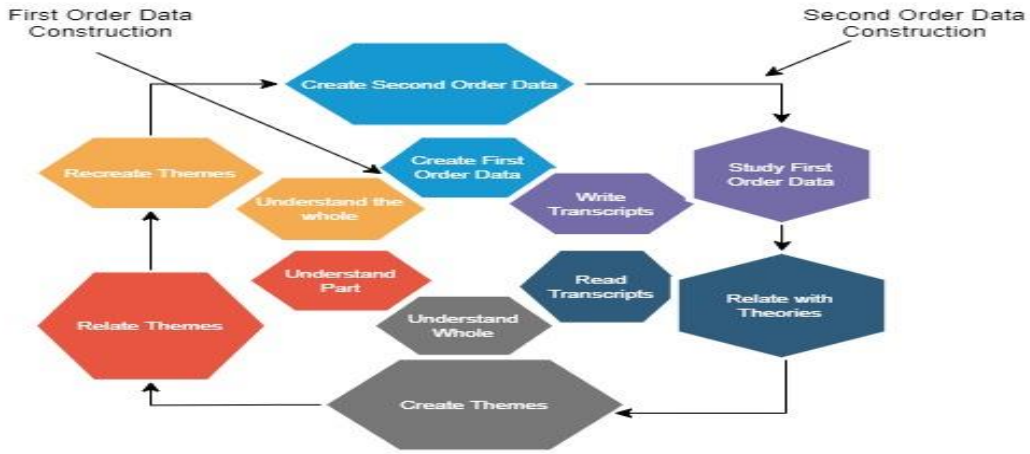
There is no distinct data collection and analysis in qualitative research like that of the quantitative approach. Data collection and analysis are concurrent and overlap each other as one affects the other and vice versa (Maaneen et al., 2007) thus analysis in qualitative research is regarded as a mode of analysis (Myers & Avison, 2002). There are different types of modes of qualitative analysis, including hermeneutics, semiotics, and narrative and metaphor (Myers, 1997). Semiotics and narrative modes of analysis are concerned with finding the meaning of signs and symbols in a language and narrative analysis of a story, while hermeneutics focuses on finding meaning from a text (oral or written) in a circular fashion between the whole and the part of understanding (Myers, 1997). Hermeneutics aligns with the interpretive approach, which interprets hidden meaning from explicit meaning, and, thus, is adopted for this study.

The researcher's role in hermeneutics is iteratively extending the concentric circles of understanding meaning moving from part to whole iteratively. Thus, understanding the phenomenon being studied is only possible if all the details are related to the whole (Zimmerman, 2015). Thus, hermeneutic analysis was used to understand the whole (i.e. IS implementation balancing), requiring an understanding of parts as standardization and evolve-ability activities conducted in IS implementation, while also relating back to IS implementation balancing in the larger context. Furthermore, understanding IS implementation balancing as a whole phenomenon requires the interaction of the

researcher's prior knowledge about IS implementation with the informants' view of IS implementation in their contexts as parts.

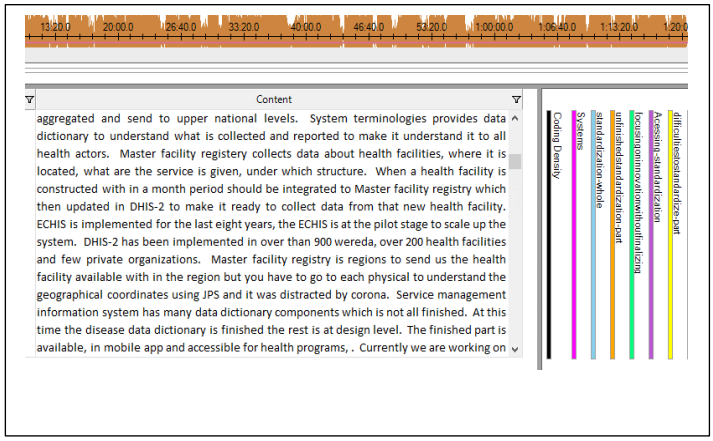
The analysis in this study was not a linear process. Rather, it was an iterative process of reading and re-reading, coding the collected data, reviewing the literature, and extracting themes in line with the research objectives and theoretical concepts. The iterative whole and parts analysis was conducted in two levels of iteration as first-order and second-order constructions (Klein & Myers, 1999). First-order data construction is getting the whole picture of the phenomenon from the collected data through a repetitive process of coding, recoding, and relating the coding to each other to form a theme and find recurrent themes and issues. The author creates second-order data by taking first-order data and linking it with the concepts adopted from theory and literature to make sense of the phenomenon being studied.

Figure 11 Hermeneutic Data Analysis (Klein and Myers, 1999)



The theory was used in this study to shape initial data collection and analysis (Walsham, 1995a), as the researcher's prior knowledge in hermeneutics affects the gathering of the data (Myers & Avison, 2002).

For analysis, initially, participants were organized into three categories, managerial, health program, and IT in their respective institutional levels, ranging from MOH to health facility. The qualitative analysis software, NVIVO 10 has been used to organize and code the collected qualitative data accordingly (Brandão, 2015). The analysis involves transcribing the interview data by listening to the interview records several times to generate emergent insights that also guide subsequent data-collection efforts by modifying the subsequent interview guides to get quality data (Klein & Myers, 1999; Silverman, 2005).



IFigure 13 First Order Coding

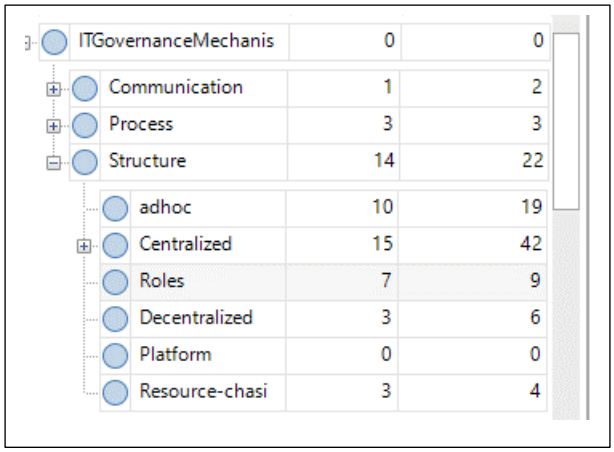


Figure 12 Second Order Coding

national and sectorial policy, strategic, planning, and reporting documents were also iteratively reviewed to generate appropriate themes and codes for first-order data construction. These first-order data were then related to literature and theoretical concepts to generate second-order data. IT and IS implementation and governance literature related to stakeholders' perspectives were frequently used while analyzing the data. The categorization of second-order data was initially informed by the literature and theory coded broadly as institutional logic, standardization, and evolve-ability, IT governance mechanism (structure, process, and communication). An initial list of codes was prepared. For example: centralized and decentralized were coded for structure, controlled, and autonomous for process, top-down and bottom-up for communication, health expert, managers, and IT for institutional logic and acquisition, compromise, separation, loose coupling, collaboration for institutional logic management as described by (Bradley et al., 2007). Attempts were made to link these codes with first-order generated data in iterative ways. Some of these codes used during analysis were changed, dropped, and sustained until the end which is briefly presented in table 4. For example,

Table 3 Concepts used, changed, and dropped in data analysis

Implementation	Logics	Structure	Process	Communication
Either/or strategies(standardization or evolve-ability)	Health expert, managerial, IT	Centralized, decentralized	Autonomous, centralized	Top-down, bottom-up
Balancing strategies to standardization and evolve-ability	Ambidextrous	Structural separation Integration at the top level	Compromising, loose coupling, Temporal separation, contextual, scanning,	Horizontal, network,

Implementation	Logics	Structure	Process	Communication
			seizing, reconfiguring	
Emerged concepts	Partner organization, DHIS2, Resource logic	ad-hoc, integrated Inclusive IT Governance Mechanisms Resource chasing collaboration, platform governance	Implementation is considered as a paradox to handle the dynamic activities of standardization and evolve-ability, boundary resource model	Personal relations
Merged, changed, dropped Concepts	Partner organization, DHIS2, HISP, health, Resource logic, expert logic		Compromising, loose coupling,	

loose coupling, acceptance, and accusations were dropped. Compromise, separation, and loose coupling were replaced with structural, contextual, and temporal mechanisms. Others, like institutional logic, structure, process, and communications, were utilized as-is for the analysis and interpretation for addressing research questions one and two. New concepts such as dynamic ambidexterity and boundary resource-related concepts were added at the later stages of analysis during second-order data construction while reviewing literature and theories to relate the second-order data construction to answer the third research question of the study- (how IT governance mechanisms could be improved to balance standardization and evolve-ability?)

The earliest stage of the analysis focused on searching the logic through understanding organizational practices, and interpretations of the informants at different levels of the health care structure (institutional, organizational, group, and individual). The institutional logic dimensions (principle, assumption, identity, and domain) were used as a guide to identify and describe the institutional logic of heterogeneous actors (Reay & Jones, 2015). It involved several readings of the collected data to capture diverse informants' logics, and how it influenced the IT governance mechanisms at various stages of the implementation resulting in standardization and/or evolve-ability. For example,

the logic of managers, IT, health experts, and partner organizations at various levels was sought regarding their decisions when establishing teams, defining processes, evaluating systems, and various documents, such as the Information Revolution Road Map document and IS implementation planning documents developed as a guide for digitalization and implementation of DHIS2 in the sector. Finally, the logic behind why and how actors linked with specific governance mechanisms such as separating, integrating, centralized, decentralized, controlled, and uncontrolled and leaned towards either standardization, evolve-ability or both were identified. The analysis placed more emphasis on IT governance mechanisms (structure, process, and communication) to link with standardization and evolvability. This analysis also an enabled understanding of the relationship between diverse institutional logics, cooperation, and contradiction, and how they affected IS implementation regarding standardization and evolve-ability. These standardization and evolve-ability categories were also cross-checked with data from related health documents and reports generated from the sector, such as Information Revolution and health sector development program documents that state the strategy, philosophy, and plan of health information systems. Data analysis was finished once no new patterns emerged from specific data sources.

The study followed Myers (1998) interpretive case study hermeneutic principles, contextualizing, abstracting, and generalizing, dialogical reasoning which was used to show the reliability and validity of the data. Hermeneutic circle – relating whole text i.e balancing with parts of standardization and evolve ability action, relating how their team is organized with the governance approach, how they planned, perform their activities, governance approach with structure, process, and communication; structure and centralized and decentralized, process and controlled and uncontrolled type of process.

Contextualization refers to relating what they are saying or doing with the implementation context. The research was contextualized to help reveal the impacts of resource shortages in the government budget for IS implementation, poor IT staff carrier structure, the influence of partner organizations in IS implementation and its governance, how the previous HIS implementation experience impacted disregarding new actors; how lack of resources forced them to collaborate with the new actor; and how system implementation was considered as IT human resource retaining mechanism.

Generalization and abstract refer to relating the concepts found in the literature with finding ex. dynamic and institutional logic is used as a lens to uncover the data collected from the participants, and systemic logic is related to the partner organization principle. Further, institutional and IT governance mechanism-related concepts were used to generalize the collected data without restricting change in the initial assumptions of the study. For instance, "resource chasing collaboration" and resource logic concepts emerged from the data that revealed the influence of context in IS implementation and governance.

Dialogical reasoning is meant to challenge the existing theories i.e how merely institutional distance is inadequate for collaboration which also required inclusive IT governance mechanisms in resource-constrained countries; how merely collaboration did not help us achieve balancing and revealed how resource-chasing collaboration did not help to address both standardization and evolve-ability simultaneously.

Furthermore, initial drafts of the manuscripts with results were sent to key informants, who were also engaged in a discussion to check the finding's validity with some comments for modifications such as "resistant to DHIS2" to be changed to "challenging DHIS2". For instance, consensus was reached regarding how partner organizations facilitated the evolve-ability and the lack of standardization activities in the effort.

In general, the analytical process was a hermeneutic process of analysis where the continued review of concepts and alternative explanations led to a deeper understanding and growing analytical sophistication. The first level began during my initial period of manuscript writing based on institutional logic and later extended to dynamic ambidexterity and boundary resource model to give the complete picture of the study. The institutional logic concept was used to investigate the existing logic and its management behind the implementation; the boundary resource model and dynamic ambidexterity were used for understanding IT governance mechanisms which detail the relationship between actors, and the process of IS implementation with a focus on balancing standardization and evolve-ability.

Figure 14 Summary of the Research Approach and Methods

CHAPTER 5: **Research Setting and Context**

This chapter presents the research setting and context of this study and is divided into four sections. In the first section, the geography, social, economic, and political situations and the status of ICT in Ethiopia are described and followed by the health care in Ethiopia. Section two describes the healthcare organization and its services. The historical of HIS implementation and its governance. And digital health strategies describe the various digital health strategies to guide HIS implementation.

5.1 Demography of Ethiopia

Ethiopia is in the horn of Africa and shares borders with Somalia, Sudan, Djibouti, Kenya, and Eritrea. It is the tenth-largest country in Africa, with a size of 1,104,300 $km^{2,}$ and the second most populous country, with 115 million. Ethiopia is the 12^{th} most populous country in the world. Almost 80% of the population lives in rural areas and depends mainly on subsistence agriculture (Central Statistical Agency of Ethiopia, 2012).

5.2 Socio-Economic and Political Situations

Ethiopia is an independent country in Africa and was never colonized by a European country. The country is home to various ethnicities who speak more than 80 different languages. Ethiopia uses its script and calendar, which is behind seven from the European calendar. The Ethiopia constitution, introduced in 1995, created a federal government structure composed of eleven ethnic-based regional states: Tigray, Afar, Amhara, Oromia, Somali, Southern Nation Nationalities and Peoples Region (SNNPR), Benshangul-Gumuz, Gambella, Harrar, Sidama and Waliata and two city administration councils of Dire Dawa and Addis Ababa. Regions are further organized as zones, weredas, and kebeles administration offices. The government follows a decentralized administrative system where the regional states have legislative, executive, and judicial powers.

Ethiopia is a low-income country with a gross domestic product (GDP) per capita (current US$) of $772 in 2018, up from about $340 in 2010 (Central Statistical Agency of Ethiopia, 2012). The Ethiopian economy is based on agriculture, which accounts for 46% of GDB and 85% of total employment. Since, 1991, the country has implemented several macroeconomic policies, including a market-based and agriculture-led industrialization. With a firm dedication to sustaining the current economic growth and achieving rapid,

broad-based, sustained, and equitable economic growth that can eradicate poverty and help Ethiopia become a middle-income country by 2025, the Ethiopian government in cooperation with development partners, has embarked on the fourth poverty reduction strategic plan, referred to as the Growth and Transformation Plan (GTP)(MOH, 2021c). Ethiopia is currently engaged in rapid, comprehensive development activities to transition from poverty to sustainable, reliable growth and prosperity. For example, the government has implemented major and ambitious public sector projects, such as the construction of the Grand Ethiopian Renaissance Dam, which will be the largest in Africa. According to UN reports in 2017, Ethiopia has shown remarkable socio-economic deployment compared to most African countries over the past two decades (Shiferaw, 2017). GDP has risen from USD $8 billion in 2000 to USD $84 billion in 2018 (Shiferaw, 2017). During the same period, life expectancy increased from under 52 years to nearly 66. It is one of the fastest-growing economies in Africa, experiencing an average annual growth of about 10% between 2004 and 2014. However, despite its significant economic growth, the country remains one of the world's poorest.

In 2019, the Homegrown Economic Reform Agenda and the Ten-Year National Development Plan (2020-2030) were adopted (FDRE, 2021b). To achieve its goals, the government of Ethiopia has considered ICT as a key driver and facilitator for transforming Ethiopia's predominantly subsistence-agriculture economy into a knowledge-based economy and information society. In the second Growth Transformation Plan (GTP II), one goal is implementing a digital economy that requires leveraging ICT technology.

5.3 ICT in Ethiopia

ICT is one of the Ethiopian government's strategic priorities in the first and second Growth Transformation Plans (GTP I and II). During the five-ear period of GTP I (2009/10-2014/15), Ethiopia's ICT infrastructure has shown significant improvement. Mobile telecommunication grew from 6 million subscribers to 39 million in 2014/15 and its growth proportion reached 60% in 2017 (with 41% active subscriptions)(FDRE, 2016, 2021a). The number of Internet users rose from less than 1 million close to 4 million. Internet coverage has grown at an annual rate of 45%. Government and social institutions, such as secondary schools and hospitals have benefited from growing networking infrastructures (FDRE, 2016).

However, the adoption of ICT in Ethiopia remains low in comparison with regional and global peers. For instance, mobile adoption is low compared to peer nations. Active mobile broadband subscriptions are owned by 7.1%, of the population, compared to an average of 24.8% in the region. Internet coverage annual growth rate of 45% is also slower than peer nations. The ICT sector in Ethiopia has faced substantial challenges, including a lack of the latest broadband technologies, cost of broadband connectivity, incomplete government institutions connectivity in education and health sectors, absence of ICT legislation and regulation to facilitate ICT adoption and evolution, and lack of digital literacy and awareness to enable all citizens to access and contribute to sharing of information, ideas, and knowledge.

To overcome these challenges, ICT policy and various implementation strategies have been developed to direct the adoption, evolution, and use of ICT in various sectors. For instance, digital Ethiopia 2025, a digital strategy for Ethiopia's inclusive prosperity has been developed based on GTPII (FDRE, 2021a). The digital Ethiopia 2025 strategy encompasses a four-part digital economy framework comprising infrastructure, enabling systems, applications, and the broader ecosystem. The strategy also identified how and by whom digital technologies will be used in the economy.

Leveraging this digital economy requires a new mind-set and leadership style from the government (FDRE, 2021a). Thus, the e-government interoperability framework (ENEAF) and its governance and compliance implementation strategies were developed to facilitate interoperability among provided ICT solutions based on thirteen principles (Addis Ababa University & Technology Ministry of Innovations, 2021). Of the thirteen principles, six are related to the main themes of this thesis, standardization, and evolve-ability, and are discussed as follows. Principles that promote standardization are centralized coordination, security, reuse, and interoperability, highlighting the importance of identifying common components across domains to facilitate sharing and collaboration. The ENEAF principles promoting evolve-ability include open standards, scalability, diverse participation and engagement, access to a global competitive market, and a technology that delivers infrastructure to emphasize scaling up, adapting, and responding to changing and growing institutional needs and requirements. The Ministry of Innovation and Technology (MINT) forwarded these implementation guidelines to sector organizations including MOH to guide implementation.

5.4 Health Care in Ethiopia

The Ethiopian health sector is organized in a federal structure that leverages the MOH to engage in providing strategic direction to be implemented by regional health bureaus. Ethiopia has undergone four Health Sector Development Plans (HSDP I-IV) from 2000-2015. Based on the critical evaluation of HSDP, MOH embarked on a 20-year (2015-35) health sector transformation plan entitled "Envisioning Ethiopia's Path Towards Universal Health Coverage through Strengthening Primary Health Care" which guides strategies from health access to quality and equity (FMOH, 2014) and showed significant results in HSTP I (2015-2020).

Regarding health infrastructure, 17,550 health posts (HPs), 3,735 health centers, and 353 hospitals were available to provide health services in 2018(MOH, 2021b). Primary Health care units (PHCUs) (17,550 HPs and 3,735 health centers) are the main source of primary care health services in Ethiopia, especially for rural communities. The Health Extension Program (HEP) provides 18 primary care packages. Hospital-based services are categorized into primary, general, and specialized hospitals. Regional variations in health indicators are dominant in Ethiopia, caused by multiple factors such as gender norms and harmful traditional practices, low economic and educational status, low access to basic utilities, poor road communication networks, and food insecurity.

Although the health sector has shown significant progress during the development plans, it is still below regional peers and world standards. For instance, health worker density was estimated at 1.0 per 1,000 population which is lower than the 4.5 per 1000 population standard proposed by WHO to achieve universal health coverage. Ethiopia's total health expenditure was estimated at 72 billion ETB ($3.1 billion), accounting for 4.2% of the country's GDP which is lower than the expected average of 5% for low-income countries. The share of government contribution for total health expenditure was 8.1% in 2016/17, which is lower than the low-income country's average government health expenditure of 8.7% (MOH, 2021c).

In terms of the health network infrastructure system (Health Net), 1,636 health facilities are connected by a cabled virtual private network (VPN), and 1,944 sites are connected with a wireless 3G option. An additional 25 health facilities with no cabled VPN or Wireless 3G options are connected by customized options (MOH, 2021c). While an E-

health architecture has been designed, a large part of the information revolution road map activities remains unimplemented (Addis Ababa University & Technology Ministry of Innovations, 2021). With regard to data quality, report completeness improved from 72% in 2015 to 89% in 2019 (MOH, 2021b). Data consistency also improved, leading to a reduced discrepancy between the data from routine information systems and data in surveys.

Learning lessons from HSTP I, the second sector's five years national health sector strategic plan (HSTPII) (2020/21-24/25) was developed with 14 key strategic directions to improve the health of the population (MOH, 2021a). Of the five priority transformation agendas, two of them are about HIS, enhancing digital health technology, and strengthening the governance and leadership to enhance the availability and use of quality data with a special focus on improving the routine health management information system (HMIS) for informed evidence-based decision making in the sector.

5.4.1 HIS implementation in Ethiopia

Within Ethiopia's health system, data are collected and managed at different levels and the available data sources are siloed or stored in separate systems. Computerized HIS was initially introduced by various international organizations to support data collection, processing, and reporting activities. Following the Health Management Information System (HMIS) reform in 2008, 108 indicators were identified to track the domains of health, determinants of health, and health status. These indicators have been periodically revised over the past two decades driven by local priorities and developments and international standards, priorities, and commitments. The number of indicators increased from 108 to 122 in 2014 and 131 in the 2017 HMIS revisions, respectively (FMOH, 2017). An indicator reference guide has also been prepared with the aim of standardizing, creating common understanding and eventually improving the quality of data and its use. Based on this indicator guide, e-HMI systems were developed and deployed countrywide from 2010-2017 for health data management.

Despite various efforts to overcome the fragmented system's problems through health transformation from 2005-2017 (FMOH, 2010), the expected result was not as expected (FMOH, 2010, 2016). According to the digital health systems App Inventory, more than 77 unique electronic sub-systems were deployed by different institutions to meet specific

requirements (MOH, 2016). These systems are standalone, transaction-based systems that are not adequate to address advanced decision support, data mining, knowledge discovery, and business intelligence demands.

Currently, MOH emphasizes to HIS in both HSTP I (2015-2020) and HSTP II (2020-25), which was manifested in the Information Revolution Road Map and digital health blue print national strategies. IR is one of the five health sector transformation plans aimed at digitizing the prioritized HISs and making a cultural change in the use of health information to provide quality and equitable health services to citizens (MOH, 2016). The 'One Plan, One Report, and One Budget' principle of harmonization and alignment to enhance existing technology and innovation was considered while developing the IR document. The MOH, IT, and Policy plan and evaluation directorates from the government and implementer organizations, such as John Snow Institute-Data Use Partnership (JSI-DUP) from partner organizations have greatly contributed to the development of the IR document.

Policy Plan Monitoring and Evaluation (PPME) directorate engages in the preparation of annual, strategic, and pragmatic planning, and monitors health sector activities. To discharge this responsibility, the PPME directorate, in cooperation with the IT directorate, plays a key role in the preparation and implementation of data collection tools and manual and electronic systems. The IT directorate's main aim is digitizing and implementing HIS in the health sector in a prioritized manner and providing technical support to the sector. These directorates are leading the sector digitization using IR documents for the development and implementation of IR strategy throughout the health sector.

Currently, various systems have been designed and implemented at national, program, and regional levels. Of these DHIS2, an electronic Community Health Information System (ECHIS), Master Facility Registry (MFR), Human Resource Information System (HRIS), and a National Health Data Dictionary were national-level efforts found at various stages of implementation (underdeveloped, developed, and deployed in the sector) (MOH, 2019). This study's focus, DHIS2 implementation, has been considered since 2017 as a national-level platform for routine health management information systems that can overcome system fragmentation and partner organization dominance (B. W. Lagebo, 2019).

DHIS2 is a generic open-source, web-based freely available software with data warehousing functionalities and customizable modules for integrated health data capturing and analysis, which is designed and implemented by a health information system program (HISP) (Adu-Gyamfi et al., 2019). HISP is the Oslo university project engaged in researching, designing, and implementing DHIS2 in more than a hundred low and middle-income countries for more than two decades through local HISP teams in each country, such as HISP-Ethiopia, HISP-Tanzania, HISP-Uganda, etc.

Regardless of HISP, IT, and PPME directorates were mandated for DHIS2 implementation in cooperation with existing partner organizations. DHIS2 was then customized based on the national level indicators and subjected to iterative testing, improvement, and implementation until fully scaled-up with user-friendly data use features since January 2018. MOH has registered several significant achievements regarding DHIS2 implementation including deployment of online and offline instances, full ownership of DHIS2 customization, and implementation by MOH. Upgrading the software to version 2.300 that more in-house-built apps for disease and public health emergencies and monitoring (PHEM) reporting and, data use applications (Scorecard, BNA and action tracker, custom reports and new features of data quality checks, dashboards for decision makers). At the end of 2020, 95% of public facilities were covered, of which 3,065 (64%) public facilities and health offices were able to access the online DHIS2 and the remaining were using offline versions. Challenges include poor connectivity, frequent failure of computers, servicer down time, and technical problems. In general, leveraging digital health in Ethiopia has been challenged by several inevitable challenges, such as highly fragmented initiatives, poor coordination, scarcity of a health workforce prepared for digital health, poor power, and internet infrastructure, lack of sustainable financing, and several others (MOH, 2021a).

5.4.2 HIS Governance

The health service delivery is organized into three tiers primary, secondary, and tertiary-level health care services as shown in Figure 15. The primary health care unit (PHCU) consists of health posts, health centers, and primary hospitals. A health center with five satellite health posts provides preventive and curative health services to approximately 25, 000 people. Primary hospitals offer emergency procedures, such as caesarean sections and blood transfusions, inpatient, and ambulatory services to about 100,000 people. General hospitals provide similar services to an average of 1 million people. Health centers and hospitals under each tier serve as referral centers and practical training sites for their respective lower levels of health professionals (MOH, 2021c). Under a decentralized governance framework, Woreda health offices and regional health bureaus are directly accountable to their respective governments.

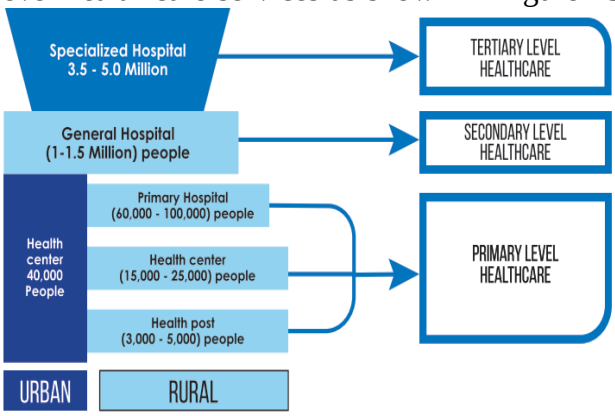


Figure 15 Ethiopian Health Tier System (MOH, 2021)

The Ethiopian health sector is organized in a federal structure that leverages the MOH to engage in providing strategic direction to be implemented by regional health bureaus. Various platforms, such as the Joint Steering Committee (JSC), Executive Committee (EC), Joint Consultative Forum (JCF), and Joint Core Coordinating Committee (JCCC) are put in place to coordinate work with different stakeholders, including regional health bureaus, agencies, donors, and partner and private organizations, by using regular communication channels to review and monitor the performance and make timely decisions. JSC holds regular meetings every two months with RHB. EC meetings take place with directorates and agencies of the MOH every two weeks. JCF meetings are held semi-annually between MOH and donors. JCCC meetings between MOH and developing partners address technical and operational issues (MOH, 2021c). The MOH also began engaging local universities in capacity-building and mentorship programs.

There are also various HIS governance-related documents at different levels of development aimed at guiding and standardizing the HIS interventions, including

connected Woreda Implementation strategy, Master Facility Registry management and governance protocol, and National HIS governance framework, National Health Data Dictionary, data access and sharing directive, e-health architecture, and guidelines on incentivizing data quality, use, and performance improvement.

Though several efforts have been made to strengthen structural HIS governance prerequisites, there are still persistent gaps in governing the HIS due to delayed endorsement of a HIS governance framework in most of the regions, the limited functionality of HIS governance structures, failure to finalize drafted HIS governance documents, lack of standards for digital platforms, absence of interoperable systems, and an absence of HIS or sub-component policies and legal framework to ensure HIS principles and accountability (MOH, 2021a).

5.4.3 Digital Health-Related Strategies

To harness such challenges, MOH has recently been working on the development and cascading of various digital health-related national strategic and policy documents, which includes IR Roadmap II (2020- 2029), IR Strategic Plan (2018 -2025), Ethiopia e-Health Architecture (2019), and ICT Policy and Digital Health Blue Strategy (2020-24) (MOH, 2021a). The analyses of these documents are either at the initial draft level or unpublished, yet created unclear implementation and scale-up plans, a lack of binding policies and roadmaps among stakeholders, and a rework of the same documents. Furthermore, these documents do not give much attention to rapidly changing and booming digital health technologies (MOH, 2021a).

To complement these plans and strategies, Digital Health Blue Print (DHBP) was recently developed in 2021 in compliance with the "Digital Ethiopia 2025: A digital strategy for Ethiopia Inclusive Prosperity" and HSTP II for quick decisions by the leadership for rapid, cost-effective, and sustainable development of digital health (MOH, 2021a). Based on World health organization (WHO) recommendations, the digital health blue print identified four pillars (Access and Delivery, Solutions and Services, ICT Infrastructure, and Data Hub) and five enablers (standard and interoperability, governance and leadership, research, and innovation, and work force and system security).

DHBP illustrates how current and emerging technologies can be incorporated into health care delivery processes to enrich functionality, generate greater efficiencies, and enhance the experience for health service providers and consumers. Thus, the scope of the blueprint is to create an overarching foundational 10-year plan for digital health in Ethiopia (2021-30).

The DHBP identified ten priority areas for the coming ten years, two of which are related to concepts emphasized in this thesis: Digital performance management and data exchange across systems. Digital performance management for accountability and a merit-based performance evaluation is one of the critical challenges in the Ethiopian health system related to HMIS. Data exchange across systems refers to creating the capability for electronic systems to communicate and exchange data through specified data formats and communication protocols, e-health architecture, and data ware house approach. A draft e-health architecture document outlining the different components and the mechanisms explaining how these components exchange data among themselves was developed. Data exchange efforts amongst various systems have been attempted which includes MFR/DHIS2, the eCHIS/ DHIS2, and DHIS2 tracker and Laboratory Information System. However, the magnitude of the integration and interoperability agenda is at an early stage and currently not functional.

CHAPTER 6: **Case Description**

This chapter presents a case description of DHIS2 implementation in the public health care context of Ethiopia in five sections. The first section describes the Ministry of health and HIS implementation organizational structure. Section two discusses the role of partner organizations in HIS implementation followed by the history HIS implementation to give a background of the case. Section four describes the DHIS2 implementation process ranging from DHIS2 adoption to DHIS2 use for data management under the topic of standardization. Finally, section five provides information about how new systems, applications, and components were customized and deployed in various settings.

6.1 Health Care Organizational structure and HIS Implementation

The MOH at the federal level is led by a minister and directors of the directorates, the heads of the federal hospitals, and health agencies as shown in figure 16.

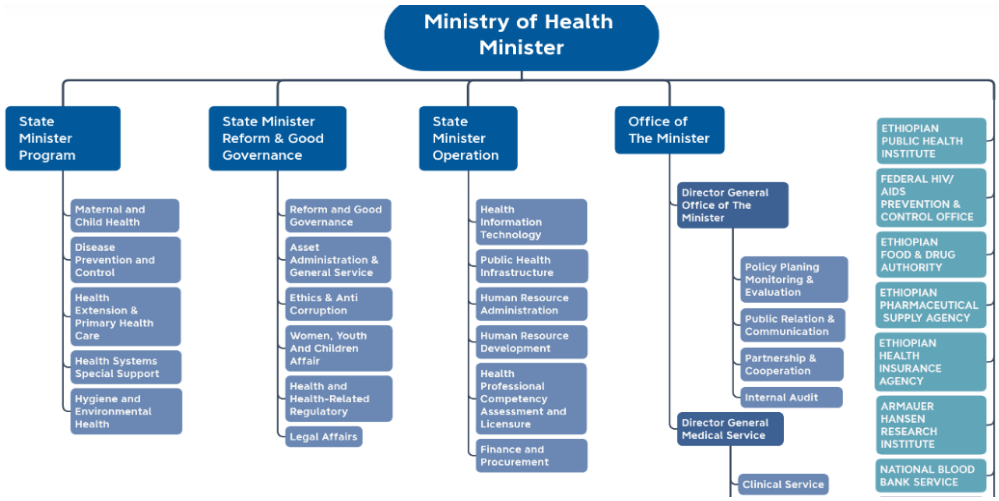


Figure 16 Ministry of Health Organizational Structure (MOH website, 2022)

The Ethiopian health sector is organized in a federal structure that leverages the MOH to engage in providing strategic direction to be implemented by regional health bureaus. HIS implementation has three hierarchical levels at the national level to oversee the HIS implementation as seen in Figure 17. They are National Information Revolution Steering Committee (NIRSC), Information Revolution National Advisory Group (IRNAG), and Digitization and Cultural Transformation Technical Working Group (TWG). The steering committee incorporates donor organizations led by the state minister and focuses on providing guidance, navigating the political landscape, and mobilizing resources for

implementation. The advisory group is comprised of the implementation partners, policy plan, and IT directorates that follow the actual implementation and communicate with the technical working groups (TWGs). The TWG is the high-level entity that makes national-level technical decisions, including who is involved in the implementation, what is to be designed, and how and when the implementation can be conducted. The TWG members are comprised of people involved in system development, deployment, training, maintenance, and support at the national level. Similar types of IR-TWG, digitization, and data use, are organized at the regional level. The TWGs at the region's level receive technical and financial support from the MOH and the region's partner organizations. The regional-level IT departments in turn established similar teams at zonal and woreda levels.

Figure 17 Ethiopian National Health Information System Governance source (Information Revolution Document, 2017)

In 2016, MOH laid down a long-term health sector transformation plan that shifts the strategies from health access to quality and equity. IR is one of the five health sector transformation plans aimed at digitizing the prioritized HISs and making a cultural change in the use of health information to provide quality and equitable health services to citizens (MOH, 2016). The IR document development considered the principle of harmonization as a 'One Plan, One Report, and One Budget' for the alignment and enhancement of the existing technology and innovation.

PPME directorate engages in the preparation of annual, strategic, and pragmatic plan, and monitors health sector activities. To discharge this responsibility, the directorate conducts periodic data collection, compilation, and dissemination of health data from health facilities on periodic bases and renders support to health institutions ranging from health facilities to different ministry health programs. Furthermore, the directorate plays a key role in the preparation and implementation of data collection tools, and, manual and electronic systems, in cooperation with IT directorate. The IT directorate's main aim is digitizing and implementing HIS in the health sector in a prioritized manner and providing technical support to the sector. These directorates are leading the national-level sector digitization using IR documents for the development and implementation of

IR strategy throughout the health sector in cooperation with donor and partner organizations.

6.2 Partner organizations and their role in HIS implementation

Most of the health sector's budget was gained from donor organizations (Teshome & Hoebink, 2018), including USAID, the Gates foundation, CDC, the Global Alliance (GAVI), and other donors. Donor organizations make agreements with various MOH health programs and office directorates to support the health sector ranging from program-specific support to general system development and implementation. Donors, in cooperation with MOH, recruit partner organizations for the implementation of the agreement in specified health programs, periods, and spaces with allocated funds. There are regional and national-level partner organizations that work with MOH, regional health bureaus, and health programs in system development and implementation activities. Partner organizations are expected to deliver the required products and services to the health sector and submit performance reports to donor organizations in a specified time. MOH, RHB, and donor organizations oversee the partner organizations' performance and reports, recruit partner organizations, release funds, secure additional funding, and extend, or terminate the project. Thus, partner organizations are expected to be competent enough to survive in the sector. The informant of this study said this about partner organizations "*Every partner organization is competing to put their legacy in the sector*" (Director, PPMED). This excerpt was supported by other informants as this "*There is a tendency in partner organizations grasp every activity*" (Senior Developer, Partner Organization). Most of the IS development and implementation of financial and technical resources have heavily relied on these partner organizations. Despite the donor organizations' key role in system development and implementation, most of the country's health documents, research results, and the informants of this study described how multiple partner organizations introduce HIS to collect, process, and analyze health data generated by multiple fragmented systems in the health sector (FMOH, 2010, 2016; Gebre-Mariam & Fruijtier, 2018).

6.3 HIS implementation history in Ethiopia

In the early days, multiple partner organizations in cooperation with regional health bureaus developed and deployed different systems to computerize the paper-based data collection and reporting systems (Mengiste, 2009). The absence of MOH involvement in

the computerization effort was considered as a factor for system fragmentation (Birkinesh & Mekonnen, 2005). To counter this, the national MOH harmonized the health HMIS implementation effort from 2006 to 2010 to overcome the fragmentation issue. MOH mandated two partner organizations, A & B, to system development and implementation in distinct regions, one in eleven regions and the other in one to continue its previous computerization effort in the region. Besides the system development and implementation roles, the assigned partner organizations were responsible for related resource supplies such as computers, hard disks, and networking of the health institutions, which strengthened the relationship between partner organizations and health institutions. These partner organizations, especially those assigned to the eleven regions, were overwhelmed with responsibilities ranging from system development implementation to equipping eleven regions' health institutions with the required technical resource and infrastructure.

Ultimately, the region-based assignment without national-level coordination resulted in two un-communicable electronic health management information systems (e-HMISs) with different technologies, support systems, and resources. e-HMISs were the first national computerized health information systems and were developed and implemented by two different partner organizations with different technology, technical,and resource capacities. This effort reduced multiple system fragmentations which were created by multiple partner organizations earlier into two fragmented e-HMISs.

However, MOH was challenged to generate a periodic national-level report from these two distinct systems. The Policy Plan Monitoring and Evaluation Directorate (PPMED) staff involved in report generation said:

> *"…as it was impossible to generate the national report from these systems, an intermediate system was designed by an American company to integrate the data that came from the distinct systems"*- Experts, PPMED.

The other PPMED staff described how they generated reports from these systems as:

> "*No one understood the messes that we had while generating a report from the two systems…first, we export data to excel spreadsheets from both systems….import it to the intermediate system to generate the report"* Former, PPMED head.

These experts revealed the challenge they had while generating a national-level periodic report. In addition to the fragmentation problem, the significant running cost was required to address the frequent technical problems, such as aggregation problems,

missed indicators, reports, summation problems, and system failures. These technical issues required frequent physical maintenance and support at each of the 4,600 health facilities, demanding partner organizations' IT professionals make long journeys to each health institution from the head office, some 500 kilometers away. This demand was reduced later, as issues became more stable towards the end of the implementation. This forced HIS functioning to continue relying on partner organizations' resources and support. The following excerpt was a response to why the health institutions' ICT staff did not handle the issue. *"The IT department let alone the source code did not have a password to change the user name*" - Directorate, MOH. This statement was seconded by various MOH reports and documents. A 2013 assessment of the e-HMIS states that *"there is a strong dependence on the IDP at all levels for a range of functions, including software development, support, infrastructure, training, and others. This reduces the capabilities of the health systems to become self-reliant and sustainable."* (FMOH, 2013, p.14). The national strategic plan states that there is a "*lack of appropriate structure to guide planning and implementation of HIS components*" *(FMOH, 2013, p. 21).*

In addition to the above-mentioned problems relating to technical, interoperability, and partner organizations' dominance, these systems were not responsive to address the emergent needs following the revision of the indicator reference document. In 2017, MOH revised the data collection and reporting formats to incorporate new and modify existing data elements, and indicators, which required great investment with the existing e-HMISs in relation to proprietary systems.

Despite various efforts to overcome the fragmented system's problems through health transformation from 2005-2015 (FMOH, 2010), the expected result was not realized (FMOH, 2010, 2016). Besides, the routine e-hmis, the MOH system survey found more than 70 different applications were deployed by partner organizations in the sector without any sustainable support mechanisms (FMOH, 2016). This caused duplication of effort, wastage of resources, and increased workload on data collectors at the health facility level (Gebre-mariam & Bygstad, 2019; S. M. Mekonnen et al., 2015)

Thus, technical failures and dependency on partner organizations were part of the agenda in various HMIS meetings. Ultimately, MOH in cooperation with stakeholders reached a consensus for having a government-owned centralized system to address such system fragmentation and overcome the partner organizations' dependency. However, choosing

which systems of the two would become the future centralized system was an emerging problem for MOH. as both partner organizations put great investment in health institutions ranging from equipping health institutions with IT equipment and networking to designing and deploying the system in the course of e-HMIS implementation. The former IT directorate described this as: *"you know, it was difficult to say just goodbye for an actor who has gone through many ups and downs with us for the implementation in the absence of infrastructural and technical capacity. They did great jobs in establishing the current IT infrastructure and capacities"*- Director, IT. This statement depicts the indispensable value of partner organizations in HIS implementation.

MOH attempted two alternatives, system evaluation, and system integration, to maintain the partner organizations' systems, though neither of which materialized. First, a committee was established to evaluate the two systems and select the one that would be chosen as the centralized system. However, the evaluation committee result was rejected because of the other party's complaint about evaluators. Therefore, the either-or strategy based on the system evaluation did not materialize.

MOH proceeded to consider another alternative by incorporating both parties and building a hybrid system by taking the two better features of each system and leading the implementation by MOH. This approach was considered to have a two-fold benefit: first, re-using the developed IT capability and infrastructures for ten years related to these systems and giving recognition to both partner organizations for their work. Second, shifting the system ownership right to MOH from partner organizations to overcome the partner organizations' dependency. Thus, MOH created a deadline for partner organizations to submit their source code for system integration. However, the partner organizations did not hand over the source code within the specified deadline, which frustrated MOH and led to the planning of the development of a new system from scratch using local capacity. This alternative made MOH staff suspicious because of the absence of advanced IT skills needed to develop the system. Ultimately, the MOH high-level official who was exposed to a new system called District Health Information System (DHIS2) at an international conference suggested DHIS2 be considered as a third alternative system besides the two existing e-HMISs.

6.4 Standardizing HIS

HIS standardization in Ethiopia began with system adoption, configuration, and deployment which are described as follows.

6.4.1 DHIS2 adoption

The DHIS2 system has been used in more than seventy low-income countries in Africa, Asia, and the Middle East countries since 1994. The previous version of DHIS2, DHIS 1.3, and 1.4 was also being used in Ethiopia from 2003-2005 at the regional level until MOH launched a harmonized system.

During the introduction of DHIS2, HISP played a key role in introducing and piloting DHIS2 in Ethiopia for a couple of years at the request of the MOH in 2014. However, it was not a trivial task to adopt DHIS2 in place of the dominant partner organizations' systems, which had a well-established and long-standing network in all hierarchies of the sector. Thus, adoption of DHIS2 was delayed for about three years, due to the incongruence of the opponent and proponent groups of the MOH with decision-making positions.

The idea of DHIS2 initially received significant pushback from most of the experienced managers and staff who were involved in the previous e-HMIS implementation. Reasons for challenging DHIS2 were the absence of ready-made DHIS2 functionalities, such as disease reporting, top ten diseases, special aggregation, layout, and format compared to the previous system, its open-source feature, and foreign system, which required us to rely on external organization. Furthermore, they recalled the big investment that had already been put into the existing e-HMIS and suggested improving it or developing a local system from scratch, rather than accepting a foreign system, DHIS2. The following excerpt described how DHIS2 was challenged by different stakeholders at the initial stage: *"We invested a lot in infrastructure, resource, system development, now when it became stable…it was difficult to ruin all and start from scratch"*- PPMED, manager. *Ano*ther mentioned *"The data entry was not simple as e-HMIS which has two data entry formats one for plan the other for the routine data; DHIS2 merged both." (*IT staff, at regional level). These excerpts describe how DHIS2 was not a choice for some managers and staff.

As a response to these issues, the local HISP staff used the available channels, such as demonstration, training, and informal sessions, to describe the importance of open-source software for overcoming the technical capacity barriers and simplifying local system development according to its context. Furthermore, some donor organizations that have experienced DHIS2 implementation in other developing countries have shown interest in

supporting DHIS2 implementation. Similarly, the previous donor organizations who were financing the previous system implementation declared their unwillingness to continue supporting the previous system. Thus, the high-level official gave direction to commence communication between the MOH concerned directorates, ITD and PPMED, and HISP to consider DHIS2 as a third alternative. This reflects how high level-officials and donor organizations played key roles in system adoption.

All actors, including the two partner organizations, were invited to participate in the introduction of DHIS2 based on their interests and capacity. Accordingly, most stakeholders invested their time, finance, and technical capacity in the DHIS2 introduction. HISP, the developer of DHIS2, played a key role technical role in DHIS2 customization, demonstration, training, and piloting based on the MOH invitation and continued its participation informally in DHIS2 configuration and deployment.

DHIS2 introduction included demonstration, piloting, and system evaluation was conducted for about three years. However, the MOH staff was hesitant to participate in the introduction process due to certain high-level officials with decision-making power and significant stakeholders' resistance to the acceptance of DHIS2. This was described by one of the managers as this "*It was difficult to promote DHIS2 at that time as there were high-level officials, and few regional health bureaus were resisting to accept DHIS2 due to various reasons*" (Manager, MOH). This statement was complemented by a former member of the PPMED staff stated, *"Most of the government staff including me did not want to participate in DHIS2 introduction because it was not firm to become the future system. The partner organizations' staff of the MOH hugely participated in the process"*. The statement revealed the opponent group's influence in DHIS2 introduction.

The DHIS2 demonstration was followed by formal and informal communication with DHIS2 developers, HISP leaders, and African countries that have already deployed DHIS2 to enhance the system understanding. After a certain level of system awareness was achieved through demonstration and communication, MOH piloted DHIS2 in selected weredas comprised of good and poor resources in four regions' (Gambela, Addis Ababa, Afar, and Oromia).

A five-day pilot training was conducted in the Kuyera training center for staff representing pilot regions in December 2015. After six months of DHIS2 piloting, an in-house system evaluation was conducted to examine the functionality of the system in a

diversified context. The evaluation results depicted the success of the system by diminishing the 28-day reporting time in hours and improving the analysis capacity, visualizing feature, and online and offline capacity of the system to serve both well-resourced and poor-resourced health facilities. The introduction of the DHIS2 process also enabled actors to enhance their system understanding. The informants had expressed their interest in DHIS2 as:

> "*When you compare it with DHIS2, the analysis feature of the previous system was too limited, I did not know the pivot table, and dashboard before DHIS2. Previously I did not know about pivot tables, I know it in DHIS2. it was a wonderful tool for analysis."* (Health expert, MCH).

This statement depicted how the DHIS2 introduction garnered a significant number of proponents of DHIS2. However, the opponent groups at federal and regional levels of decision-making positions kept resisting DHIS2 adoption for the above-mentioned reasons. Instead, they promoted local system development. To resolve such disagreement, an international consultant commissioned by United States Agency for International Development (USAID) was hired from San Francisco to evaluate the three systems; the John Snow Inc. (JSI) e-HMIS, the Tulane University e-HMIS, and DHIS2. The 60-to-70-page evaluation report recommended open-source software for low-income countries without specifying DHIS2 that was inclined to choose DHIS2.

The high-level official who initiated DHIS2 at that time was replaced with a new official in 2017. DHIS2 adoption then became the prime activity of the new minister due to the absence of a system after the end of 2017, when the deadline was reached for the existing e-HMIS project, and the system functionality ended. Based on these institutional pressures and external evaluation results, the newly appointed Minister declared the direction to adopt DHIS2 as a national platform in April 2017 and mandated the two directorates, IT and PPME, to lead the implementation in the Joint steering committee (JSC) meeting (B. W. Lagebo, 2019). The two MOH directorates were primarily responsible for data collection, processing, information dissemination, and digitalization in the sector (MOH, 2019). The direction was given to involving potential actors in supplying technical and financial resources for the implementation.

In 2017, MOH embarked on the implementation of DHIS2 in cooperation with donor organizations to overcome the persistence of fragmented systems and partner organization dominance problems (MOH, 2017). Health institutions and their managers and staff wanted to be involved in the implementation, which comes with resources, IT equipment, and infrastructure beyond the system benefits. The following statement

depicts the benefits they got from the implementation "*Previously let alone the internet we do not have a functional computer. Now we can easily enter data and immediately reaches the upper level*"(IT expert, Wereda). Other informants from the region stated "*One of our problems is ICT experts do not stay long because the IT area like the health programs does not go out for field work which supports employees with allowance money. This motivates them to stay in the field*" (Head, RHB). The national staff expressed their view regarding the implementation "*DHIS2 competence is highly needed as it has been implemented in various programs, so we all need the knowledge to be competent*"(Coordinator, MOH). These statements illuminate how the health workforce developed an interest in DHIS2 to gain financial and technical resources in addition to the data management benefits.

6.4.2 Organizational Structure of DHIS2 Implementation

Following, the launch of DHIS2 as a national system platform, the MOH steering committee and the HIT and PPME directorates established the national-level DHIS2 implementation team (NIT) to oversee the DHIS2 implementation, composed of the two directorates and a representative from partner organization JSI-DUP. To realize DHIS2 implementation, the TWG under NIT reached a consensus on configuring and deploying DHIS2 using in-house capacity without significant assistance from external organizations. This decision aimed to overcome the partner organizations' dominance. Thus, the DHIS2 core customization team (CCT) with members of technical staff with IT backgrounds and system development and implementation experience from TWG, was made responsible for DHIS2 customization. The team members were coordinated and led by the IT directorate representative. Thus, the decision implicitly excluded HISP, who had a key role in DHIS2 introduction, from DHIS2 implementation. The justifications given for HISP exclusion were, 1) that DHIS2 is an open-source software, so we can customize and 2) to avoid the partner organization dependency, an ownership issue in the previous e-HMIS implementation. In addition to the technical

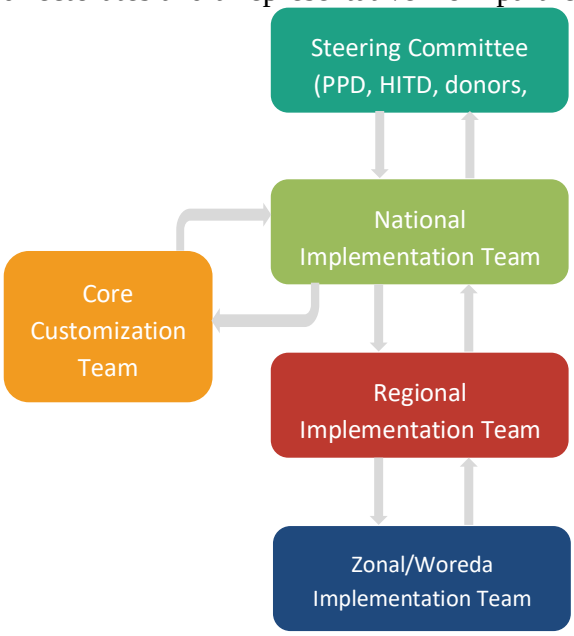


Figure 18 DHIS 2 implementation governance structure

team, hierarchical implementation teams ranging from MOH to wereda level were established for deployment. The teams were comprised of IT and policy departments and partner organization staff at each hierarchical level as shown in Figure 18.

However, the CCT without HISP initially had less competence to develop and customize DHIS2. Thus, the NIT decision to configure DHIS2 in an in-house capacity was challenged by the absence of DHIS2 experts in the CCT. Soon, the CCT was given a direction to involve local HISP members by limiting their participation in number and type. Two HISP-Ethiopia members involved in DHIS2 demonstration, piloting, and training joined the team due to their DHIS2 expertise. Later, the Ethiopian citizen HISP global system developer, who resided in Oslo, Norway, enrolled in the CCT to address country-specific requirements, which require core code modification. The HISP staff participation in DHIS2 implementation was purposefully limited in the CCT to avoid system ownership issues and strengthen the government system ownership right. For instance, HISP staff were representing themselves as individuals instead of their employees, HISP, or the University of Oslo. Though both the HISP members and HISP as an institution were not happy with the approach, they continued participating in the implementation process to scale DHIS2 in one more low-income country. These informal ways of involving HISP in DHIS2 customization were reiterated by informants of this study as follows:

> *"I was asked to assist as an individual not as HISP by stating the problem they had before relating to system ownership. I informed HISP of the MOH decision and they allowed us to participate as individuals" (*International DHIS2 developer, HISP*).*

> *"The University of Oslo pays us and we work for MOH but we are not officially responsible for MOH because there is no agreement between the University of Oslo and MOH neither between us and MOH" (Software Developer, HISP).*

> *"HISP staff sometimes represented themselves as individual and other times as HISP….they were considered as volunteers"(F*ormer Staff, PPMED).

These excerpts were also seconded by the MOH documents and reports related to DHIS2. For instance, the MOH implementation document describes the HISP staff in CCT implicitly as external experts *"The CCT/TWG comprises HITD, PPD, DUP and other external experts "* (MOH, 2017). However, the customization activity relied heavily on HISP members who have better DHIS2 knowledge and skill. Except for the HISP members, most of the team members who took part in customization were new to DHIS2. *"At the*

beginning, we did not know much about DHIS2, which might bring system errors in the 1st release of DHIS2" (Coordinator, IT). The partner organization describes this as *"For truly speaking if HISP staff were not there I suspect this success"* (Developer, Partner organization). Team members developed the DHIS2 expertise through time in practice and HISP staff dedicated support. Most were able to make basic DHIS2 configuration independently, and few began engaging in code-level DHIS2 configuration, which depicts how the DHIS2 knowledge and skill was transferred through practice.

The team members' engagement in customization activity was then highly dependent on the MOH coordinator, who provided customization activities. At times, the customization team was very tense with many urgent tasks to complete, while at other times they might not have any work at all. Such inconsistent customization activity changed the place of customization activity (i.e. hotel, outside of the city, home, their working place, MOH, and/or partner organization office). Often partner organization offices or hotels were used for urgent and coordinated customization activity. They can also work independently at their preferred place, home, or working place and they meet either to receive activity or deliver their output.

The CCT members were not dedicated to DHIS2 implementation, rather they performed customization in addition to their routine occupational duties, such as administrative activities, lecturing, and performing other system consulting and performing other system implementation activities. Informants put this as:

> *"If you take, the MOH representatives, they have their day-to-day administration activities to discharge, the HISP staff have also engaged in customization activities when they have time"* (Director, partner organization).

> *"I was a lecturer at that time, I was told that there is part-time work so I worked still I am a lecturer in the university" (Developer, HISP).*

> *"Our organization's main agenda is data use but we are involved in DHIS2 customization because we need the system to talk about data use"(Director, Partner Organization).*

> *"My role is developing various data visualizer, dashboard system to support managers in decision making, yet I am working with CCT team to customize DHIS2, after implementation my work will be on these" (Senior Developer, Partner organization).*

Despite DHIS2 configuration not being their permanent work, all team members involved in DHIS2 customization activity had a great, interest in the project and a team-work-spirit. The following excerpts depicted this:

> *First of all, I want to contribute something to my country, and I am happy to be part of DHIS2 implementation. We work as a team, we are like a family* (Developer, HISP).

> *You will get some kind of pleasure when you see your software is used in health institutions* (Developer, Partner organization).
>
> *The participation gave us great knowledge and skill about DHIS2 which is now becoming a criterion for job promotion, and selection. There is no difference whether you come from the government or a partner organization in the team, the difference is when you received the salary* (IT expert, MOH).

These excerpts indicate how much the team members were motivated to be part of the implementation team regardless of their main duty. This eight-to-ten-membered CCT was given a couple of months to finalize the customization activity and deliver a ready-for-use system.

6.4.3 DHIS2 Requirement Definition

As required, the team primarily prepared a work plan for the DHIS2 implementation process detailing requirements definition, customization, training, installation, maintenance and support, plan specified tasks, and responsible body/individual (MOH, 2017). The PPME representative was assigned to requirement document preparation and HISP staff began their work by capacitating the team with the required DHIS2 customization knowledge and skill. After short customization training, all team members started involvement in various level customization activities under HISP staff guidance and support.

DHIS2 customization is guided by what, where, and when data will be collected. Data to collect includes various data elements (Birth-date, still-birth), data sets (Maternal health, HIV), and indicators (maternal mortality rate). Data collection periods include monthly, weekly, and annually. Health institutions that provide health services, such as health facilities or administration offices (Adama health center, Adama Wereda health offices) were chosen as locations from where data could be collected.

The PPMED representative on the CCT, who had major experience in previous e-HMIS and indicator reference document preparation prepared the DHIS2 requirement document. The informants of the study describe the requirement as follows: "*There is no need to go to a health facility to get the requirement for DHIS2, there are already prepared documents which state what is going to be collected*"(Directorate, IT). The indicator reference document is the national-level standard document used as guidance for routine health data collection, processing, and reporting, describing what, when, and where data should be collected (FMOH, 2017). The document provides the necessary information or meta-

definition to customize DHIS2 data sets, data elements, and indicators. Each health program has an indicator to measure its performance. Indicators represent calculated data from the data element (maternal_mortality_rate), which are used to measure the performance of the mother and child health program. The document also specifies the data collection periods as daily, weekly, monthly, and annually, and requires health institutions to report these data as scheduled information. The document was prepared by MOH and its stakeholders and is revised every four years in relation to new or modified health services in the health sector, which requires the revision of the indicator reference document to include changes in data collection. For instance, the COVID-19 case requires new data to be collected that were not present in the previous data collection tools. Most of the health programs' informants stated the inadequacy of the indicator reference-based data to measure health services. The following statements indicate this "*The indicator data is helpful for policy and planning people but not for us, we need detailed and specified data to plan and monitor each service*" (Experts, Health Programs). In addition to the indicator reference document, the requirement document gave a directive to use the previous system, e-HMIS, to get the health institutions' data and to mimic the data entry interface and reporting formats of the previous e-HMIS.

In addition to the standard what, when, and where to collect data, the MOH requirement mandated country-specific requirements be included, such as the Ethiopian calendar, special aggregation, data entry, and reporting formats similar to the previous e-HMIS. The Ethiopian calendar begins from Meskerem (September) and ends with Nehassie (August) which is different from the global DHIS2 calendar that uses the European calendar (September to January). The Ethiopian financial budget year begins on Hamle 1 (July 8, 2020) and ends on Sene 30 (June 7, 2021). The special aggregation requirement is associated with some data needing a different data entry approach from the standard DHIS2. The standard DHIS2 data entry uses health facility-level data entry. In addition to this, MOH required department-level data entry, which is aggregated later at the facility level. This was because different departments in a health facility provide the same service that should be entered by the department in different periods, which requires data aggregation based on the last data value. The global DHIS2 aggregates data either by period (weekly, monthly, quarterly) or by case, whereas the special aggregation requirement of the MOH is somewhat in between, aggregation varies time data entries by considering the last data value. These requirements were beyond the basic customization

activity and required app development and core code modifications which are called international HISP support.

6.4.4 DHIS2 Configuration

The team categorized the MOH requirements into two groups, one that can be handled by a local team and the other that requires skills beyond the local team's capacity. This categorizes the DHIS2 customization into two categories basic customization and code-level customization. The local team handled basic customization activity, including meta-data, and data element definition, coupled with simple app development for data migration, data entry interface, and reporting formats. Staff with minimal training were involved in basic customization activities, including metadata definition, form preparation for reporting, and data entry, whereas HISP representatives on the team were involved in app development for data entry and reporting. The customization used the indicator reference document as a guide to define data elements (ex. no of birth), the data set(ex. Maternal health), and indicators (ex. stillbirth), while waiting for the final indicator revision in August 2017. Furthermore, a small app was developed to extract the health institutions' data, including its organizational hierarchy, from the previous e-HMIS.

In addition to the standard DHIS2 customization mentioned above, the local team developed two data entry and reporting applications like the previous e-HMIS data entry interface and reporting formats to address the MOH unique requirements of familiar data entry interface and reports. Initially, the DHIS2 customization heavily relied on two HISP members, and later the rest of the team members, to start performing basic customization activities after short customization training and guidance. The HISP experts, and later the JSI-DUP senior developer, engaged in high-level configuration, and coding activities with significant support and guidance from an international developer who resided in Norway through e-mail and video-conferencing app Skype. The local DHIS2 customization based on the 131 revised indicators was finalized and awaiting the calendar solution from the HISP international side.

The HISP international expert modified the core code to address the calendar, special aggregation, and fiscal year-related requirements that necessitated advanced level DHIS2 competence beyond the team capacity. The first version of DHIS2 customization for Ethiopia was carried out from April 2017 to October 2017. Despite the CCT being given a couple of months to finalize the customization work in April 2017, the team took six months to deliver the product due to a lack of DHIS2 expertise in the team.

Despite the DHIS2 rollout plan mandated unit testing, system, and user acceptance testing before implementation, merely random unit testing was conducted by each CCT member in respect to what they did. Further, system testing was done at the national level by entering a three-month data and generating random reports. However, user acceptance tests in the field were not conducted, causing more issues for the implementation. Informants of this study described this case as follows

> *You know everything in this house is urgent, you know there was no system after December 2017, so we have to be fast to deploy DHIS2 to get the routine data on time (Developer, HISP)*
>
> *We did not evaluate the system rather we checked the coverage of DHIS2 (Directorate, IT)*
>
> *The developers were eager to implement the system so they did not make proper testing (Coordinator, IT).*

These excerpts indicate the inadequacy of system testing due to tight deadlines, lack of staff, and the absence of evaluation mechanisms for MOH. For a question raised for regarding controlling mechanisms for design stated as

> *The controlling mechanism is often provided in the requirement document for instance for ECHIS design, the developer organizations provides internal and external quality assurance protocol categorized by stages of system development in the requirement document however it is hard to follow the guides as often the system development works are urgent but also, there is a case to be seen during the implementation stage,*(Directorate, IT).

This excerpt evident the inadequacy of a standardized controlling mechanism for system design and its implementation. As a result, several system bugs and errors were identified and reported while conducting the first training and installation in various training centers.

Due to the extent of the errors, the Oromia Regional Health Implementation Team (RIT) took the initiative to make field system testing by preparing a checklist for a data set, organizational units, data entry, aggregation, analysis, reporting, and testing the offline and the online database functionality. Field system tests were conducted using the checklist by installing and entering real data at regional, zonal, weredas, and health facility levels. The identified system errors included an inability to install in 32-bit computers, missing or duplicating organizational units, missing data elements, and indicators in data entry screens and reports, an inability to export data to pivot tables,

missing specific reports, aggregation problems, an inability to generate custom reports. The problem associated with organizational unit or health facility data was duplication of health facility names with unique ID, missing health facility names, and categorizing health facilities under the wrong administration hierarchy. The identified issues were communicated to the CCT over the phone for immediate action and sent in the form of a report to the national team for system redesigning.

The CCT analyzed the identified issues and devised directions for how to resolve the issues. Some system issues were resolved by modifying the customization and others by giving guidelines describing how to install the system in some incompatible computers, such as those with 32-bit systems. The rest of the health institution data issues required getting authoritative data because the health institutions' data issue was identified as imported from the previous e-HMIS including erroneous data. This was not a trivial task. Rather, it was a major problem that took a relatively long period of time to solve due to the absence of readily available health institution data at any level. Health facility data requires frequent updates as it can be changed over time due to new health facility construction, stoppage of services, or shifting to another organization status (i.e. health center to a hospital or assigning a facility to another administration office due to structural changes).

The director of PPMED described the hassle they have been through to get authoritative health institution data:

> *We communicated with the Master Facility Registry Project (MFR) members, Regional Health Bureau, and the wereda health office IT personnel to get authoritative organizational units, yet all three were not successful. The Master Facility Registry project was a system development initiative at MOH to handle the health facility data yet it was found to be at the development stage. The regional health bureaus failed to send us reliable data as expected due to different reasons some lack of authoritative data, others, there was a tendency to increase health facility numbers by corresponding the number of health facilities with the resource they expect from the federal level*".

Ultimately, the national team sent eighteen teams to each wereda to get authoritative institutions' data, install the system and instantly identify issues during installation using electronic media communication such as Google Drive, e-mail, and telephone. Informants described this system error issue as follows:

It was a mess when some issues were fixed, other health facility reported other issues when addressed another problem was popped up…anyways we overcome it"(Coordinator, MOH).

"the IT people said it is easy it will be fixed, but always I got reports of issues from different sites, it was frustrating "(Directorate, PPMED)

"the modification took months, it consumed huge resources, we were in the site for months(Expert, PPMED)

Based on the regional and the national team reports for system issues from the field, the CCT members situated in a partner organization for a month, defined the health institution's data, attended the identified and further reported technical issues day and night, and put the modified version in Google-Drive for installation. However, there were no coordination mechanisms among team members to know who addressed which technical problems and when which resulted in having different DHIS2 instances at different sites. With great team commitment and a major investment, these issues were resolved in a couple of months.

Further DHIS2 customization for PHEM and COVID-19 was conducted by taking lessons from the routine DHIS2 customization. For instance, the PHEM and the COVID-19 systems were presented first to IT and PPME directorates, and later to concerned institutions. In addition, the COVID-19 system was tested by employing twenty-three data encoders in the computer lab to test the system by entering real data and generating reports.

6.4.5 DHIS2 Installation

The hierarchical implementation teams established by NIT at national, regional, zonal, and wereda levels were responsible for DHIS2 deployment, training, installation, use, and support at their respective administration levels. Based on the regional-level implementation team proposal, MOH supplied adequate resources and infrastructure for the DHIS2 deployment for all regions.

After the customization was completed in November 2017, a hybrid approach was employed to deploy the system. DHIS2 installation and configuration were primarily made in MOH server for all users' online use and then installed in 4,925 health facilities for offline use. The purpose of the offline instance was 1) for health institutions with the absence of electricity and connectivity and 2) for connected health facilities to use the

offline version during connection and electricity disruptions. Following the first round of training and installation, many system errors were identified in an early customized DHIS2 version. For instance, it was unable to work on most health facilities' 32-bit system computers, which required converting to 64-bit processing, as discussed in the configuration section, and led to the second round of installation after resolving the issues. The next offline installation for re-designed DHIS2 was coordinated by MOH in eighteen teams who were assigned to eighteen clustered zones. The team had two roles. The first was installing the system by using the updated version from the Google Drive and the second was collecting and sending authoritative organization unit lists and reporting any installation, and system use problems to the CCT.

Regions used a different approach for the second round of system installation, with some regions sending IT staff to each health office for installation and others, like the Oromia region, holding a system installation during the training session. Besides the training information, the Oromia training invitation letter instructed attendees to bring their hard disks for DHIS2 installation. The region implementation team, in collaboration with the MOH team, set up at the gate of the training hall, received the trainees' hard disk, and gave a label in return. Some of the team members were conducting system installation using hard disks while the training occurred. The region prepared replacement hard disks in case they encountered a damaged hard disk. At the end of the training, trainees received their configured hard disk with DHIS2.

Ultimately, the system was deployed for use in January 2018 in 4,925 health facilities throughout the country. Of these 73% were fully online and able to access DHIS2 through the internet, while the remaining 27% were offline, used the offline version of DHIS2 for data entry, and exported the data with a flash drive used at their nearby health institution's IT infrastructure center or an internet café for reporting. The system installation was followed by the first DHIS2 Master of Training of Trainers (MTOT) given to MOH and regions' representatives

Figure 19 DHIS2 Training conducted in Adama, March 2019 (Pictures taken by Birkinesh Woldeyohannes, March 2019)

6.4.5.1 DHIS2 Training

A range of DHIS2 training, from end-user training to advanced application training, were organized and conducted within and outside of the country. A five

days Master of Training of Trainers (MTOT) around DHIS2 use was organized and conducted at national and regional levels and aimed to create a DHIS2 workforce at regional and zonal levels, which played key roles in cascading the training to lower levels and engaging in system installation and support activities. The CCT initially provided training to one hundred-five IT and Monitoring and Evaluation (M&E) staff from MOH, regional and zonal health offices, partner organizations, and collaborative universities in Adama in November 2017. Consequently, the region implementation team, in cooperation with MOH, delivered the regional-level training to create a DHIS2 workforce comprised of the region's partner organizations, regional health bureau, and zonal health offices. Accordingly, the Oromia region implementation team conducted five rounds of end-user training by clustering 12 zones into five universities (Assela, Nekemtee, Fichi, Adama, and Jimma Universities). More than 7,000 health staff were trained in DHIS2 country-wide using this approach. The end user-training session was also used as a communication channel to identify and report system problems, while also adding more requirements. Regardless of such training efforts, the health program informants of this study describe the inadequacy of DHIS2 training for health program experts as follows

> *I got a half-day orientation with PPMED and ITD. But before that, we used it through getting knowledge from my peers. Actually, it is mostly when you practice you know it very well (Health Experts, MCH).*
>
> *A kind of orientation has been given to all health program experts about the DHIS2 feature through PPMED to use DHIS2. I used videos from YouTube and also you will get many documents when you entered into the DHIS2 community platform* (Health Experts, HIV).
>
> *It is only given to M&E focal person. I got through colleagues and I did not get the formal training, we need formal DHIS-2 training. They gave us a kind of orientation for half day but I did not participate due to other duties* (Health Experts, Malaria).

These statements illuminate how the formal DHIS training focus was the Monitoring and Evaluation experts rather than the health experts who make decisions based on the data gained from the system.

In addition to the end-user training, a considerable number of national and regional-level IT and M&E staff took advanced-level DHIS2 training, including DHIS2 administration and configuration, server management, and app development training. Ten IT and M&E staff from national and regional levels took DHIS2 administration and configuration

training in Tanzania and thirty later at the Gondar University DHIS2 academy in Ethiopia. Server management training was also given to MOH and regional staff in Uganda. A few also participated in a DHIS2 workshop conducted by the University of Oslo, to share the DHIS2 development and implementation experience with other HISP countries. In addition to this, thirty regional, MOH, partner organizations, and collaborative Universities IT staff took DHIS2 application development training by an Ethiopian citizen international developer in Addis Ababa, Ethiopia. However, it was only the MOH and national-level partner organizations' staff involved in national-level DHIS2 configuration and app development activities. Many partner organizations such as Gates Foundation, JSI-DUP, and PATH had a key role in financing this training.

6.4.6 DHIS2 use, maintenance, and support

The MOH IT staff primarily created and provided user names and passwords to users during installation. Users use their username and password for data entry and accessing and periodically generating routine health data (weekly, monthly, and quarterly). The PPMED staff at the national level begin data entry using baseline and annual targets for all health programs and prepare the system ready for online use. The use of the system across the implementation area was not started at the same time. Rather it varied from region to region. An informant described how DHIS2 use started "*Some regions like Addis Ababa and Oromia started in January 2018 as expected, others joined in different periods in a range of January - June 2018. A letter signed by the Minister was sent to push commencing the use of DHIS2a which increased the number of health facilities to use DHIS2. Few entered the backlog data since July 2017 to maintain the fiscal year plan and others did not.* "(Developer, HISP). This variation affected the completeness of 2018 data at the national level.

Connected health facilities used the online system whereas health facilities without connection used the offline database to access DHIS2 for data entry. Paper-based reports were also used in some health facilities and weredas with no electricity or computer to send data to the next level. These paper reports were taken to a nearby connected wereda or zonal to populate in DHIS2 system. Health facilities that used the offline database exported the data to the next level using different communication mechanisms, such as e-mail, telegram, and in USB flash drives. HIT staff in connected wereda or zonal health office imported the data to the online DHIS2 system. Internet house cafes were sometimes used to populate the data into the online system when there is no connection at the facility.

According to the 2020 MOH report, health facilities with the online system increased from 30% at the start to 70% which enhanced data completeness and timeliness by 90% (MOH, 2021a). Most health facilities use DHIS2 merely for data collection and reporting purposes but do not use the analytic features of the system. The HIT and M&E staff routinely used the analytic features of DHIS2, such as pivot tables, dashboards, visualizers, scorecards, and bottlenecks at all levels except the health facility level. Despite training being provided to all end users, the health program experts tend to rely on M&E staff to generate reports for use at all levels.

The periodically collected data is often used for planning and monitoring the performance of each health program and is used to generate various types of reports, such as annual health indicators, and bulletin performance reports for the health sector. These reports are routinely provided to the concerned stakeholders, such as parliament, people representative offices, health program directorates, and partner organizations.

Although DHIS2 was used as the main data source for the health sector reporting, health programs,such as EPI, Malaria, and HIV, often used other systems, including Public Health Emergencies and Monitoring (PHEM), Data for Accountability, Transparency and Impact Monitoring (DATIM), HIV AIDS performance and monitoring tool (HPMTCT) systems in addition to DHIS2.

Regular maintenance and support activities have been handled by the DHIS2 workforce, created at all levels in subsequent MTOT DHIS2 training. For instance, the wereda, zonal, regional, and federal-level HIT staff, and concerned health program staff are responsible for checking the data completeness periodically and providing technical support when needed. Feedback has been given to lower levels based on their performance, including when the data are incomplete, missed, inconsistent, or erroneous. Maintenance issues beyond the health institution IT staff were reported to the next higher level for support. Telegram and e-mail communication was the most widely used medium for technical support and maintenance at regional, zonal, and wereda levels. Often, telephone and physical communication were regularly used at the health facility level to maintain and provide feedback and support.

However, some health programs such as HIV and TB, are still reporting technical problems, such as aggregation, validation rule problems, and data variation problems. A study informant at the national level describes technical issues as this: "*I think there is many design problem. For instance, when I entered DHIS2 to get the report based on the indicator, it duplicates a lot. If you get 1,000 patients tested, it generates all of these members as*

positive. In addition, when you download data in a data element, it duplicates the data element. We knew the problem recently so we never download it, we just copied it from the pivot table. But how much it is known by regions or lower health experts how to correct this issue, I don't know. We told the PPMED people and advised as to use the pivot table for now and we are working on it using the pivot table data" (Expert, HIV). This excerpt was also shared by the regional health bureau HIV and TB experts and verified by my site observation. However, the CCT member declined this report: "*It is difficult to receive this comment because we have adequate DHIS2 workforce at various level regional, ministry and program level to look after this issue …but if the problem is still there, they can communicate us. if it requires a major change we have a bi-annual modification plan but if it is a minor change like what you said we have experts who can fix it online as most of them now use the online version, they can get the updated version immediately* "(Coordinator, CCT). This contradiction indicates the absence of communication between the health program experts and the CCT. Often the health program experts did not have direct communication with the CCT. Rather they often communicate with PPMED experts regarding DHIS2 use.

In addition to the above-mentioned data errors, the absence of a deadline for data entry has contributed to variations in DHIS2 reports in a slight period difference. One of the informants described the report variation issue as this: *"If you generate the June report today and tomorrow might not be the same as data entry can be conducted at any time. You have to wait for about two months to get complete data as some might not enter according to the schedule due to various reasons such as connection, electricity problem and so on"(Health Experts, TB).* Users were demanding a set deadline for data entry to get similar reports over time. The indicator reference document states the deadline for periodic data reports for every level, yet it was not inscribed in DHIS2 due to the absence of a reliable internet connection and electricity and other demanding issues for meeting the deadline.

After the DHIS2 was upgraded to address new requirements, the system had become slower and unable to work for close to three weeks. Initially, there was no clarity regarding whether the CCT, the PPMED, or the HITD should attend to the issue. However, the complaint was large and required all actors to be involved to address the issue. For instance, the international developer identified and removed the calendar-related bug while the IT directorate with partner organization support moved the DHIS2 from the MOH data center to a cloud-based system to overcome the server management issues. The CCT committee organized by PPMED also recommended re-innovating the

MOH data center with newer technologies to handle huge amounts of data. Ultimately the issue was resolved to serve users.

The system has been in use since January 2018 despite these issues, while identified system errors and bugs are addressed over time. DHIS2 has currently been stable, data has been collected from 4,900 health facilities and used by all organizational hierarchies, and partner organizations can view, analyze and generate reports using either their desktop computer or mobile device with an internet connection.

6.5 DHIS2 Evolving based on the MOH Unique Requirements

Solutions to the unique requirements for Ethiopia (calendar, financial year, and special aggregation) were beyond the basic DHIS2 configuration, needing core code-level modification that required HISP, DHIS2 developer, and support which was declined at the start. Instead of formal relations with HISP, the MOH partner organization, JSI-DUP, approached the Ethiopian HISP international developer to work with the core customization team to address the unique requirement of Ethiopia. In the tri-partite discussion amongst JSI-DUP, the IT directorate of the MOH, and the developer; the IT directorate required the developer to work with the team as an individual, not as the HISP team. The ownership issue was given as a reason for the absence of interest to work with HISP. After a long discussion, the Ethiopian citizen HISP international developer became a member of DHIS2 core team and addressed the unique Ethiopian requirement. The global DHIS2 has been extended to incorporate the Ethiopian calendar, financial year, and special aggregation. The calendar and the financial year requirements required modification of the DHIS2 core code, which forced the Ethiopian DHIS2 and the global DHIS2 systems to split. The disease requirement that enables users to generate a report of the top n (ex. 10) disease report was also addressed with DHIS2-event capturing application development. The event-capturing app allows data entry at each health facility unit or department based on inpatient disease (IPD) and outpatient disease (OPD) categories. Each department or unit first selects either IPD or OPD, then chooses morbidity and mortality, and finally selects the appropriate disease on which to enter the data value. Accordingly, a reporting app for disease reports was developed. The reporting app enables users to aggregate all departments or units IPD and OPD morbidity and mortality cases. This shows which department enters data, and generates reports of a top number of diseases under the OPD and IPD categories. There is also a pivot analysis

feature for generating monthly reports for specific health facilities, which was a major requirement of the MOH.

Following the implementation and accessibility of DHIS2 for timely routine data collection and reporting, health programs and agencies started posing program-specific requirements to be addressed in DHIS2. The requirements included a system for public health emergencies (PHEM), TB, HIV, and wereda transformation data collection and reporting, and later the COVID-19 system due to the global pandemic. One of the informants described this as: "*You know the accessibility and timeliness of DHIS2 increased the health experts' data demand*"(Expert, MCH). To respond to these program-specific requirements, various stakeholders, ranging from the CCT to the decentralized IT workforce engaged in DHIS2 configuration, extended DHIS2 with new apps, features, modules, and systems. These initiatives used two channels. The first channel was through the CCT and the other used an independent structure created by decentralized actors at the program, regional, and national levels described in the next section.

6.5.1 CCT re-organization to address Stakeholders' Requirements

Different health institutions and agencies, including Ethiopian Public Health Institute (EPHI), WHO, UNICEF, and CCT members approached the MOH IT directorate at various times to address the PHEM, data quality systems, national tropical disease, and the covid-19 data needs in DHIS2. These organizations initiated, funded, and guided the incorporation of these requirements that necessitated a certain level of development and customization activity. The convinced IT directorate forwarded these requirements to the national advisory group which includes the PPMED and the partner organizations' representatives for approval. After approval, the DHIS2 CCT was reorganized several times by adding members from initiated organization to address these emergent specific requirements for the configuration and deployment of DHIS2. HISP members were not changed while other members were changed due to re-organization. One of the HISP members stated this: "*I engaged in various DHIS2 development teams like the DHIS2 core customization team, data quality analysis app development, COVID-19 team, yellow fever, multi-sectoral team, etc.*" Developer, HISP. "*System development team is often organized by the technical experts and the directorate's staff of system development*" (Directorate, ICT). The CCT re-organization returned most of the previous technical members of the team to their routine activities such as maintenance and support of the DHIS2 use except the local

HISP staff who were permanent throughout this study. Some of the MOH technical teams who were involved in DHIS2 routine customization were assigned to work in the new team to support the configuration and requirement definition. New members from different health institutions, such as the Ethiopian Public Health Institute (EPHI), and donor organizations, such as World Health Organization (WHO), Digital Health Activity (DHA), HISP-Tanzania, Uganda, and Gondar University, joined the DHIS2 CCT at different times for a specific period to enhance their technical capacity, system functionality, and address the data quality application developments, PHEM and the COVID-19 data requirements, which are described as follows.

6.5.2 The PHEM data app development

The PHEM requirement was initiated by EPHI, which is one of the MOH institutes with three objectives. EPHI conducts surveillance for the early identification and detection of public health emergencies. It has a legacy system with dedicated staff in health facilities to collect data regarding early identification and detection of these emergencies, such as malaria. E-mail was used for reporting the data to the next level. Aimed at improving this legacy system, the EPHI director communicated with the international DHIS2 developer and HIT directorate at various times to address the PHEM data requirement in DHIS2. Following the decision to customize DHIS2 for PHEM data, the PHEM requirement was defined in support of PPMED staff of the MOH. The PPMED staff explained this as; "*As we have experience in setting system requirements, we engaged in PHEM system development team*". This indicates the crucial role of the PPMED staff due to their previous data collection tools and system design and implementation experience. The deployed DHIS2, which is capable of data collection using the Ethiopian calendar, was used for PHEM system customization. The PHEM data element, data set, and collection period were customized and made it ready for data collection. However, it was impossible to use the Ethiopian DHIS2 for reporting due to the calendar difference. "*The issue was the PHEM data collection and reporting periods are different that use Ethiopian and European calendar respectively which forced us to use the global DHIS2 for reporting"(Developer, HISP)*. The reporting period of PHEM uses the EPI (Expanded Program on Immunization) week which is the WHO requirement for emergency cases. The EPI week is used in the European calendar. An app was developed to export the PHEM data from local DHIS2 to the global DHIS2, which uses the Gregorian calendar. Then they used the global DHIS2 for reporting to get the EPI week report. This

development required huge support from the international DHIS2 developer. "*Most of the code development concerning the PHEM system was conducted by the international developer*" (Developer, local HISP). Such great dependency on an international developer was reduced over time as local developers gained more knowledge and experience. The COVID-19 system and data analysis app development were also heavily reliant on the local IT staff capacity.

6.5.3 Data Analysis Apps Development and Upgrading of DHIS2

DHIS2 has a data quality app based on validation rules for data elements. For example, the first visit to Antenatal Care (ANC) is greater than the fourth visit, outlier analysis. Further, data analysis apps that include score card, bottleneck analyses, and action trackers, have already been developed, deployed, and are under development in various HISP countries, like Tanzania and Uganda, which were sponsored by UNICEF. The data quality analysis performs by identifying associations between two or three focused indicators. Of these, the score card, and the bottleneck analysis developed by HISP-Tanzania team are available in DHIS2 app store to freely access, customize, and implement according to the required context. Furthermore, the WHO data quality app is designed based on data completeness, data consistency, time consistency, and outliers

Similarly, UNICEF and WHO initiated and sponsored the development and deployment of these data quality analysis apps to enhance the quality of health data in Ethiopia. A developer who participated in this initiative described the effort as: "*One partner organization brought the HISP Tanzania member to customize these data analysis apps for Ethiopia. However, it was based on the European calendar which should be in the Ethiopian calendar and integrated with Ethiopian DHIS2. So I was assigned to work with them. I participated in various conferences organized by UNICEF in Kenya" (Developers, HISP).* This indicates how local technical expertise is required in system configuration beyond technical excellence. The purpose of score-card, bottle-neck, and action tracker apps is to identify indicators of performance and possible actions to improve the performance. The scorecard app identifies indicators' performance and creates colored reports for each indicator: green if the score is greater than 85% green, yellow if between 75 and 84%, and red if lower than 75%. The bottle-neck analysis begins with the scorecard result to identify what caused the specific performance indicator to turn red.

The action tracker suggests what kinds of actions should be taken for each red indicator, and tracks the progress of the action and the indicator. The action tracker app converts

the bottleneck root cause and possible solution into action. It creates a plan that describes step-by-step instructions and responsible personnel.

The Ethiopian team, in cooperation with the HISP-Tanzania team configured and incorporated the scorecard and bottle-neck analysis apps into the local DHIS2. However, both the action tracker and the WHO data quality apps, which require more development due to calendar issues were under process and distracted by the COVID-19 pandemic.

In addition to addressing the above requirements, the first version of DHIS2 was upgraded to version 2.27 from 2.3 to leverage additional features of 2.3. HISP developers stated about the upgrade "*The upgrade includes the above-listed apps and enhance the performance of the system the server was upgraded from 6 – 18, the operating system from 2.7 to 2.9, the DHIS2 from 2.27 to 2.3. These upgrades made on the operating system, server, and database change enhance the performance of the system*". DHIS2 version 2.3 in place since 2019.

After the deployment of DHIS2 version 2.3, the customization team involved in other customization activities such as migrating data from the previous system into DHIS2, multi-sector system customization, and the WHO data quality app development, were all disrupted by COVID-19 system development work. In connection with the COVID-19 pandemic, the CCT members initiated the configuration of DHIS2 for handling COVID-19 data for Ethiopia. The team shifted to covid-19 system implementation activities using the DHIS2 tracker.

6.5.4 COVID-19 Pandemic Surveillance System Development

The local HISP team with the routine DHIS2 customization experience downloaded the Sri Lanka COVID-19 app from the DHIS2 app store and customized it for Ethiopia with little support from the international developer. The HISP developer described how it was initiated: "*In mid-march 2020, the Sri Lanka HISP released the COVID-19 app in DHIS2 app store when the first COVID-19 case was identified in Ethiopia. The covid-19 app was developed based on the DHIS2 tracker".* The DHIS2 tracker differs from the routine DHIS2 system, with the former handling case-based data and the latter aggregating data. The DHIS2 tracker customized for Ethiopia to handle COVID-19 data was first demonstrated to IT and PPME directorates, then to the COVID-19 national task force and the Ministry of Innovation for approval. Ultimately the system was chosen from other alternative systems presented to the Ministry and configured and deployed in the head-quarter data center to be used online by health institutions. The COVID-19 system collects data from

three major sources. First, health institutions with internet connections directly enter the COVID-19 data using the online COVID-19 system. Second, data collected and reported from offline health institutions and quarantine centers to EPHI using paper-based formats centrally entered data into the DHIS2 tracker by twenty-five data clerks deployed in the EPHI IT innovation center. Third, the DHIS2 core team developed an intermediate system to pull the COVID-19 data from the data depot to the tracker. A Data depot is a national database that stores multiple data including the COVID-19 data from diverse COVID-19 applications.

In addition to the DHIS2 tracker, there were small apps developed and deployed by another partner organization, Digital Health Activity (DHA), that enabled Android and tablet devices to collect COVID-19 data from Airports, drivers on land corridors, the 8335 call center, quarantine centers, health centers, and hospitals. The data from these apps transfer to a national data depot.

System analysis and reporting were conducted using the pivot table analysis tool, dashboard, and visualizer. The use of DHIS2 for COVID-19 revealed the importance of using DHIS2 to address emergent problems in the health sector and also showed how the local team gained sufficient technical knowledge and skill to manage DHIS2 themselves. Following the use of DHIS2 for various emergent data requirements, the technical director of the partner organizations said "*Currently, I heard that DHIS2 is suggested for everything i.e MFR, data analytics, even from EMR which is not correct. We have a health architecture that was developed independently of any system. Different systems such as ECHIS, MFR, and laboratory systems came independently and come to interoperable layer, DHIS2 is also considered as one of these systems mainly for HMIS*". This statement indicates a contradiction regarding the use of DHIS2 in the sector. Some considered DHIS2 merely for routine HMIS, while others emphasized the importance of DHIS2 even for case-based data. One of the informants said, "*We did not exploit DHIS2 properly, we need case-based data collection as our program, malaria, is becoming at the eliminating stage, DHIS2 has a tracker module that we could use for real-time data that we need*" (Expert, Health Program). The case has shown the use of DHIS2 for different emergent needs in the health sector, including PHEM, COVID-19, TB, HIV, wereda transformation system, and the certificate delivery system for Yellow Fever.

Though DHIS2 has been extensively used by health sector stakeholders as a formal national-level system, it is not the only system used for health sector performance and monitoring. Health experts from different directorates state as follows "*We used DHIS2*

as a major data source but also survey data, PHEM data which is reported in a weekly basis from EPHI, were compared and used for planning, monitoring and reporting " (Experts, MOH). The regional health expert also described his use of other systems for data comparison: "*I triangulated our data from DHIS2, DATIM system while preparing a report*" (Experts, HIV, region). DATIM is the U.S. President's Emergency Plan for AIDS Relief (PEPFAR) specific version of DHIS2 for collecting HIV data at all levels with different support staff. The PHEM system uses a Microsoft Excel application coordinated by EPHI to collect and report weekly data to the concerned directorates.

Such parallel system development, deployment, and use have flourished using DHIS2 as a standard artifact because of its open-access DHIS2 feature and the enhancement of technical competence in the sector over time. Of these, DHIS2 was configured to handle the HIV data at the regional level and TB data at the program level, exemplifying parallel system development using DHIS2 are discussed as follows.

6.6 DHIS2 Configuration by Third Parties

In addition to the national DHIS2 customization team, new actors and structures were created at regional and health program levels to address the emergent health program requirements using DHIS2 without the involvement of the national team. Of these, the DHIS2 configuration and deployment for TB and HIV data is presented as an example of a health program-specific system configured and deployed by third parties. The regional and program-level partner organizations (CDC, USAID, and DHA) initiated and supported the configuration and deployment of these systems with resources and technical expertise.

6.6.1 DHIS2 configuration for HIV data

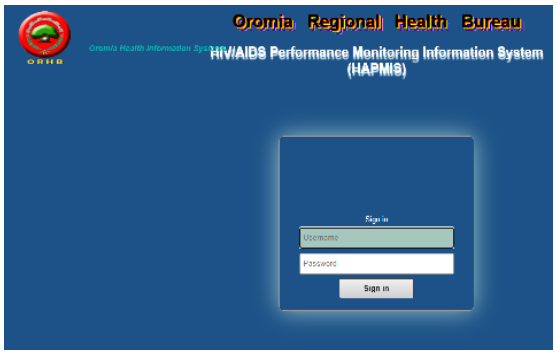


Figure 20 Region based HIV/AIDS Information System

DHIS2 configuration for an HIV/AIDS performance and monitoring information system (HAPMIS) was initiated by the Oromia Regional Health Bureau IT staff who took part in end-user and advanced DHIS2 training. The International Compliance Assurance Program (ICAP) partner organization had come up with an HIV data monitoring system, developed

by C-sharp, for deploying the system and providing training for the region. The region staff involved in the system training asked them to incorporate more regional-level requirements into the system. The organization was not ready to incorporate the regional requirements but instead, to deploy as-is because it was already deployed in Amhara region. IT staff of the region took the initiative to develop HIV system with DHIS2 incorporating the region's requirements. He described how the regional-level HIV system was designed: " *I prepared a proposal to design and implement a new HIV system using DHIS2 that can satisfy the region requirement. Upon approval of the proposal by the region and partner organization to fund, I from IT and an expert from M&E unit began defining detailed the region-level requirement based on the reporting formats and register books*" (Developer, ORHB). The IT staff who took on the initiation educated themselves with DHIS2 knowledge and skill through various mechanisms such as by being a member of DHIS2 community to access online resources, watching DHIS2 videos, reading manuals, and asking for guidance on where and how to locate resources from the Ethiopian international developer. The customization used the basic DHIS2 framework and added new code to satisfy the requirement. DHIS2, for HPMTCT used three organizational structures, compared to the four structures used by DHIS2 aimed at enhancing the performance of the system. Customization was finished within a year and training was given to appropriate regional, zonal, wereda, and health facility focal persons, HIT and M&E staff. Valuable feedback and comments given during training were used to improve the system. The difference between this system and routine DHIS2 regarding HIV data collection was described as follows by the developer: "*Our system collects detailed HIV data from registry books whereas DHIS2 populates aggregated data. These data are highly used by partner organizations to monitor HIV-related services*" (IT Expert, Region).

The deployment has been funded by CDC to purchase a new server for the region, dongle wifi devices for non-connected health facilities, and increased bandwidth for connected health facilities. Region server was used to deploy the system which is now used in twenty-six the PEPFAR sites. Data entry was handled by HIT and M&E staff with account and user names in the PEPFAR sites. In addition to the government staff, partner organizations like CDC and ICAP, were given unique usernames and passwords to access the system for viewing the periodic data. The regional, zonal, wereda level managers, experts, and partner organizations' staff extensively used the system to view and generate reports. The HPMTCT is now widely used in the region apart from DHIS2 and DATIM

for HIV data requirements. However, the configuration and deployment of DHIS2 for HIV were not formally known by MOH.

6.6.2 DHIS2 configuration for TB data

DHIS2 has been configured for TB program in cooperation with USAID by Digital Health Activity (DHA). DHA is a five-year $62 million dollar project that aimed to design, implement, and provide digital technology solutions for the health sector. The developer of this organization described how DHIS2 configuration for TB was initiated: "*We were asked by a partner organization to design TB system as the routine dhis2 did not collect the required data elements which are very useful to track the TB cases. It is only given in a few organizations,…We used DHIS2 as it is familiar in the sector, you will not face difficulty for deployment*" (Senior developer, Partner Organization). The statement indicates how the partner organization initiated and sponsored the system development and deployment to address the information needs of the TB program.

Data for the TB requirement were collected from the two federal hospitals, Petros and Paulos, to customize DHIS2. Petros and Paulos hospitals are the two federal hospitals that provide TB treatments. Defining this requirement definition was conducted through document analysis, observation, and interviewing key persons at these hospitals. The document analysis included patient cards, manual cards, and reporting formats. Based on these requirements, DHIS2 has been customized for TB and is ready for piloting during the data collection period of this study. The DHIS2 competence required for DHIS2 customization was gained through engaging in various level DHIS2 training conducted by MOH, contacting the MOH core team, and surfing the internet.

In general, these program-specific DHIS2 implementations conducted at lower levels did not involve the DHIS2 core experts situated in the Ministry of Health.

Table 4 summarized stakeholders and governance mechanisms underlining DHIS2 implementation and figures 21 and 22 summarize the DHIS2 structure and implementation process with actors involved over time.

Table 4 Summary of DHIS2 Implementation Actors, Governance Mechanisms, Implementation, and Systems

Actors	Systems	Governance Mechanisms used			Standardization	Evolve-ability
		Structure	Process	Communication		
NIT, a Partner organization	DHIS2 for routine health management data	Centralized ad-hoc team with DHIS2 core experts complemented by hierarchical Teams for deployment	Self Assessed complemented by RHB	Top-down	Few standards employed i.e indicator reference	Constrained by lack of DHIS2 competence, absence of bottom-up communication
NIT, Health Programs, Partner organizations	DHIS2 for PHEM, COVID data, data quality apps	Distinct ad-hoc teams with DHIS2 periphery knowledge and skill complemented by hierarchical teams for deployment	Self Assessed	Top-down and Horizontal	Few standards employed i.e previous Org unit, the routine DHIS2 codes re-used	
RHB, partner organization	DHIS2 for regional HIV data	Decentralized	Self Assessed	Decentralized	Absence of standard at all	Facilitated by open access of DHIS2 and partner organizations' resources
Health Programs, partner organization	DHIS2 for TB in special hospitals	Decentralized	Self Assessed	Decentralized	Absence of standard at all	

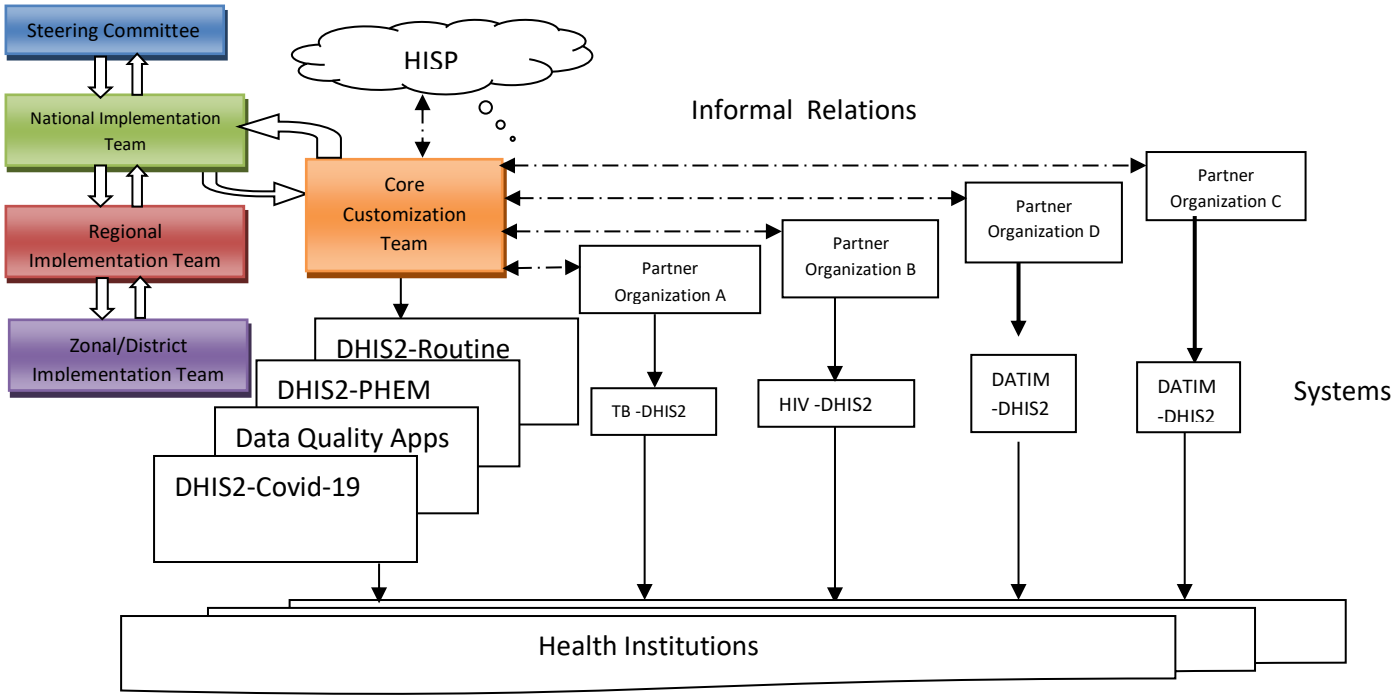


Figure 21 DHIS2 Implementation Structure and Relations

Figure 22 depicts the DHIS2 implementation centralized and decentralized organizational structures led by MOH and partner organizations respectively. MOH established a hierarchical implementation team ranging from national to wereda level while receiving advanced level DHIS2 technical support from HISP using informal relations. Partner organizations to satisfy the health programs' detailed information need to establish distinct structure for specific health program information configuration and implementation with receiving support from HISP using personal relationships.

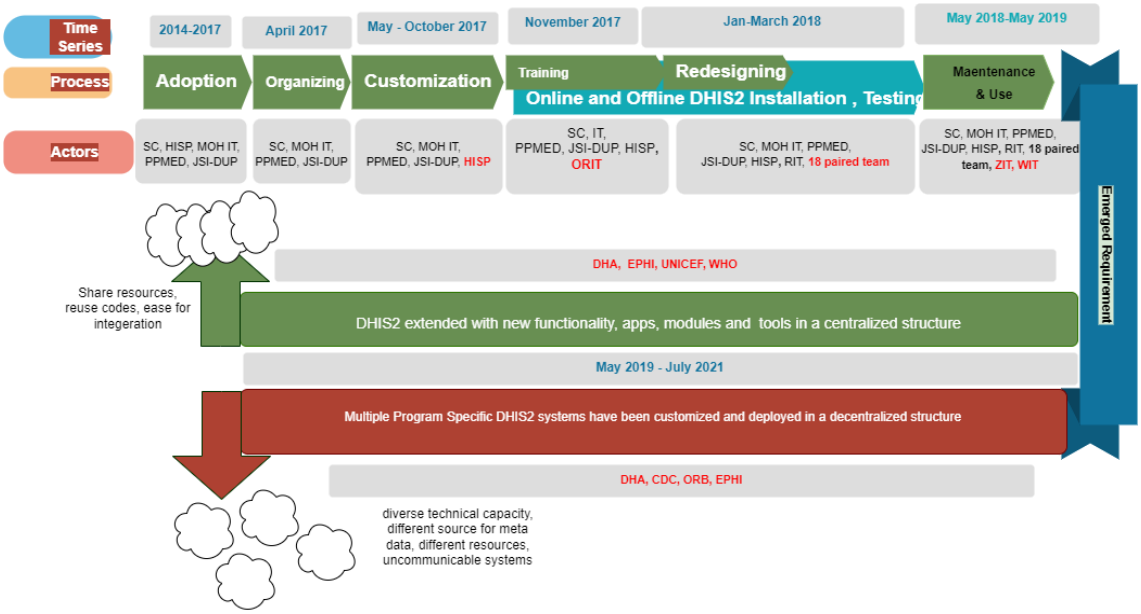


Figure 22 Temporal DHIS2 Implementation Process (2017-2020)

Notes: Actors with rec colors new actors joined the implementation over time to new requirements

Figure 22 depicts the DHIS2 implementation process across periods when actors are involved in system implementation and its impact on DHIS2 implementation with standardization and evolvability.

Both the centralized and decentralized DHIS2 innovations required well-established information infrastructure including networks, computer resources, and data centers which are described next.

6.7 Infrastructure Development

6.7.1 Health Net Coverage Enhancement and Cloud Hosting DHIS2

DHIS2 is a web-based system that requires network infrastructure to provide the data collection, processing, data warehouse, and other potential services. However, the health net coverage in Ethiopia at the deployment of DHIS2 was only 30% and was not reliable due to unstable electricity and poor server management and network devices. Except for the high-level administrative offices, most health facilities had neither virtual private networks (VPNs) nor internet access. The health net was a long-standing MOH VPN project aimed at connecting health facilities using the wereda net infrastructure. Wereda net infrastructure was established by the government to connect the wereda administrations through a network. The MOH health data center hosts various health sector databases and web applications, including DHIS2 to provide data collection, storage, and access services to the health sector.

The limited health net coverage and unreliable network infrastructure forced connected and non-connected health facilities and hierarchical administration offices to deploy the offline DHIS2 database instance, which would mitigate issues in times when connectivity is lost. The plan was to then have connected health facilities and administration offices use the online DHIS2, which was hosted in the MOH data center. However, managing more than 4,000 DHIS2 database offline instances installed in distributed health facilities was challenging particularly when the database was maintained and updated. These challenges encouraged the MOH to strengthen the health net infrastructure.

After an agreement with an Ethio-telecom agency with a $1 million investment, more than 3,000 health facilities were connected within three months. In addition to the $1 million investment, MOH started paying a yearly subscription fee for health facilities with the assumption health facilities will take over this responsibility in the future. However, poor coordination challenged the establishment of a health network. PPMED director recalled what they faced during the networking effort "*The telecom staff appeared in the health facilities for connection without the health facility knowledge. Health facilities neither agreed nor were informed about the project. At that time, the health facilities might be closed, not willing or they were not ready for the work at all. Such absence of transparency created misunderstanding between the health facility and the telecom staff and consequently delayed the connectivity"*. Several hierarchical communications and discussions were required to begin connectivity.

The project used fiber cable, ADHL, and CDMA to connect health facilities depending on their location. To be able to use the online DHIS2, hospitals, and wereda health offices required an eight-megabyte internet connection, while health centers need a two-megabyte connection. Though the process was not complete, connected health facilities increased from 30% to 70% from 2017-2019, which in turn increased the health facilities' online DHIS2 use (MOH, 2019).

However, the enhancement of health net coverage slowed down the MOH data center services due to an increased number of connected health facilities. In the meantime, users were unable to access the online DHIS2 for about two weeks in December 2020. Several DHIS2 users from the government such as data clerks, health program experts, managers, and partner organizations kept calling the MOH head office to resolve the issue. Soon after, the CCT members attempted individual, group, and organizational-level efforts to resolve the issue. Per the recommendation of the concept note written by the MOH IT directorate and partner organization, DHIS2 was moved to a cloud-based system that resolved the server-related issue. However, this transition has been challenged by the MOH technical committee established to mitigate and propose the system issues, the committee criticized the cloud solution for the security issue and suggested re-innovating the data center with high-capacity data storage, firewall, network devices, and automatic UPC to enhance the performance of the data center as a permanent solution. One of the informants put this issue as this "*DHIS2 was down by the server capacity, connectivity, electricity, and human resource issues, so MOH was forced to move DHIS2 to the cloud and now it is stable, people raised the security issue but I don't agree to bring back DHIS2 to the local server for the second time instability*"(Technical Director, Partner organization). Based on the technical working group suggestion the Data Center re-innovation was carried out yet DHIS2 was still in the cloud at the writing of this thesis.

6.7.2 Data Center Re-innovation

The existing health net was challenged to provide a service for more than 4000 DHIS2 users, initiating the data center re-innovation. During the data collection period of this study, data center re-innovation in the head office was carried out. The re-innovation included replacing the existing network devices with the latest network devices and installing an automatic generator, high-capacity UPS, and high-capacity servers. Another data center was also established and launched in May 2020 in Petros Hospital to serve as an alternative local server for backup services. It is also expected to be used as a

development hub. Furthermore, the health-net infrastructure has been improved at the regional level in relation to the deployment of HAPMIS in Oromia region data center. The process of health-net infrastructure development has shown in Figure 23 and Figure 24 is an example of a new data center in a health facility. .

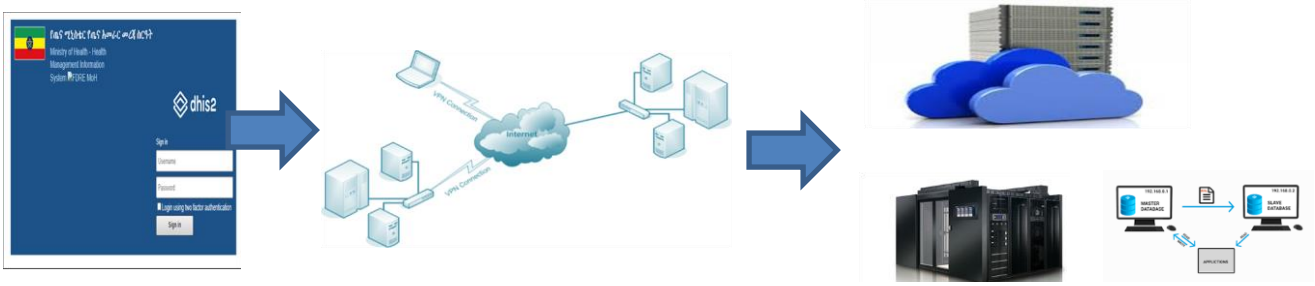


Figure 23 Health-Net Infrastructure Development

Figure 24 Innovation Center in Petros picture taken by Birkinesh Sept. 2019

6.8 Summary

The study depicted how DHIS2 implementation involved standardizing HIS and introducing new systems, components, and app development to satisfy the unique and emergent requirements of public health care in Ethiopia. Often DHIS2 implementation was initiated and implemented by MOH and partner organizations using a centralized and decentralized governance structure. MOH to establish harmonious HIS focuses on standardizing HIS using a centralized approach and partner organizations focus on specific health program HIS innovation to address unfulfilled health information needs. The nationwide DHIS2 implementation effort led by MOH has been challenged by infrastructural, contextual, technical, and new requirements at various stages of DHIS2 implementation which led to reconfiguring the IT governance mechanisms (structure, process, and communication) of the implementation. DHIS2 implementation led by multiple partner organizations in a decentralized governance structure led to duplication of work, and parallel and fragmented systems. The open-source feature of DHIS2 and its freely accessed resource tools encouraged multiple health programs to design and deploy their health program-specific HIS which led to uncontrolled evolve-ability without

establishing a coordination mechanism. Given DHIS2 is a web-based technology, the use of DHIS2 in the sector facilitated the establishment of the healthcare IT infrastructure including networking, computer, electricity, and data center resources.

CHAPTER 7: **CASE ANALYSIS**

This chapter is divided into three sections and provides an analysis of the case of DHIS2 implementation in Ethiopia, based on the integrated framework using institutional logic, dynamic ambidexterity, and boundary resource model concepts. In the first section, the institutional logic concept was used to identify the logics which have driven the DHIS2 implementation. Dynamic ambidexterity concept and boundary resource model were used to reveal the IT governance mechanisms employed at organizational and project levels to govern DHIS2 implementation in sections two and three. Section two describes the organizational-level analysis of DHIS2 configuration, including structure, process, and communications employed in DHIS2 implementation. Lastly, the boundary resource model is used to provide project-level analysis in section three. Tables 5 and 6 summarized the prevalence of institutional logic and governance mechanisms based on profession and organization.

Table 5 Institutional Logic by Profession

Concepts	Health Experts	IT	Managers	Total
1 : Adoption				
Innovation*				4
3 : Deployed system in other countries DHIS2		X		1
4 : Functionality			X	1
5 : Open source		X	X	2
6 : organizational problem			X	1
7 : System fragmentation			X	1
Integration*				4
9 : Concerned for Resource Invested		X	X	2
1 : Hybrid system from the two system		X		1
11 : Lead by MOH			X	1
Systemic*				2
13 : Improvement as to MOH requirement		X	X	1
14 : Lack of capacity at MOH		X	X	1
2. Implementation				
Centralized*	X	X	X	3
Local Capacity		X	X	2
One Plan One Policy One Report		X	X	2
Systems and app development	X	X	X	3
IT*				

Concepts	Health Experts	IT	Managers	Total
Development	X	X	X	3
One Plan One Policy		X		1
The technical capacity		X	X	2
Systemic*				
Disaggregated data	X	X	X	3
Lack of time	X		X	2
Program Specific Data	X	X	X	3
Work with Partner Organization	X	X	X	3

Table 6 IT Governance Mechanisms by Organization

	PO	MOH	RHB	HP	HISP	Total
IT Governance Mechanism						
Communication*						
Bottom-up	X	X	X	X	X	5
Communication gap	X	X				2
Lack of information	X	X		X	X	4
Networking	X	X		X		3
Top-down		X	X	X		3
Process *						
Autonomous	X	X	X		X	4
Absence of control	X	X	X	X		4
Application	X	X	X			3
Boundary-Resource designing		X	X	X		3
Certification	X	X				2
Evolve-ability	X	X	X	X		4
Controlled	X	X	X	X	X	5
customization		X	X	X	X	4
Lack of capacity	X	X	X	X		4
Maintenance	X	X	X	X		4
Requirement	X	X	X			3
Training	X	X	X	X	X	5
Use	X	X	X			3
Structure*						
Ad-hoc	X	X	X		X	4
Centralized	X	X	X	X	X	5
Decentralized	X	X			X	3
Management*						
Competing	X	X	X		X	4
Collaboration	X	X	X	X	X	5
Resource-Chasing Collaboration	X	X	X	X	X	5

7.1 Stakeholders Analysis Using Institutional Logic Concept

Multiple logics may be simultaneously in play, contributing to institutional contradictions (Friedland & Alford, 1991). Accordingly, this study described three major institutional logics during DHIS2 adoption as systemic, integrating, and innovation logics and centralized, systemic, and IT logics during the post-adoption period, which are shown in Figure 25 and described in detail in Tables 5 and 6 respectively. During DHIS2 implementation, these logics sometimes conflicted with each other and other times complemented each other. The contradictions identified during implementation are reflected as a centralized and decentralized system, our system and your system, MOH and partner-organization system, foreign and local system, local and external capacity, aggregated and dis-aggregated data, and integrated and program-specific system.

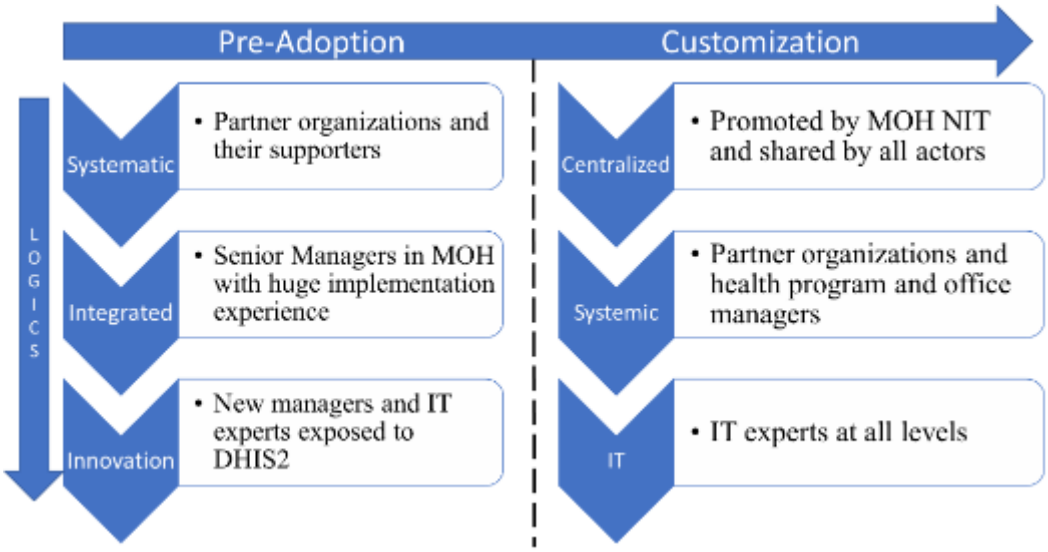


Figure 25 Institutional Logic in DHIS2 Implementation

7.2 Institutional Logics and Contradictions at the Adoption Stage

The systemic logic emphasized specific system development, improvement, and deployment with distinct sources of funding to satisfy the MOH interest. It was facilitated by partner organizations that emphasized competition to outshine their systems over other systems. MOH facilitated the integrating logic by relying on experienced IS implementation managers who emphasized developing a hybrid system by reusing the two partner organizations' established technology, systems, and infrastructure. Finally, the innovation logic was initiated by a high-level official based on an understanding of the existing systems' technical and organizational limitations and suggested a new

system, DHIS2, which has been widely used in middle and low-income countries.

I. The Systemic Logic

The systemic logic emphasized specific system development, improvement, and deployment with distinct sources of funding to satisfy the MOH interests. The systemic logic was introduced following the MOH decision in 2008 to assign the two partner organizations in different regions to system implementation without proper coordination mechanisms at the federal level. The logic emphasized competition through specific system development and implementation with different sources of resources and technologies for different regions. It was facilitated by partner organizations, managers, and staff of health institutions ranging from MOH to regional health offices, which are involved in system implementation. Furthermore, these actors supported these systems to sustain the material and financial advantages gained with the implementation apart from the system benefits for data management which were emphasized in the case description of the role of partner organizations in equipping health institutions with IT infrastructure ranging from computer to network establishment.

Scholars have argued that organizational fields are organized by a dominant institutional logic that guides the behavior of social actors (Thornton & Ocasio, 2012). This study identified systemic logic as a dominant logic in the initial stage of system adoption, as it guided the incumbent actors of health institutions ranging from health facilities to MOH due to a well-established network from the federal to health institution level through fulfilling the technical, financial, and material resource constraints of the implementation for more than a decade. The partner organizations' region-based systems conflicted with the MOH's need for a centralized system because it was unable to generate national-level reports with two distinct systems. In addition, MOH designed another system to pull data from these distinct systems to generate a national-level report. Given the absence of adequate technical and financial capacity in the public sector, these two competing systems were being used for more than a decade despite their fragmentation and frequent technical problems. This depicted how the functionality of HIS relied on these partner organizations' systems, which influenced MOH to devise various mechanisms, such as geography separation and intermediate system development, to sustain these systems. However, this was found to be inadequate for handling the revised data collection elements and indicators made at the national level in 2014, forcing MOH to make a system selection of the two systems.

The two partner organizations began competing to sustain their systems in the sector that is regarded in this study as your system and our system contradiction. Competitive institutional logic conflict results in the change or new account of activities, whose consistency brings stability to an organization's field (Thornton & Ocasio, 2012). Similarly, the MOH strategy, system evaluation, to select a better system was not materialized, as the failed system's partner organization in the evaluation rejected the results of the evaluation which depicted how much partner organizations competed to influence the MOH decision. MOH became indifferent towards selecting one over the other, leading MOH to play a reconciliation role.

II. The Integration Logic

The integration logic was drawn from the MOH 'One Plan, One Budget, One Policy, and One Report' principle aimed at implementing a centralized and harmonized system (FMOH, 2016). The logic emphasized the investment in the previous systems' resources and established technical capability, systems, networks, and infrastructure as basic elements needed for implementation. Thus, they wanted to have a smooth relationship with the dominant logic, systemic, which had already established system and technical capacity in the sector but also promoted the role of MOH in HIS implementation by minimizing the role of partner organizations. The integration logic was facilitated mainly by experienced MOH key directorates (policy, plan, and IT), who devised various mechanisms for the co-existence of the two competing systems in previous e-HMIS implementation. However, the integration logic did not bear fruits due to the unwillingness of the existing partner organizations to collaborate, which forced MOH to explore alternative, innovation logic. This dynamic shows how the systemic logic emphasized competition instead of working together and did not allow acceptance of the MOH integration logic. This systemic logic competitiveness led MOH to find other alternatives, promoted local system development from scratch, and led others to introduce a new alternative system, DHIS2, to the health sector.

III. The Innovation Logic

The dominant-led IS implementation characterized by competition often results in sustainability failures (Werder & Heckmann, 2019). Similarly, the systemic logic emphasized in competition later was replaced with innovation logic. The innovation logic was initiated by a new high-level official because of HIS fragmentation and competing

actors' unwillingness to collaborate to address the emergent needs of centralization expressed by the Ministry. Institutional entrepreneurs bring about change by providing alternative models for mobilizing resources to challenge existing structures (Seo & Creed, 2002). Similarly in this case, the innovation logic suggested a new system, DHIS2, which had been deployed and used in many developing countries to alleviate existing systems' fragmentation, technical, and organizational problems.

Despite the effectiveness of DHIS2 that was revealed in the (demonstration, piloting, experience sharing, and system evaluation), the innovative logic received great challenges from supporters of the existing logic (systemic and integrating). Both systemic and integrating logic proponents recalled the investment that was made for a decade to the existing systems and promoted the reuse of these infrastructures, technical capacity, and systems through improvement instead of importing a new system from outside, as described in case description section 6.4.1. Although this challenge did not lead to the rejection of DHIS2, it caused the adoption of DHIS2 to be delayed for three years. This study reveals how a systemic logic was dominant in the sector due to the monopolization of both the technical and resource capacity that pushed the actors to continue supporting the partner organizations' flawed systems. Reconciling diverging logics requires the senior manager's distance from prevailing institutional logic to employ collaborative strategies for successful IS implementation in complex settings (Berente & Yoo, 2012; Boonstra et al., 2017; Jones et al., 2015; Lepoutre & Valente, 2012). In line with this, the finding depicted how distance from the prevailing institutional logic matters in system adoption. Those who did not have affiliation in previous e-HMIS implementation (i.e. new high-level officials, managers, and staff exposed to the new system) were supporting the innovation logic, while those who were involved in the previous e-HMIS implementation opposed the innovative logic. Such conflict led by high officials sustained for about three years while silencing without any action, garnering more supporters of the new system through piloting, capacity building, conducting evaluation, and exchanging information from experts, developers, and implementers exposed to the new system in other developing countries as it was detailed in section 6.4.1. Ultimately, the new-high level official decided to adopt DHIS2 by referring to the external evaluation result. Thus, this study argues that although both system excellence and resources are crucial for system adoption, managers should separate system technical excellence from its resources for better system adoption, which requires distance from

the existing institutional logic. Tables 5 and 6 summarize the institutional logic behind DHIS2 implementation.

Table 7 Stakeholders and their institutional logic dimensions during pre-adoption DHIS2

Logic	Actors	Principle	Assumption	Identity	Domain	Representative Quotes
Systemic	Partner organizations and health institutions managers and staff	Provide technical and financial support to health care sector	The absence of technical capacity with in MOH can be supported by partner organizations for financial and technical resource	Competent organization with highly paid staff, equipped with technical and financial resource in system implementation	Health Information System implementation	*It is possible to improve system to satisfy the MOH requirements* (Experts, Partner organization) *It is better to develop new system locally from scratch instead of bringing foreign system* (Higher Official, MOH) *Minimum adjustment is needed as there is various health information infrastructure such as computer, networks, trained monitoring and evaluation work force at all levels are in place* (Unit head, MOH) *Technically partner organization's system was fine but geographically partner organization B covered large sector* (Unit head, MOH)
Integration	MOH managers and staff	Centralized System to overcome the fragmented systems	Integrating the deployed health information systems by re-using the established health information infrastructure	Long experience in deploying the existing system in cooperation with partner organizations	Legitimizing health information systems, coordinating with partner organizations	*The IT department let alone the source code did not have a password to change the user name"(Former staff, MOH)* *"you know, it is difficult to say just goodbye for an actor who has gone through many ups and downs for the implementation in the absence of infrastructural and technical capacity. They did great jobs in establishing the current IT infrastructure and capacities"*- Director, IT *We invested a lot in infrastructure, resource, system development, now when it became stable…it is difficult to ruin all and start from scratch"- PPMED, manager*

Logic	Actors	Principle	Assumption	Identity	Domain	Representative Quotes
Innovation	Senior official, HISP, donor organizations, managers and experts exposed to DHIS2	Customizable, open system suitable to developing countries and various contexts	The existing systems are unable to respond the current need of MOH and dependency on partner organizations	Initiated by medical background and supported by HISP members, new to HIS implementation and to the existing deployed systems	Leading and Guiding health institutions	*There was strong dependence on the IDP at all levels for a range of functions, including software development, support, infrastructure, training, and others. This reduces the capabilities of the health systems to become self-reliant and sustainable(MOH reports, 21)* *I am advocate of DHIS2 because I knew it prior to the MOH talk about DHIS2 I am the member of DHIS2 community(Expert, MCH)* *When you compare it with DHIS2, the analysis feature of the previous system was too limited, I did not know the pivot table, and dashboard before DHIS2. Previously I did not know about pivot table, I know it in DHIS2. it was a wonderful tool for analysis."* - Health expert, MCH. *It is a global public good, you can use it according to your interest*(Staff, MOH) "*Donor organizations also pushed to use DHIS2, as they knew it in other countries"*(Developers, HISP)

7.3 Institutional Logics during DHIS2 Configuration and Deployment

Following the selection of DHIS2, a new high-level official gave a directive to involve potential actors in DHIS2 customization and deployment. Accordingly, this study depicted various actors with centralized, systemic, and IT logic in DHIS2 configuration and deployment.

I. Centralized Logic

Often, organization field change is related to dominant logic (Thornton & Ocasio, 212). After DHIS2 selection, the MOH concerned managers who were promoting the integrating and innovation logic combined with a centralization logic which was shared by all actors. The centralized logic was drawn from the MOH 'One Plan, One Policy One Budget, and One Report' principle to implement a government-owned, centralized DHIS2 to alleviate the existing fragmented systems deployed by partner organizations and their dominance. For this to happen, different partner organizations and donors were requested and rendered their financial and technical support for the implementation.

The centralized logic IT governance mechanisms (i.e. centralized structure, monopolization of the customization process by a central team, and top-down communication, which will be discussed in detail in governance mechanism section 7.1.4) depict how the DHIS2 implementation was heading to standardization as depicted in figure 26. In this, local and foreign systems; local and external capacity, and aggregated and disaggregated contradiction were identified. However, the implementation of DHIS2 under centralization logic was soon challenged by IT logic because of a lack of DHIS2 competence and systemic logic for specific neglected disaggregated health program data. The centralized logic reconsidered the situation and accommodated the IT and systemic logics to address the lack of IT competence to customize DHIS2 and address the emergent requirements initiated by health programs, agencies, as well as the environment i.e. COVID-19 pandemic. Ultimately, the centralized logic enabled it to address both standardization and evolvability at a certain level as depicted in Figure 26.

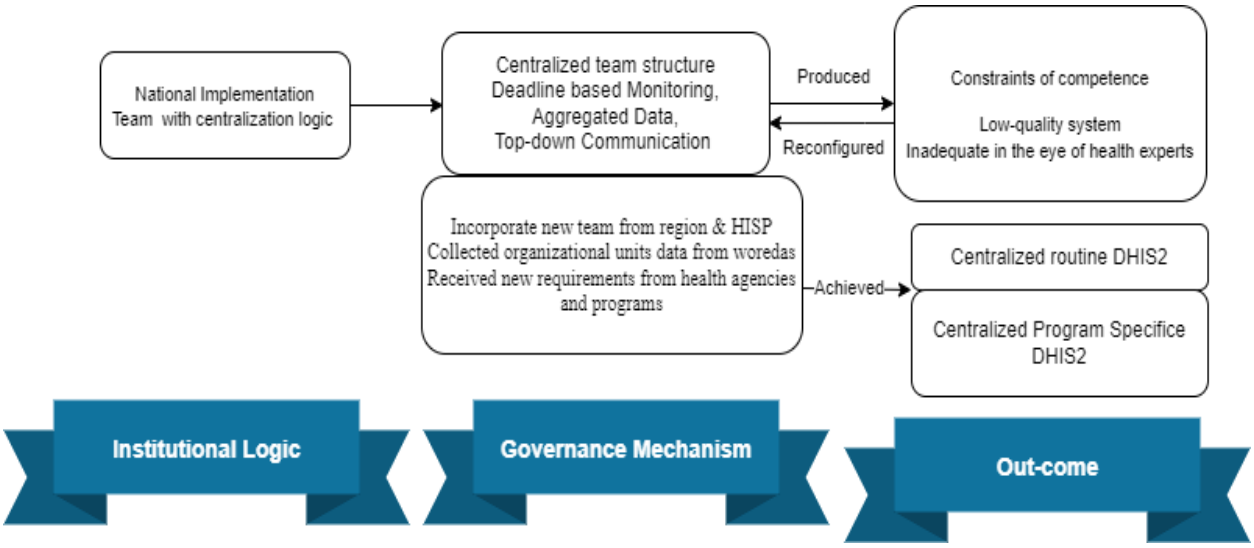


Figure 26 Centralized logic achieved Limited standardization and evolveability

II. Systemic Logic

Health experts, health managers, and partner organization managers at different health programs required detailed and/or case-based information from the system to monitor, plan, and evaluate the performance of their specific health program. Given the disaggregated data was neglected by MOH while configuring DHIS2, program-specific system implementation initiatives were organized by various partner organizations. Some through the MOH team and others with distinct structures have implemented program-specific systems in a scattered manner. The health program's role was then legitimating and facilitating the program-specific system implementation. This depicted how systemic logic characterized by evolve-ability, was initiated and facilitated by multiple uncoordinated partner organizations with different sources of resources and legitimized by health program managers. Here, aggregated and disaggregated data, centralized and decentralized system contradiction was identified. Partner organizations with systemic logic exploited IT experts ranging from HISP to each health institution at various levels. The system logic is summarized in Figure 27.

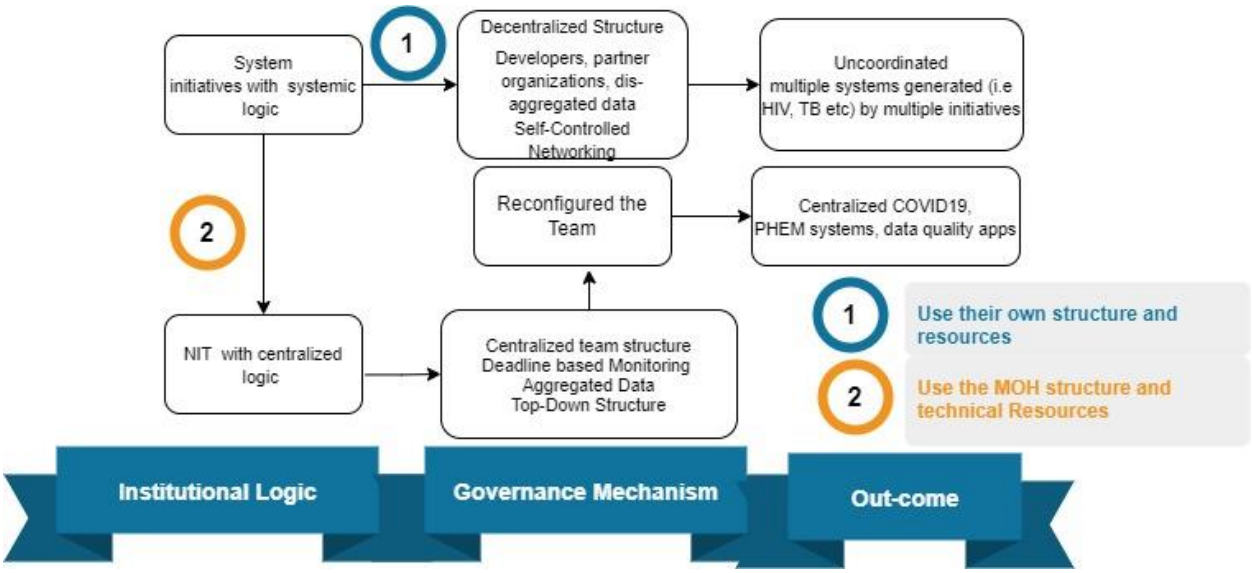


Figure 27 Systemic logic to uncontrolled evolve-ability

III. IT logic

IT professionalism emphasizes technical knowledge gained from IT education, and personal, and work experience (Agresti, 2011). However, this case revealed how the IT logic underpinning DHIS2 implementation disregarded the personal and work experience gained from DHIS2 development and implementation by excluding HISP under the NIT's direction to use the local capacity to customize DHIS2. However, the technical team with IT education was soon challenged by the lack of DHIS2 competence regarding code-level customization, which led to a restructuring of the team to include a few HISP members, discussed in the Re-Configuration of CCT under section 7.1.4. This revealed the importance of technical knowledge gained from personal and work experience in system implementation rather than IT education.

Furthermore, IT logic is concerned with measurement and testing to offer precession for implementing rational standards using appropriate development methodologies (Mok, 2010) that builds on systems sciences (Agresti, 2011). However, the IT experts on the CCT dominated by centralized logic, did not use the appropriate measurement and testing mechanisms due to the absence of controlling mechanisms and constraints of human resources in the CCT with deadlines given by managers. Despite the centralized logic emphasis on controlling, system testing was self-assessed without a controlling mechanism.

On the other hand, the open-source feature of DHIS2 facilitated easy access and configuration of DHIS2 with a certain level of IT capacity for multiple health program systems sponsored by various partner organizations. IT experts working at different levels of health care, from both government and partner organizations, used the DHIS2 open-source feature to learn, configure, and deployed health program-specific systems in the sector. Such multiple system implementation initiatives used distinct technical and resource capabilities for the implementation due to the absence of national-level common resources for the implementation. Thus, IT logic in DHIS2 implementation facilitated both the centralization and systemic logic under the guidance of these logics. IT logic in NIT facilitated the centralization logic, whereas, at various program and region levels, it facilitated the system logic by availing DHIS2, tools, training documents, and API freely through the internet channel as shown in Figure 28.

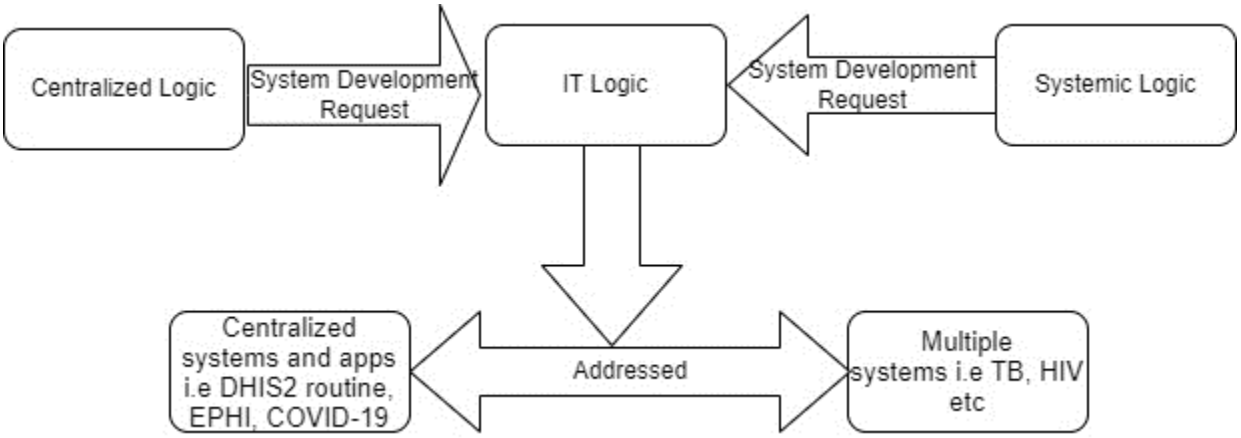


Figure 28 IT logic polarizing systemic and centralized logic

Table 8 Stakeholders and their institutional logic dimensions in DHIS2 configuration, deployment and use

Logic	Principle	Assumption	Identity	Domain	Characterization	Quotes
Centralized	One Policy, one Plan, one Budget, and one Report Emphasizes aggregated data	Aggregated data enables nationwide yearly and semi-annually as well as pragmatic planning, monitoring, and measuring of the health sector. Using partner organizations' financial and technical support to fulfill the IT and financial capability problem helps develop and implement a centralized system financial and technical support to fulfill the IT and financial capability problem developed and implemented centralized system	Large workforce with lower finance and IT capability organized in a hierarchical structure to legitimize and authorize the IT activities Deploying a government-owned centralized system Expecting technical and financial resources from partner organizations	Health information system implementation based on the health architecture	Emphasis on standardization later on accommodating certain evolve-ability	*we have zero tolerance principle for partner organizations who want to develop parallel systems* (Coordinator, PPMED) *'we have only one national health information system, no regional, zonal health information system* (IT directorate) *'It is the MOH paying for telecom for the use of the data services for 3000 health facilities. if our internet is shut down means all 3000 health facilities can not access the system and use it at all 'we have health Enterprise architecture project where we define interoperable layer* (HIT, director, MOH)

Logic	Principle	Assumption	Identity	Domain	Characterization	Quotes
Systemic	Emphasize detailed and specific health data to monitor and evaluate program performance in a specified geographic area or health institution to achieve the objective of the specified program	The national DHIS2 system based on aggregated data is not sufficient to monitor the program and must be engaged in implementing program-specific systems based on detailed data to satisfy the program information need	Functionally and hierarchically organized health program-specific workforce in cooperation with partner organizations work as a team to monitor the health program performance, 50% of the staff are partner organizations	Specific health programs engaged in planning, implementing, and evaluating health program service	Evolve-ability	*We mainly use two systems DHIS2 and PHEM which run by MOH and EPHI. EPHI sent us the PHEM data on weekly basis in excel format It is good to have PHEM data in DHIS2 which does not require intermediary to get EPI data*(M&E expert, MCH). ‘ *The malaria program is at the elimination stage which requires case based and real time data rather than aggregated data which is found in DHIS2. Currently we are negotiating with higher officials to incorporate this data in ECHIS which is different from DHIS2*(M&E expert, Malaria) . *Like that of national partner organizations, we have a number of regional and program oriented partner organizations which support local IS*

Logic	Principle	Assumption	Identity	Domain	Characterization	Quotes
						implementation initiatives(IT directorate, MOH) *I am working for CDC which concerns HIV, so I customized DHIS2 to collect HIV data which is not found in routine DHIS2*(IT expert, RHB)
IT	Digitalizing the health sector with local capacity according to the actual relation, those who worked with NIT enact centralized logic ,whereas those worked with health programs enact the health program logic	DHIS2 is open source and familiar to health sector people so let us use the partner organization and local capacity to replace fragmented systems with the government-owned centralized system on the other hand the NIT DHIS2 is not adequate, health program-specific DHIS2 should be implemented to get detailed data	Low-paid IT skill is associated with public staff, and highly paid and advanced IT skill from the partner organization Engaged in both national system and health program-specific system implementation	Engaged in the digitalizing health sector	Standardization and evolve-ability	*We pulled the partner organizations' financial, technical and human resource for DHIS2 implementation*(IT director, MOH) *Our project is a five-year project with $60 million to support MOH in system development and implementation.* *We engaged in TB system design and implementation with USAID. We also work with MOH for national COVID-19 system implementation*(Senior developer, partner organization)

Logic	Principle	Assumption	Identity	Domain	Characterization	Quotes
						Initially, I had taken knowledge and skill from DHIS2 implementation and then designed and implemented HIV system for our region using DHIS2(IT expert, RHB

7.4 Governance Mechanisms During Pre-Adoption

The governance mechanisms of pre-adoption were shaped by centralized, integrated, and innovative logic that used various governance mechanisms to influence the adoption of the future system as shown in Figure 29**.**

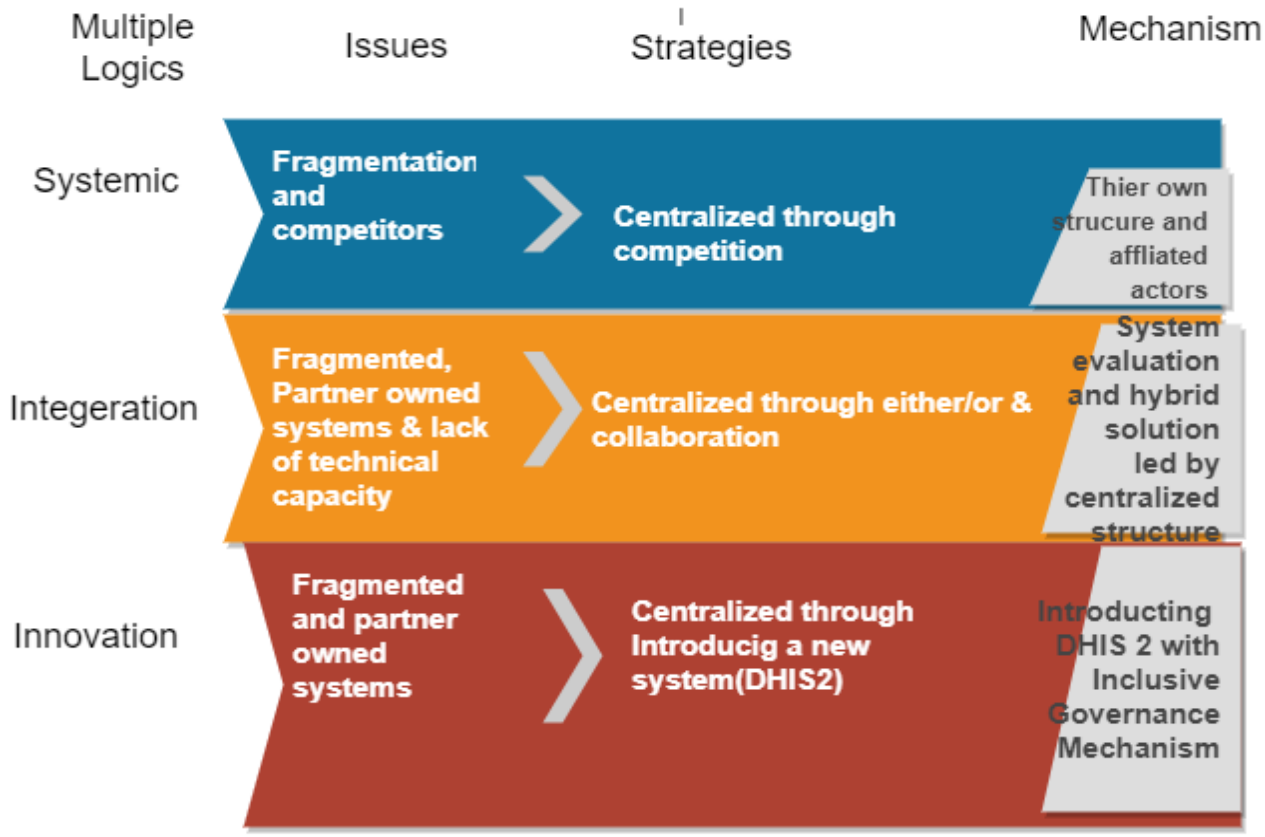


Figure 29 Governance Mechanisms during Adoption

I. Structural Separation

Structural and temporal separation has been advocated to handle contradictory logic (Al-Gharbi Khamis N., 2015), which requires a coordination process at the top management level to integrate the distinct activities (Raisch & Birkinshaw, 2018). However, MOH with resource and IT capability constraints, had given the full-fledged e-HMIS implementation responsibility to two different competing partner organizations in a different geographical context without playing a coordinating role. As a result, the fragmented systems were implemented at the regional level, which prohibited MOH from generating national level reports. To alleviate the system fragmentation problem, MOH and other partner organizations developed and implemented an intermediate system to generate national-level reports from the two distinct systems without

integrating the two systems. Although the two e-HMIS systems served the sector for a decade by devising a structural separation and intermediate system solutions, it was found to be inadequate to handle the revision of data collection elements and indicators made in 2014 (Gebre-Mariam & Fruijtier, 2018; B. W. Lagebo, 2019). This finding confirms that a separation solution is important for handling contradiction at certain times in certain specific contexts, but is not sufficient for the dynamic nature of the healthcare setting (Gibson & Birkinshaw, 2014; Magnusson et al., 2021), and for resource-constrained settings where IS implementation relied on multiple partner organizations as is the case in this study. Top-level integration is essential for coordinating the work of separated actors, units, and departments. However, this case confirmed the structural solution critics of the coordination problem (Gibson & Birkinshaw, 2014).

II. System Evaluation and Hybrid Solution Proposal Failure

Thus, all stakeholders reached a consensus on replacing the existing systems with a centralized system capable of addressing the above-mentioned problems (technical failure and fragmentation), as well as responding to the emergent needs of the MOH concerning indicator list revision. However, the MOH system evaluation and hybrid system development proposals to re-use the established systems, technology, and infrastructure both failed due to the partner organizations' unwillingness to compromise their logic due to their competitive nature. These partner organizations' actions revealed the dominance of the systemic logic in previous e-HMIS implementation, which indicates how the dominant-led IS implementation characterized by competition often results in sustainability failures (Werder & Heckmann, 2019).

III. Entrepreneurship and Inclusive IT Governance Mechanisms

Exposure to different institutional logic may increase the awareness of shortcomings of the dominant logic and enable central actors to become institutional entrepreneurs (Thornton & Ocasio, 2008, 2012). Likewise, recognizing the dominance of partner organizations, experienced managers of MOH planned to take the leading role in IS implementation from partner organizations in future system implementation. On the other hand, the new high-level official suggested considering a new system that was developed in the North region and implemented in many developing countries in the South.

Research suggests managers should distance themselves from the prevailing institutional logic to accommodate other logic in the organization field (Boonstra et al., 2017). Likewise, this case depicted how the high-level officials' distance from the prevailing institutional logic as they were

new to the organization enabled them to accommodate other logics to the existing logic (Birkinesh et al., 2022; Gizaw et al., 2022; B. Lagebo et al., 2022).

Entrepreneurs are responsible actors, individuals, groups, or organizations who have the resources, abilities, and skills for new or changed institutions (Hardy & Maguire, 2018). These findings reveal how the DHIS2 adoption was initiated by high-level officials with decision-making power, technically supported by HISP, the developer of DHIS2, and financed by donor organizations who have been exposed to DHIS2 in other developing countries. To engender change in stable institutional settings, institutional entrepreneurs need to reveal the existing institutional context and its inefficiencies and provide an alternative solution that solves the identified problems (Greenwood et al., 2022). Similarly, actors who were behind the innovation logic introduced DHIS2 through inclusive IT governance mechanisms, which allowed the participation of all stakeholders with their capability and resources in the demonstration, piloting, experience sharing, and system evaluation. Thus, the innovation logic accommodated the integration and the systemic logic through their actors' participation in the new system adoption process by reusing the established technology, technical capacity, and financial resources. Furthermore, the inclusive IT governance mechanisms developed the new system understanding, while also realizing the drawbacks of the existing system. This dynamic created the necessary distance from the dominant logic to shape the innovation logic.

Entrepreneurship is beyond creating a business organization. Rather, it focuses on new organizational models and policies to bring fundamental change in organizational activity (Hwang & Powell, 2005). Similarly, the innovative logic has brought two fundamental changes in system adoption for the public health care setting of Ethiopia. First, MOH began considering open-source software as a criterion to overcome the technical and infrastructure capacity constraints of the context (the evaluation document). Second, the dominant logic influence on system adoption was shaped by inclusive IT governance mechanisms, which resulted in actors' necessary distance from the dominant logic to challenge and support the new institution. Furthermore, it facilitated stakeholders' collaboration by effectively allocating their finances, time, technology, and technical capacity in the adoption process.

7.5 Governance Mechanisms During Configuration and Deployment

The centralized, systemic, and IT logic employed various IT governance mechanisms during DHIS2 configuration, and deployment as shown in figure 30 .

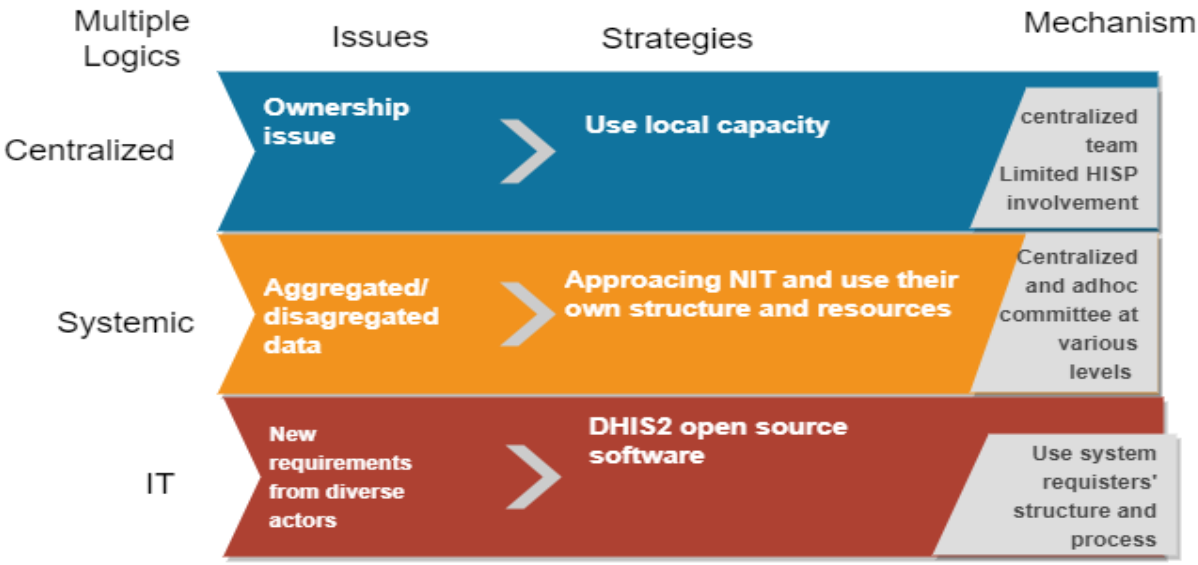


Figure 30 Governance Mechanisms during Configuration and Deployment

I. Hierarchical Implementation Teams

NIT designed IT governance mechanisms (structure, process, and communication) to replace the partner organization-owned fragmented systems with a government-owned centralized system. Decentralized or organic structures and autonomous processes promote evolvability, whereas centralized or mechanistic structures and controlled processes promote standardization (Hanseth & Bygstad, 2015; O'Reilly & Tushman, 2008). Structurally, a centralized core customization and implementation team at the national level was established and comprised of partner organizations, MOH IT, and policy plan directorates' staff, with a motto: "Use in-house IT capacity for DHIS2 customization". The customization team was responsible for configuring DHIS2 and the implementation team was responsible for supplying requirements and deploying DHIS2 respectively. The "Use in-house IT capacity for DHIS2 customization" motto did not allow including HISP, the developer of DHIS2, in the CCT in an attempt to overcome system ownership issues experienced in the previous implementation. Furthermore, health programs were not adequately represented in the team, because the NIT aim was for an integrated system with an aggregated data focus instead of disaggregated data.

Top-down communication was also employed through established implementation teams at each level, ranging from MOH to the wereda level to deploy the system under the guidance of the NIT. NIT supplied resources based on the regional health bureaus' proposal for DHIS2 deployment.

The dominant logic-led IT governance might lead implementation to one extreme, either to standardization or evolve-ability, which is not suitable for long-term sustainable system implementation (Montealegre et al., 2019; Smith & Lewis, 2011). Similarly, the central actor, NIT, used a hierarchical centralized structure for DHIS2 implementation which limited the involvement of key actors of the implementation like HISP and health programs.

II. Indicator Reference Document and e-HMIS use for Requirements Definition

IT structure should be complemented with processes to monitor activities(De & Grembergen, 2004). In this case, the CCT was given a deadline to come up with a functional DHIS2 based on the indicator reference document which holds national aggregated data sets and data elements that are heavily used by the Policy and Plan directorate for periodic planning and monitoring. An indicator reference document was used as a reference to determine what data was to be inscribed in DHIS2. e-HMIS was used to extract health institutions' data and determine the interface of DHIS2.

The NIT monitored the implementation progress during periodic meetings across deadlines and supplied the required resource accordingly. Contrary to the centralized structure, an evaluative mechanism was not established to measure the quality of the designed system nor supported by process tools to follow the DHIS2 configuration. The DHIS2 configuration heavily relied on the CCT. Furthermore, poor communication and processes at the national level restricted team's ability to search for and integrate new health system requirements. Rather, stakeholders often had to approach NIT to address their requirements and get technical support and legitimacy. In general, the process was not supported by process tools, such as scorecards (De & Grembergen, 2004), Control Objectives for Information and Related Technology (COBIT) (Damianides, 2005), decision rights matrix (Korhonen & Pirttila, 2003), and the IT alignment maturity model (Weill & Ross, 2005).

III. Re-Configuration of CCT to Address Emergent Requirements

Different from the established hierarchical structure, the health programs-specific system initiatives with system logic used two structures, centralized and decentralized, to develop and deploy program-specific systems using DHIS2. One, using the national implementation team by

approaching and convincing the NIT managers of the importance of the program-specific system to get technical support. Accordingly, the NIT re-configured the CCT to respond to emergent requirements. The others who assumed themselves technically capable initiatives used distinct teams by establishing formal and informal relations with different organizations at regional and program levels to customize and deploy program-specific DHIS2 systems without MOH involvement. Both the national and decentralized teams' purpose was to fulfill their resource gap to achieve the system development and deployment goal, which is referred in this thesis as resource-chased collaboration. These uncoordinated initiatives with the absence of a standard for DHIS2 configuration produced multiple program-specific systems that did not communicate with each other or with the existing systems, as there was no standard or guideline to follow while configuring DHIS2 for their programs. For instance, the initiatives' coding structures and naming of organizational units, data elements, indicators, and organizational structures were often different depending on developers' contextual and technical understanding.

7.6 Impacts of Governance Mechanisms in DHIS2 Implementation

I. Institutional Distance and its Impact

Health sector managers and staff proximity to the previous systems and its partner organizations hindered their ability to consider new alternatives. Instead, they attempted various solutions to sustain the existing systems. Furthermore, despite adopting DHIS2, the developer of DHIS2, HISP, was not formally represented in DHIS2 implementation until the practice of configuration required greater DHIS2 competence.

On the other hand, the high-level official's distance from the existing logic (systemic and integration) enabled them to consider new alternatives and design an inclusive IT governance mechanism that allows all actors to participate in DHIS2 introduction. Furthermore, the proximity of donor organizations to DHIS2 in other developing countries encouraged them to provide resource support. Finally, the inclusive IT governance mechanism enhanced the stakeholders' new system understanding which enabled them to maintain distance from the existing logic and shift support to the new system. This study argues that in addition to institutional distance, the inclusive IT governance mechanism devised for DHIS2 introduction was crucial for the competitive environment like the case at hand.

II. Either/or strategies and their impact

The either/or strategies such as system evaluation to select a better system, and competition to win in a specific system in a competitive situation during adoption, led to changes in the existing systems by a new system. The either/or strategies include aggregated/disaggregated data, centralized/decentralized system, local/external technical capacity. The choice at the initial stage of configuration limited DHIS2 configuration and evolvability due to a lack of DHIS2 experts, compromising health experts' need for detailed information. The absence of local DHIS2 experts influenced the local technical capacity use strategy to shift and establish informal relations with HISP, which helped them address the MOH's unique requirement of having an understanding of the basic DHIS2 code found in HISP.

The MOH centralized logic, which emphasized aggregated data and centralized structure, did not establish governance mechanisms to obtain and address heterogeneous actors' emergent information needs. This generated multiple decentralized organizational structures at regional and program levels for developing program and region-specific systems at lower levels. Furthermore, health programs' need to evaluate their own system led to multiple fragmented systems that caused duplication of work. Research suggests collaboration is more conducive than either/or strategies for the successful implementation of systems (Berente & Yoo, 2012)

III. Resource-Chasing Collaboration and its Impact

Multiple system development initiatives intending to procure needed resources from other actors led to multiple uncoordinated collaborations aimed at addressing the emergent temporal information system need of the sector. For instance, the informal MOH collaboration with HISP addressed the then-current issue (i.e. Calendar in DHIS2 configuration). However, MOH was challenged to address further unique requirements due to the absence of a formal relationship with HISP and no local capacity to address the calendar and other advanced code-level issues. Such resource-chasing collaboration facilitated system evolve-ability at the program, regional, and national level in a specific space and time, but limited system standardization to allow emergent requirements to be addressed in the future. The DHA collaboration with the TB health program and the CDC collaboration with Oromia Region all provide DHIS2 solutions to emergent specific requirements in a specific place and time which did not have a plan to institutionalize the system

throughout the sector and maintain communication across health programs and regions. The resource-based collaboration caused by the lack of technical, financial, and institutional resources is referred to in this study as a resource-chased collaboration because it might enable teams to address both standardization and evolve-ability at a certain level, but is not sufficient, as it might miss one or more logic if the required resource is fulfilled by other logics. Thus, we argue that resource-chasing collaboration can facilitate evolve-ability with limited standardization but should be complemented by the logic-based collaboration to allow centralized, systemic, and IT logic participation to address both standardization and evolve-ability. Research suggests that organizations coordinate, manage, and prioritize the ongoing IT projects, activities, goals, and stakeholders' conflicts (Jiang et al., 2014) to allow organization-level analysis.

7.7 Organizational Analysis with Dynamic Ambidexterity Concept

7.7.1 Lack of Common Vision for DHIS2 Implementation

Dynamic ambidexterity advocates for the dynamic capability of the organization as a driver of performance and a necessary prerequisite for success in changing environments, and contexts (Birkinshaw et al., 2016). This dynamic capability is held together by a common strategic intent, an overarching set of values, and targeted structural linking mechanisms to leverage shared assets (Teece, 2007). However, the research identified the lack of a common vision to simultaneously address both standardization and evolvability in DHIS2 implementation, as IS implementation has hugely relied on various system implementation initiatives sponsored by different international organizations. As a result, DHIS2 implementation was followed by various system implementation initiatives' logics (centralized, systemic, and IT) until it was confronted with a lack of technical and institutional competency that impeded implementation progress. Centralized logic leads to standardization, systemic logic leads to evolvability, and IT logic enhances the tension between the two logic when they work independently.

This type of system implementation initiative logic drove implementation to one extreme, either to standardization or evolveability. Health institution managers and experts at all levels collaborate with all system implementation initiatives to take advantage of resources without a common vision, with some leading to standardization and others to evolve-ability which creates vulnerability to sustainability failure. The resource-chased collaboration is insufficient to address

both standardization and evolvability, which requires scanning the implementation context to establish logic-based collaboration.

7.7.2 Lack of sensing and its consequence in DHIS2 implementation

Unless ambidexterity is consciously managed, senior leaders can easily make invalid inferences from their organizational learning (Denrell, 2003). The centralized logic considered HISP as a threat that would dominate DHIS2 implementation, which is based on previous implementation experience, instead of viewing the partnership as an opportunity to gain the required DHIS2 competence. Consequently, the centralized logic-dominated DHIS2 implementation was initially challenged by IT logic for disregarding IT competence and methodologies for DHIS2 customization, as discussed above in the IT Logic section.

Furthermore, the centralized logic did not identify and use the regional-level IT capability to overcome the human resource constraints of the CCT to conduct field-level system testing. The deployment of the initial version of DHIS2 was customized with centralized logic and characterized by many system errors that contradicted the institutional environment (existing HIS routine), practice, and IT infrastructure (computer type, network capacity, and health professionals) due to the lack of institutional environment knowledge and IT human resource constraints at a national level. However, this study identified experienced regional-level IT teams in system customization and deployment as most of the previous IT initiatives were initiated and deployed at regional levels.

Regarding what data needs to be customized, the centralization logic focus on aggregated data was challenged by health experts and health managers for disregarding program-specific and detailed data while customizing DHIS2. As a result, some health managers initiated communication with the central team to address their information and technical resource needs despite no existing process or formal communication channel between health programs and the central team. Others with peripheral technical capacity and financial resources used an independent structure to configure and deploy decentralized program-specific DHIS2, which was facilitated by its open-source feature, the federal structure of the sector, and partner organizations' resources. This case vividly depicts how the national team missed important collaborations (i.e HISP, regional IT

teams, health programs) that could have helped them overcome the exhibited implementation challenges from the start due to the absence of a process for scanning the implementation context.

Similar to the centralized logic, most system implementation initiatives with a peripheral technical capacity and required financial capacity at the program and regional level created multiple distinct teams to address their program-specific information needs instead of searching for options to address their needs in cooperation with the existing initiatives. Accordingly health programs or health institutions, in cooperation with partner organizations, configured and deployed various program-specific systems using DHIS2 at program and region levels in a scattered way without MOH involvement (i.e TB, HIV, multi-sectoral health information systems). Furthermore, these initiatives did not scan the existing related program-specific systems in the context to avoid redundancy. As a result, two HIV systems based on DHIS2 were identified with varying levels of data specificity in a region i.e. DATIM and HPMTCT. In addition to this, they used different levels of organizational hierarchy and naming while configuring DHIS2 for their respective health programs, further challenging communication among DHIS2 systems, like DATIM, HPTMPCT, and DHIS2.

In general, the absence of sensing opportunities and threats by DHIS2 implementation initiatives led the implementation to multiple competitive logic instead of collaboration that facilitated parallel systems evolve-ability, which is characterized by low-quality and fragmented systems with multiple sources of resources to satisfy their interest.

7.7.3 Seizing and Reconfiguring the CCT

Seizing opportunities is about making the right decisions, crafting a vision and strategy, and deciding on resource allocation, timing, and execution (Harreld et al., 2007). The manifestation of institutional logic contradictions and stakeholders' initiatives to bring their logic to managers' attention showed the limitation of the central team to identify opportunities and threats. These contradictions and stakeholders' initiatives convinced central actors about the importance of these logics to overcome the identified technical and financial resource constraints and encouraged them to establish various mechanisms to work well with heterogeneous actors. For instance, NIT decided to involve local HISP staff members as a citizen, not as a representative of the HISP institution, use the regional IT capability to enable system-level testing and allocate and mobilize

resources from health programs to extend DHIS2 customization from aggregate data to disaggregate level data, to address emergent system requirements and tackle the implementation challenges.

The case shows how senior managers were committed to acting when they realized the importance of other logic during the implementation. For instance, the CCT was continuously reconfigured to enroll more actors, as described above such as HISP, health programs, and partner organization staff, at different times to respond to heterogeneous actors' requests and institutional issues. The teams were continuously reorganized to respond to the stakeholders' requests, such as DHIS2 routine, EPHI, COVID-19, data quality, and Yellow Fever certification. Furthermore, central actors played a key role in mobilizing resources from different partner organizations and allocated resources for regions to facilitate the implementation, exposing the underlying institutional logic during the implementation that enabled managers to reconfigure the IT governance mechanism on an ad-hoc basis and led to implementation with a certain level of ambidexterity.

- **Informal Relation with HISP**

The central actor-managers, who recognized the importance of DHIS2 competence to complement the CCT's lack of DHIS2 expertise, employed a range of informal and temporal mechanisms. This included allowing two local HISP staff to join the design team without any binding agreement, hiring an Ethiopian citizen DHIS2 developer from the global HISP, and bringing other HISP DHIS2 expertise from other countries through partner organizations.

These temporary informal relationships with HISP enabled the team to address the current need for DHIS2 competence to implement DHIS2 and alleviate the MOH partner organization dominance concern. As a result, MOH has established trust in HISP over time. Similarly, HISP has got an opportunity to implement DHIS2 in Ethiopia, though a formal agreement was not announced. HISP has continued serving all logic upon their request, which has played a key role in DHIS2 evolvability in an uncoordinated fashion.

- **Using the regional-level IT capability for field-level testing**

Given the limited number of members on the centralized team was inadequate to mitigate the DHIS2 deployments in each health institution across 284,537 sq. km., the regional-level team has better institutional and environmental knowledge to identify and fix environment-related issues that challenged the deployment of DHIS2, such as institutional computer compatibility issues with

DHIS2, missing and duplicating health facility data, the construction of new health facilities, and organizational structure change that requires up-to-date health institutions data. System testing was bypassed by the national team to meet the deadline and became the prime activity of the region-level IT teams. They made a field-level system test to identify system errors and appropriate the institutional environment context of the system by supplying actual health institutions' names, configuring the existing 32-bit computers to the 64-bit required for DHIS2, organizing how health institutions without a computer or network could use the IT infrastructure at the next upper level. Involving regional-level teams in the implementation facilitated the redesigning of DHIS2 to address the identified system errors and institutional issues.

- **Enacting systemic logic**

NIT was convinced by the public health and emergency program managers and IT experts from CCT initiatives to develop and implement the EPHI and COVID-19 systems and reconfigured the team by incorporating new staff, allocating and mobilizing resources from initiatives.

The representation of health experts on national teams helped the technical team quickly learn and inscribe the program-specific detailed data in DHIS2. Similarly, the knowledge, skill, tools, and codes accumulated by the CCT while designing and deploying the routine DHIS2 were re-used for the COVID-19 and PHEM configuration and deployment. With this, both the centralized 'One Plan, One Policy, One Budget, and One Report' principle and the specific and the specific health expert information needs were addressed.

However, such an ad-hoc structural and resource-chased collaboration as a response to the current conflict was inadequate to address multiple actors' emergent requirements without establishing an appropriate formal structure, process, and communication. This showed the senior managers' dynamic capability is limited to waiting for opportunities and threats to manifest for establishing resource-chased collaboration. They lacked a common vision, processes, routines, and communication that enable managers to scan, search, and explore system implementation initiatives and respond accordingly to emergent environmental and contextual changes.

7.8 Project Level Analysis Using Boundary Resource Model

7.8.1 DHIS2 as an internal system

DHIS2 is an innovation platform that enables the co-creation of value in the platform ecosystem by complementors (Tiwana et, al, 2010). It requires platform governance, which divides the

decision-making authority between platform owners, app developers, and control mechanisms that impact the platform ecosystem (Tiwana, 2014). In this case, however, DHIS2 was considered an internal system governed by a dominant actor at the national level on a managerial hierarchy basis (Farshchian & Thomassen, 2019) and at health program and lower levels by decentralized governance strategy. All stakeholders, including MOH at the national level and international organizations at program and regional levels, independently downloaded, configured, and developed apps, and components and deployed multiple DHIS2 systems for a different purpose without role categorization. MOH at the national level with core DHIS2 experts extended the DHIS2 implementation from routine DHIS2, which is based on aggregated data, to specific health program DHIS2, which is based on disaggregated data, to respond to the various health programs and health agencies in a centralized way. This indicates the MOH tendency to monopolize the DHIS2 implementation process and diminish the innovation platform's purpose of 'co-creation'. On the other hand, MOH neither had the adequate required IT experts with DHIS2 competence nor a mechanism to learn and address all health institutions' system requirements across the large extent of Ethiopian health care in terms of geography, health programs, and users.

In addition to the national level DHIS2 implementation, multiple international organizations with periphery DHIS2 knowledge and skill that worked closely with health programs and institutions initiated and engaged in DHIS2 configuration and deployment for their respective health programs at various administration levels. Such organization initiatives with different structures and sources of resources have proliferated multiple DHIS2 systems (DHIS2 HIV by CDC, TB by USAID, DATIM by CDC) that generate duplication of effort and system fragmentations. For instance, the issues surrounding duplication of efforts and data discrepancy is highlighted when all system developers customized the organizational units, data sets, and indicators, which are common for all health programs with different sources of information. Some configured DHIS2 as four hierarchical structures (Region, Zone, Wereda, and health facility), while others used three hierarchical structures (Region, Wereda, health facility) based on their different perspectives, making communication between systems difficult. Furthermore, all deployed DHIS2 systems require management and support mechanisms, which also require the scarce resources of the sector.

Both the centralized managerial hierarchical governance by MOH and decentralized governance by multiple actors at lower levels did not allow teams to leverage the innovation platform of DHIS2

that allows partitioning of the decision-making authority between actors (i.e. as platform owner and as application developers).

7.8.2 The Lack of Boundary Resources for Controlling DHIS2 Configuration

Platform owners engaged in designing boundary resources, such as tools, and regulations that are used to govern the co-creation of value in platform ecosystems (Eaton, 2015). HISP and MOH, as platform owners of DHIS2 at the global and national level provided DHIS2 capacity building ranging from app development to end-user training, established DHIS2 academy and prepared DHIS2 manual to enhance the DHIS2 configuration and use capability. In addition to capacity building and software tools and API, data boundary resources are provided by the users of a platform and can be made accessible to the complementary (Gawer, 2014). However, MOH as a platform owner for Ethiopia did not give equal attention to boundary resource design to control third-party development. MOH focused on centralized system configuration and app development based on self-assessed mechanisms to meet the heterogeneous actors' emergent requirements instead of establishing process tools to define who configures the system, what should be configured in the system, and how the system can be configured. This can be explained by the minimal effort put forth by MOH in designing boundary resources in Master Health Facility Records (MHFR), health data terminology projects also ceased or become inactive by shifting the resources to DHIS2 implementation. These projects aimed to generate standard health institutions and health data terminology that can be used throughout the country. As a result, there were no national-level digital or manual boundary resources that could have been a common reference point for DHIS2 customization by multiple parties. The manual national indicator reference document, which is reviewed and revised every four years did not have a common reference point for actors involved in DHIS2 configuration and deployment.

Thus, DHIS2 implementation used various sources of health data terminology and health facility information to customize DHIS2, creating discrepancies. For instance, the CCT used the national indicator reference document and the previous e-HMIS to customize the data set, data elements, indicators, data periods, and organizational units in DHIS2. Other system development initiatives collected these data physically from health institutions, while the rest used health-related data from various sources, including reports, and annual review documents for DHIS2 customization. Furthermore, incorporating changes related to health data terminologies and organizational data

was challenged after DHIS2 deployment because system developers and organizations often transition to work on other projects or left the institutions after project expiration. In general, MOH paid little attention to national-level data boundary resource design. Rather, they focused more on the centralized system and application development which is inadequate for the diverse many health programs of a big country like Ethiopia. Such a centralized approach without an established controlling process did not inhibit the deployment of distinct multiple DHIS2 systems deployment vulnerable to system fragmentation, duplication, system errors, and wastage of resources.

7.8.3 DHIS2 Resourcing without Securing

The platform resources facilitate a shift of design capability to external actors (von Hippel and Katz 2002). Besides promoting the global DHIS2 resources, such as the DHIS2 academy, workshop, and app store, for transferring DHIS2 design capability to the DHIS2 community, MOH, in cooperation with international organizations' staff by organizing frequent end-user and advanced-level DHIS2 training and workshops locally and abroad. For instance, more than 7,000 government and non-government staff ranging from the national to health facility levels have participated in DHIS2 training, 5,000 in end-user training, 60 MTOT, 120 Trainees of Trainer(TOT), 120 trainees in DHIS2 configuration, server training, and app development workshops. These training and workshops organized by MOH, coupled with the freely available DHIS2 tools, apps, documentation, and online training and manuals enhanced the local DHIS2 design and use capability in the sector. Health institutions at all levels have played a significant role in facilitating the implementation by accepting the system and leveraging resources accompanying IS implementation, including per-diem, IT equipment, and infrastructure. Despite having access to all these resources during DHIS2 implementation, the system still required security mechanisms to prevent uncontrolled evolvability.

In addition to providing resources, the platform owner should control and maintain the system's integrity by maintaining product quality and achieving the platform's goal (Boudreau, 2010). Despite the MOH 'One Plan, One Budget, One Report' principle, however, the MOH did not establish control mechanisms to guide DHIS2 customization, products, and deployment for maintaining quality, interoperability, and use. DHIS2 implementation was often considered the health institutions' project in which international organizations provide their technical and

financial support. Thus, there was no formal agreement to define role categorization and accountability in DHIS2 implementation between health institutions and developers' organizations or between MOH and health institutions. All stakeholders, including international organizations and health institutions, worked as a team to achieve specific DHIS2 customizations and deployments without role categorization. The absence of a formal agreement between HISP and MOH exemplifies this dynamic despite HISP having a significant role in DHIS2 configuration and app development. Similarly, region and program-level DHIS2 configuration and deployment only required a proposal to secure technical and financial support from international organizations but did not require agreement on organizations' responsibilities and accountability processes for their work. High-level managers merely monitored the process periodically to identify challenges, give direction, and provide resources when needed.

Such ad-hoc-based governance did not assign teams to establish controlling mechanisms for evaluating and validating technical capability, customization processes, and products. As a result, system functionality was determined by the system developers' self-assessed mechanism. System use-ability was often used as acceptance testing, in which end users give feedback to redesign the system.

In general, DHIS2 implementation was facilitated by global and national-level resources, also being challenged by the absence of federal-level controlling mechanisms to maintain national-level standardization. As a result, several distinct DHIS2 systems and products were deployed and proliferated in the sector, which goes against the MOH goal of 'avoiding fragmented systems' with the 'One Plan, One Budget, One Policy, and One Report' principle.

7.9 Summary

This study data analysis was by institutional logic, dynamic ambidexterity, and boundary resource model to unpack underlying IT governance mechanism and its impact on DHIS2 implementation. The study revealed the dominant systemic logic during the pre-adoption stage of DHIS2 influenced and was eroded over time through high-level managers' institutional distance complemented by inclusive IT governance mechanisms. Following the adoption of DHIS2, the finding illuminated the shift of dominant logic from systemic to centralized institutional logic to overcome the partner organizations' dominance in the previous implementation efforts during customization and deployment. However, such centralized logic dominance was also challenged by technical and contextual issues which forced the central actors to re-configure their mechanisms. The MOH

governance mechanisms re-configuration enabled to address both standardization and evolve-ability as it allowed all logics by limiting their participation. However, the inadequacy of the central actor to address all healthcare sector information need encouraged partner organizations and health programs to configure and deploy DHIS2 for specific health program HIS in an uncoordinated manner. These different actors' collaborations in both centralized and decentralized structures' main focus were resources which did not allow to address both standardization and evolve-ability simultaneously. Furthermore, they neither use controlled mechanisms nor proper system testing to check system functionality and quality which caused repetitive work to correct errors after deploying the system with huge investment. Thus this study suggested establishing logic-based collaboration which allows all logic participation to simultaneously address both standardization and evolve-ability. To categorize actors into two platform owners at the national level and third-party developers using the boundary resource model. MOH as a platform owner synchronizes multiple partner organizations' activities by designing boundary resources and partner organizations as a third-party developer to develop their system based on the boundary resources given by MOH. Figure 31 depicted the interplay of the integrative theoretical framework with key findings.

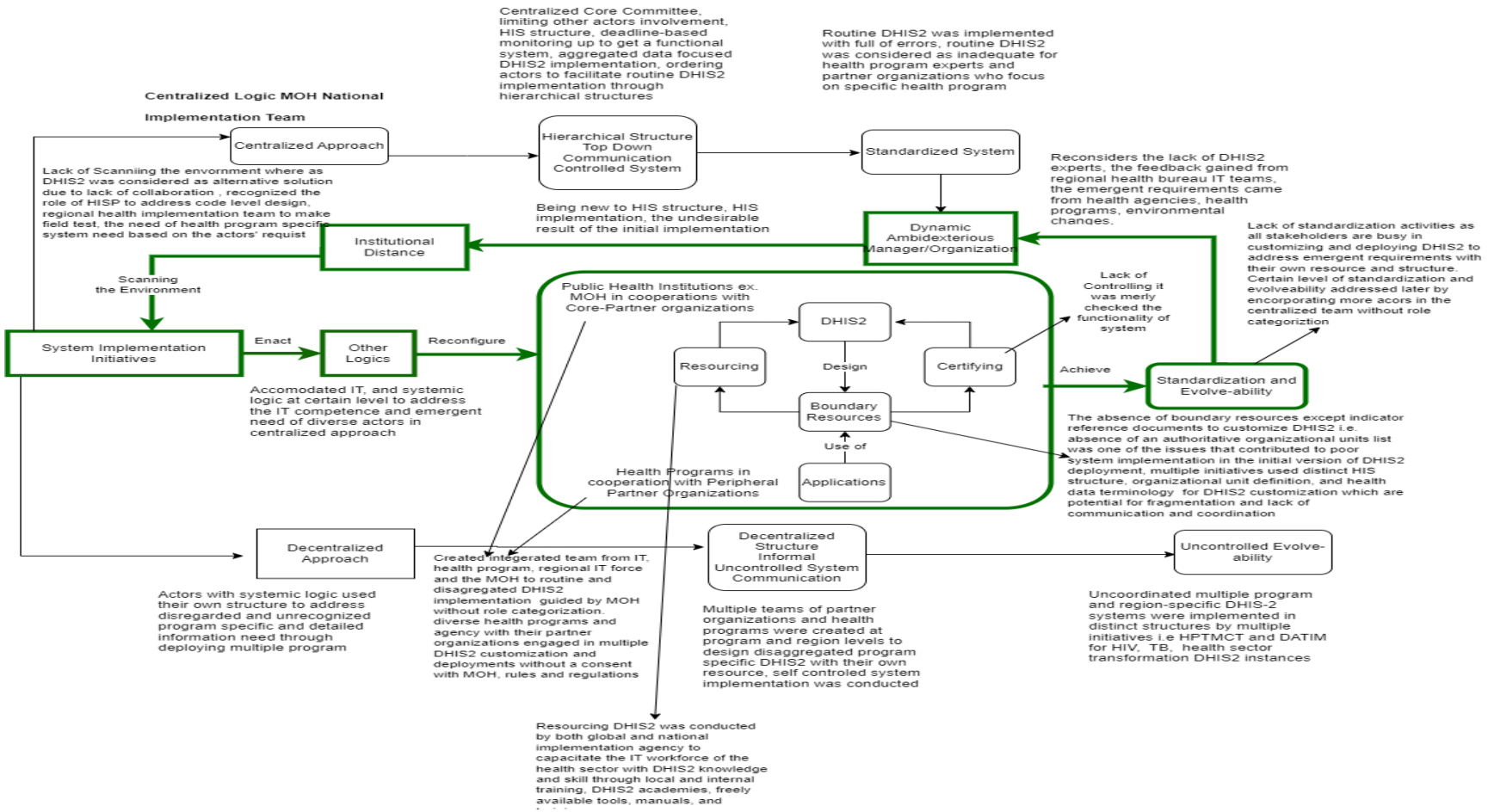


Figure 31 The interplay of the theoretical framework with major findings

CHAPTER 8: **Discussion**

This chapter discusses the empirical findings concerning the research aims and questions. This thesis aims to find and propose an appropriate IT governance approach and mechanisms for balancing conflicting activities, standardization, and evolve-ability, of IS implementation in a resource-constrained setting. The thesis raised three main research questions to achieve this goal. Research question one (RQ1) asks: What are the institutional logics underpinning HIS implementation that influence managers devising IT governance approaches and mechanisms? RQ2 asks: How did the employed governance mechanism impact achieving the contradictory issues? RQ3 asks: What possible alternative IT governance approach and mechanisms can address the contradictory issues in a resource-constrained setting? The discussion illuminates how the institutional logic behind IS implementation influenced the employed IT governance approach and mechanisms, which in turn diverged or balanced the conflicting activities of IS implementation. This chapter is divided into three sections. The first section discusses the institutional logic underlining DHIS2 implementation, how they were introduced, compete, collaborate, and influence IT governance approach and mechanisms. The second section discusses the influence of the employed IT governance approach and mechanisms on balancing standardization and evolve-ability in IS implantation. The third section discusses the proposal of IT governance and governance mechanisms appropriate for balancing standardization and evolvability in IS implementation in a resource-constrained context.

.1. **What are the institutional logics underpinning in HIS implementation that influence managers devising IT governance approaches and mechanisms?**

8.1 Multiple Institutional Logics in DHIS2 Implementation

The study revealed three major competing actors with systemic, integrating, and innovation logic underlining DHIS2 pre-adoption. The existing partner organizations with systemic logic displayed its dominance by ranging declining to deliver a password for the system and delaying the DHIS2 adoption. Additionally, the MOH senior managers employed the integrating logic to sustain both existing systems given the absence of technical and financial resources in the government institutions. The study depicts how the proximity of senior managers and staff with the previous

system implementations dictates their support of the systemic logic despite its technical excellence. Both the integration and the systemic logic emphasized reusing the existing systems and resources. This showed how the alignment of the systemic and integration logics stemmed from a lack of resources, not system technical excellence, which is referred to in this thesis as a resource-chasing collaboration. Resource-chasing collaboration was apparent when partner organizations' dominance was diminished after donor organizations' declared discontinuing financial support for the existing systems. International organization dominance was also echoed in the previous e-HMIS implementation study conducted in Ethiopia (Gebre-Mariam & Fruijtier, 2018), India (Hewapathirana & Sahay, 2017), Nigeria (Asangansi, 2012), and Jordan (Avgerou, 2004). However, there was no consensus on which system is going to be the future system. Failing to entertain both systemic and integration logic because of competition between partner organizations and the weak logic of the MOH forced them to find an alternative solution to the existing fragmented system and partner organization dominance. This finding is similar to new activities and will be an alternative when existing logic is competitive (Dang, 2021). Dang in his study of enterprise architecture adoption in two cases, revealed how professionalism and user logics were competent, and the managerial logic brought flexible and changeable management and tasks (Dang, 2021).

The third logic, innovation, was initiated to overcome the partner organizations' dominance and undesired situations of HIS by a high-level official. The innovation logic introduced a new system, DHIS2, with an inclusive governance mechanism that allows all actors to participate based on their interests. This finding is similar to that of Henfridsson and Yoo (2014) study on communication and infotainment system development in CarCorp case which defines institutional entrepreneurship as a liminal phase where multiple logics coexist and new institutional orders can arise from a resolution of conflict among competing logics. The innovation logic received significant challenges from both systemic and integrating logic for about three years despite the technical excellence of the new, DHIS2, system. Following the adoption of DHIS2, HIS configuration and deployment were driven by multiple stakeholders with systemic, centralized, and IT logic (Woldeyohannes et al., 2022). The dominancy of partner organizations during adoption was shifted to a centralized logic with the government-owned MOH centralized system, which was shared by most of the health sector stakeholders, including partner organizations. However, the inadequacy of the centralized logic to address the information needs of

heterogeneous actors influenced health programs to re-introduce systemic logic driven by multiple partner organizations, highlighting the importance of detailed and specific health program data. Both, the centralized and systemic logics were facilitated by the IT workforce at various levels of the health sector, IT logic emphasizing providing IT solutions for emergent information needs in the sector. This dynamic encouraged IT experts working at the program and regional levels with less DHIS2 experience and MOH IT experts with the support of global DHIS2 experts engaged in DHIS2 configuration for their respective health institutions.

Table 9 Major Logics Underpinning DHIS2 Implementation

Implementation Stage	Logics Identified	Characteristics
Adoption	Systemic	Promoting specific system
	Integrating	Emphasizing resources invested in the existing systems
	Innovation	Emphasizing on drawbacks of the existing systems and introducing new systems
Configuration, deployment, and use	Centralized	Draws from one plan one report principle
	Systemic	Aiming to address the unaddressed issue (disaggregated data) by the central team need to be addressed, emphasizing a specific system
	IT	Use core and peripheral IT knowledge and skill to address efficiency as well as emergent needs of the health sector

.2. How did the employed governance mechanisms impact achieving the contradictory issues?

8.2 Institutional Distance and Inclusive Governance Mechanisms

The study depicts how the high-level official's distance from the prevailing institutional logic enabled them to introduce a new system and devise an inclusive IT governance mechanism that facilitated the accommodation of multiple competing logics. On the other hand, the study showed how experienced health staff and managers who had been involved in the previous e-HMIS implementation kept supporting the previous system with systemic and integrating logic, due to

their proximity to the prevailing institutional logic. The dominant systemic and integrating logic of a significant number of stakeholders had delayed the adoption of DHIS2 mainly because system-related resources were attached to the dominant partner organizations that influence managers and staff in making decisions.

Despite a three-year implementation delay caused by the dominant logic, the innovation logic addressed this challenge with an inclusive governance mechanism that accommodates all logic in the technical and financial aspects of a new system by enhancing actors' understanding of the new system. This approach helped gain more support from managers, staff, and donors. For example, HISP was a partner organization of MOH with a technology solution, whereas others supported DHIS2 financially by equipping the MOH with resources for evaluating the new system. This finding reflects the trend of partner organizations bringing their own system, with required technical and financial resources, and highlights how to overcome partner organization dominance during system adoption by devising a governance mechanism that separates the system from its resources.

Similar to the existing literature, this finding depicts how the stakeholders' proximity and distance to the prevailing institutional logic influence system adoption (Berente et al., 2007; Berente & Yoo, 2012). Alternatively, this study shows how a high-level official's distance from the prevailing institutional logic accommodates other logics by themselves, while also enabling others to maintain their distance through inclusive mechanisms that facilitate collaboration. This study emphasizes the importance of institutional distance coupled with inclusive governance mechanisms for collaboration. The inclusive governance mechanism is similar to the change-over resolution strategy for handling conflicting logic through changing the role of actors instead of de-institutionalization the existing logic (Asangansi, 2012). The previous system producer became the evaluator, financier, and supporter of the new system. Thus, we argue that having managers with institutional distance should be complemented with an inclusive IT governance mechanism for system adoption where there are multiple competing institutional logics.

8.3 Organizational Visa vis Architectural Oriented Governance

The study identified how centralized and decentralized organizational governance was inadequate to govern DHIS2 implementation in a resource-constrained context for four major reasons. First, health institutions could not impose controlling mechanisms on system development teams, which are often comprised of diverse partner organizations to support health institutions in DHIS2

configuration and app development. Stakeholders' participation in DHIS2 configuration and implementation was not based on a formal agreement to define role categorization. Rather, it was informal and volunteer-based causing a lack of accountability among stakeholders' organizations (MOH and partner organizations; RHB and partner organizations) and difficult-to-trace system issues at the group and individual levels. Second, DHIS2 as global public good and innovation platform enables all potential individual and organizational developers to access, customize, and use it for their local purposes (Masiero, 2020). Third, health institutions configured and deployed DHIS2 as a single system despite it having a digital web platform (Adu-Gyamfi et al., 2019). Fourth, the federal system of Ethiopia uses a decentralization governance strategy, which provides autonomy for health institutions to work with international organizations (Wamai & Ph, 2000). This allowed the international organizations' system development and deployment in a decentralized fashion. Fifth, health institutions and individuals at all levels that facilitated DHIS2 implementation also enjoyed the resources accompanying implementation beyond the system benefits, including periderm, IT equipment, and new knowledge, skills, and infrastructure. All these factors did not allow MOH to control the DHIS2 configuration and deployment with organizational IT governance. Rather, it facilitated DHIS2 evolvability in a decentralized fashion. This finding supports research that disclosed that IT governance should not follow an organizational structure like traditional governance but, instead, should use an architectural structure system, particularly for large-scale e-health structures (Hanseth, 2016). This solution was also justified as e-health infrastructures are much harder to control due to their complexity, multiple heterogeneous stakeholders (Ela, 2015; Hanseth & Lyytinen, 2010), and lack the necessary skills and resources in centralized governance. Instead, they continued to depend on intermediary knowledge and skills (Nicholson et al., 2019) , which can lead to stagnation, curb innovation, and negatively affect evolve-ability (Hanseth, Bygstad, Ellingsen, & Johannesen, 2012; Meum et al., 2013). This finding is similar to existing research that depicts how public organizations are behind the business and technological changes and have a tendency to use established governance mechanisms for new technologies (Janssen & van der Voort, 2016).

Different from organizational governance and based on an architectural structure, the platform owner opened the platform and enabled the co-creation of value by dividing the role of the platform owner and third-party developers. A platform owner focuses on boundary resource design to encourage value co-creation and restrict unnecessary innovations and complementors to engaging

in value creation (Ceccagnoli, Forman, Huang, & Wu, 2012). Given DHIS2 is an open-source digital platform, this study proposes employing platform governance by dividing DHIS2 implementation activities to its respective stakeholders, platform owner, third-party developer, and user, which are discussed in detail in the platform governance and boundary resource model section below.

8.4 Lack of Resource and Resource-Chasing Collaboration

System implementation initiators, including the central actors, did not make a deliberate effort to balance standardization and evolvability because they lack a common vision of achieving standardization and evolvability simultaneously. Each DHIS2 implementation initiative driven by its logic led either to standardization or evolvability. Implementing DHIS2 at the program and regional levels with systemic logic led the implementation to evolvability, and MOH with centralized logic aimed to overcome fragmentation, leading to standardization. Despite their logic, the lack of technical, financial, and institutional resources has made collaboration viable in the resource-constrained setting to fill the resource gap of the system initiators. Such a resource-chasing collaboration at the national level enabled to the achievement of both standardization and evolvability at a certain level. Research conducted in HISP countries revealed how DHIS2 implementation relies on intermediary knowledge and skill due to a lack of the necessary skills and resources in the country 's MOH (Lars et al., 2017). Likewise, the lack of technical constraints and institutional knowledge at the national and program level created an enabling environment to align with other actors. Several distinct ad-hoc teams (i.e. DHIS2 configuration for the routine system, COVID-19 system, PHEM, data quality) were in use at different stages of DHIS2 implementation to address emergent issues. This reveals how the IT governance mechanism is not only configured intentionally by dominant actor institutional logic but is also shaped by the lack of resources. This finding is similar to a research result that shows how the institutional environment and understanding of the subordinate logic shaped the IT governance mechanism (Epstein, 2013). Similar research conducted around Malawi IS implementation showed how international organizations, universities, and health institutions collaborated and established ad-hoc committees to get infrastructure, technical, and financial resources for the implementation (Msiska & Nielsen, 2018). However, these research findings merely depict how the resource gap was resolved by collaboration but did not reveal the impact of collaboration on balancing competing logic (Berente & Yoo, 2012). This study extends the existing literature by revealing

how resource-chasing collaboration with multiple stakeholders might or might not lead to balancing. For instance, in this case, MOH achieved a balance at a certain level while collaborating with HISP, regional teams, and EPHI over time to gain technical and institutional competence and knowledge in addition to the managerial knowledge held by the central actors. However, the resource-chasing collaboration at regional and program levels of DHIS2 implementation did not involve MOH and HISP, leading to uncontrolled evolve-ability without standardization. Research depicted a risk of poor management during DHIS2 implementation, which includes losing their data in DHIS2 (Roland et al., 2017). Likewise, this finding highlighted that not all collaboration in a resource-constrained setting reconciles competing logics, but can also cause some to diverge. This necessitates an examination of the aim and benefits of collaboration to understand balancing. In general, collaboration indicates balancing competing logics might not be achieved if the required resource is monopolized by a single or few actors. For example health system developing organizations ranging from MOH to partner organizations, have the tendency to grab every system development and deployment activity and establish collaboration only when they lack resources. Thus, this study depicts the inadequacy of resource-chasing collaboration for balancing competing logics and suggests complementing with logic-based collaboration to address competing logics.

8.5 The inadequacy of Resource-chasing Collaboration for Balancing

The resource-chasing collaboration using an ad-hoc structural solution based on institutional pressure is identified as insufficient for a resource-constrained context for two major reasons. First, the approach wasted the scarce time and resources gained from donor organizations on unproductive activities for lengthy periods until the logic manifested as opportunity and threats over time, leading to the resource-chasing collaboration. For instance, despite the crucial role and technical, contextual, and domain knowledge and skills of HISP, regional IT-work force, and health program configuration for DHIS2, they were not engaged in DHIS2 configuration from the start and necessitated re-designing DHIS2. Re-designing, testing, and re-installing DHIS2 in more than 4,000 health facilities is an example of wastage that could have been avoided if these actors were involved from the start. Second, although the ad-hoc structural configuration solution to include the HISP, regional workforce, and health program was identified as a good solution to mobilize resources for the current issue, it was inadequate for searching and integrating the emergent system implementation initiatives and systems (Hornnes et al., 2010). For instance, the HIV, TB DHIS2 and multi-sectoral HIS decentralized initiatives were not mandated to integrate

with the centralized system and will potentially lead to fragmentation. These findings are similar to the existing literature on how separation without a central coordination mechanism is insufficient for handling paradoxical issues in the dynamic nature of health care setting (Blaschke & Brosius, 2018; Gibson & Birkinshaw, 2004; Magnusson et al., 2021). In general, the MOH re-configuration awaited institutional pressures instead of a common vision and mechanism to search and integrate important logic, balancing standardization and evolvability.

8.6 DHIS Implementation inclined to Evolve-ability

The decentralized health sector IT workforce equipped with DHIS2 competence through various MOH capacity-building processes coupled with the freely available global DHIS2 boundary resources encouraged local DHIS2 configuration and deployment with unprecedented international organizations' financial support. However, such DHIS2 implementation by multiple stakeholders was not sufficiently supported by data boundary resources such as standard organizational units, health data terminology, and indicators, which are essential to standardize DHIS2 configuration, deployment, and use. The central actors who advocated standardization using the 'One Plan, One Policy, One Budget, and One Report' principle have been busy with system development activities that did not give much room for standardization activities, such as establishing processes, procedures, and guidelines to certify, link, or integrate multiple system development and implementation initiatives. For instance, the previous Master Facility Registration project to standardize the health facilities' naming, health data terminology, and system integration project team members were shifted to urgent implementation activities, such as DHIS2.

Figure 32 Balance Between Standardization and Evolve-ability

On the other hand, to address both innovation and standardization, research demands flexible data standards, adaptive governance, and flexible generification for the development of integrated health information systems (Braa et al., 2004; Hanseth, Bygstad, Ellingsen, Johannesen, et al., 2012; Janssen & van der Voort, 2016). However, in this case, DHIS2 configuration relied on different sources of organizational and health data information to customize and deploy DHIS2 which created a discrepancy and duplication of work. The level of DHIS2 competence used for DHIS2

customization varied across multiple DHIS2 implementation initiatives which varied the quality of DHIS2 products.

In general, the absence of boundary resources to maintain standardization, coupled with the resourcing, national and global DHIS2 from the health institutions' implementation initiatives facilitated the proliferation of multiple DHIS2 products that led to un-coordinated evolve-ability, which can be characterized by a duplication of efforts, wastage of resources, various DHIS2 product quality and communication difficulty between multiple DHIS2 systems.

.3. What possible alternative IT governance approach and mechanisms can address the contradictory issues in the resource-constrained setting?

This study proposes dynamic ambidextrous organizations and managers should govern DHIS2 implementation with a platform governance approach and boundary resource model that addresses the balancing problems identified in this finding.

8.7 Dynamic Ambidextrous logic to entertain competing logic

Given the variation in sources of IS implementation resources in developing countries, time and space-dependent organizations, coupled with frequent changes in the health data element, indicator, organizational unit data, and technology; Dynamic ambidextrous organizations, and managers with dynamic capability are required to cater continuous change in health care and technology sectors. This dynamic capability at the organizational and individual levels requires distinct skills, processes, incentives, and routines based on major institutional logic in the implementation context that can simultaneously achieve both standardization and evolvability. The dynamic ambidextrous organization continuously scans the organization field to address the emergent need of the sector to achieve both seizing, and, reconfiguring the IT governance mechanisms. This proposal is similar to the adaptive governance approach that is often used for dealing with complex societal issues were many stakeholders have diverging interests and uncertainty about the future (Janssen & van der

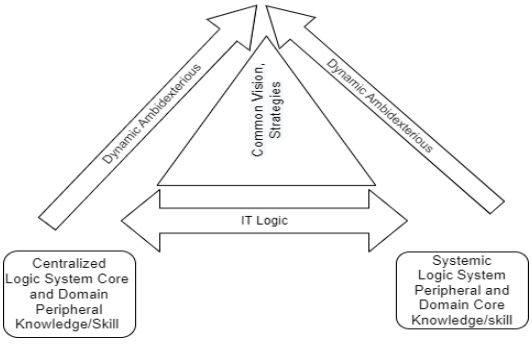


Figure 33 Dynamic Ambidextrous Logic

Voort, 2016). Adaptive governance encourages using internal and external capabilities, decentralizing decision-making power, and demanding to inform higher-level bodies from the bottom up(Janssen & van der Voort, 2016).

8.8 Establishing Common Vision at Organizational Level

The case analysis depicts how health institutions and senior managers did not sense the potential opportunities and threats to standardization or evolve-ability before they manifested as challenges that hindered the implementation, because they lacked a common vision for addressing both issues simultaneously. Thus, we argue, beginning with scanning the context and environment to identify and understand opportunities and threats to inform the enactment of other logic before embarking on implementation with a dominant logic.

Ultimately, senior managers at the national level should articulate a common vision and strategic intent valued by all stakeholders to simultaneously address standardization and evolvability. Thus, we argue that DHIS2 implementation should follow system architecture-based IT governance in the case of digital platform governance to address standardization and evolvability simultaneously.

8.9 Platform-Governance Approach

In addition to the architecture of DHIS2, a web-based digital platform with data warehouse architecture, platform governance is found to be suitable for resource-constrained settings where decentralized governance is promoted at lower administration levels and IS implementation relies on various donor organizations' technical and financial resources. These characteristics of the resource-constrained setting promote third-party innovation with various sources of resources. Platform governance allows the partitioning of the decision-making authority to stakeholders as the platform owner, complementor, and users. This study recommends that central actors shift from evolve-ability to standardization activities that play a key role in standardizing evolve-able and evolving products by leaving the evolve-ability activities for appropriate partner organizations and health programs and regions with competent few competent, and flexible teams. Such an arrangement clarifies the role of the senior team and leadership behaviors when attending to contradictory demands (O'Reilly & Tushman, 2013).

The central actors should advocate the importance of standardization activities to all levels stakeholders through workshops, training, and available channels to encourage more international organizations to invest in standardization activities that can change the system development status

quo. IT governance literature rarely addresses the process perspective (Ghazawneh & Henfridsson, 2010) by emphasizing structural change. However, this study recommends the boundary resource model to unpack the process level of IT governance in DHIS2 implementation

8.10 Proposing Boundary Resource Model for Governing DHIS2 Implementation

The structural change solution should be complemented by establishing linking mechanisms, processes, and routines to continuously navigate and enact other logic for continuously changing environments and contexts. This study suggests a boundary resource model for three major reasons: the adopted platform technology, the reliance on heterogeneous partner organizations' resources, and the health institution's autonomous power gained from the federated structure.

The platform IT governance approach using the boundary resource model is suitable to establish arm's length relations among the DHIS2 implementation stakeholders, including MOH, health institutions, and international organizations. Similarly, DHIS2 is an innovation platform that allows the division of work as an owner, third-party developer, and end user. A central actor can define a central governance core at the national level, with key systems, technical standards, and security mechanisms (Weill and Ross, 2004). Thus, the DHIS2 implementation stakeholders can divide the decision-making authority amongst health institutions as platform owners. Health institutions with the help of core technical, experienced partner organizations, and local universities can engage in boundary resource design, and experts are individuals who use DHIS2 for data entry, collection, processing, and generating reports. Partner organizations with periphery system knowledge and skill can be classified as third parties that engage in DHIS2 configuration, and app development. Thus, international organizations can be categorized into two groups based on technical, core, and peripheral, capability. International organizations, universities, groups, or individuals with core technical capability can support MOH in national-level boundary resource designing. This leverages the few global and local HISP staff in DHIS2 implementations for large-scale DHIS2 implementation. Those with peripheral technical capacity includes international organizations with IT capability, groups or individuals who often work closely with health institutions and program based on decentralized governance strategy and can be regarded as third-party developers who use the national level boundary resources for app, component, and feature development to respond to emergent requirements. This suggestion is similar to inter-organizational ambidexterity which categorizes external organizations for exploration and

exploitation as well as creating an enabling environment within a firm to balance continuous exploration and exploitation (Kauppila, 2010).

The model depicts two drivers of boundary resource design, resourcing and securing (Ghazawneh & Henfridsson, 2013). Resourcing is considered in this case as the process of evolving by which the scope and diversity of a platform are enhanced. Certifying is regarded as standardization that maintains communication, coordination, and security through controlling mechanisms of the DHIS2 to maintain the national-level DHIS2 integrity.

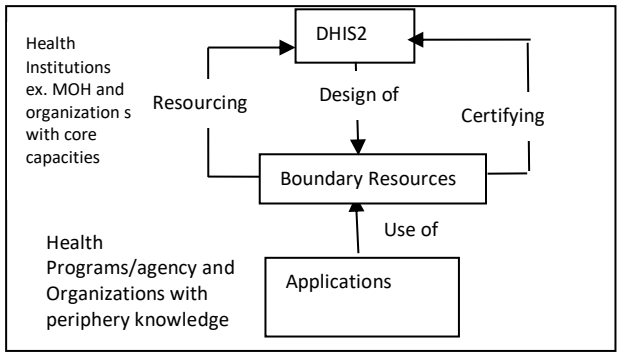


Figure 34 Proposed Boundary Resource Model for national level Adapted from(Ghazawneh & Henfridsson, 2013)

The model allows MOH, as a national platform owner in the country, to cooperate with international organizations and universities with DHIS2 core competence to focus on key systems such as routine DHIS2, when designing core data standards and communication channels to enhance the knowledge, capacity, rules and regulations for controlling third-party system innovation. In other words, MOH should focus on boundary resource designing and relying on third-party developers by shifting from app development.

Based on the findings, we recommended four major boundary resource designs, core data designing, national-level communication channels, establishing development guidelines and procedures, and establishing a repository, to achieve both standardization and evolve-ability simultaneously. First, MOH should begin by strengthening the core data designing in MFR and HDT projects and leave unstable data for international organizations that are closer to health programs and health institutions for innovation. This proposal is similar to one of the principles that suggest large-scale e-health is identifying data to be governed by central and decentralized governance stable and non-stable data elements (Hanseth, 2016).

Second, MOH should strengthen the existing and establish new communication channels, such as digital health workshops, DHIS2 academy, training, and review meetings to enhance and control local capacity development. Failure to do so is a cause for system fragmentation and uncontrolled evolvability. The communication channel enables MOH as a platform owner to learn the third-party innovation efforts at lower levels that support scale, modify and reject the third-party innovation at initial stages to shield from sustainability failure. Such early actions will reduce the

duplication of efforts, system fragmentation, and discrepancies, which were identified as consequences of uncontrolled evolve ability in the study. In other words, the communication channel maintains standardization and enhances evolvability simultaneously.

Third, establishing development agreements, review teams, rules, and regulations to terminate or extend the system development project period is often criticized as a source of contradiction (Gebre-Mariam & Fruijtier, 2018). The designed boundary resources can enable MOH's control and coordinate the implementation of DHIS2 and its operations which fulfill the One Plan, One Policy, On Budget and One Report' principle.

Finally, a repository to hold and manage these and various resources can be designed as a common reference point to deal with heterogeneity and provide shared definitions and values (Ghazawneh & Henfridsson, 2013), which solves the discrepancy problem identified in the case and facilitates the third-party innovation efforts.

The proposed model aligns with the recommendations of Hanseth (2016) and Gregory and his colleagues (2015) recommendation of three principled frameworks for large-scale e-health infrastructure to first identify data as stable and non-stable elements, standardize stable data, and governed centrally whereas less stable data can be decentralized. The difference lies in the boundary resource design addressing the stable data design to be used as a standard tool for third-party application/system development. The model suggests that attention should be given to both drivers, which are important to cultivate the DHIS2 ecosystem at the country level. One-sided attention like that identified in this case makes IS implementation vulnerable to failure over time. This boundary resource design proposal extends the global boundary resource designing to country-level boundary resource designing. Furthermore, it extends the existing boundary resource types from capacity and software development boundary resources (Mssiska, Neilson, and Jens, 2019) to core data boundary resource design at the country level.

CHAPTER 9: **Conclusions and Contributions**

This chapter concludes the study by summarizing the key research findings concerning the research aims and questions, as well as the value and contribution provides to the field. It will also review the limitations of the study and propose recommendations for future research.

This study aims to explore and propose appropriate IT governance approach and mechanisms to balance conflicting activities of HIS implementation in a resource-constrained setting. To achieve this goal, the study explored the institutional logic behind DHIS2 implementation, IT governance mechanisms, and their impact on DHIS2 implementation, with a focus on balancing standardization and evolve-ability using the institutional logic concept, dynamic ambidexterity, and boundary resource model. The institutional logic concept was used to explore the stakeholders' logic involved in adopting, configuring, and deploying DHIS2, all of which required balancing or diverging standardization and evolve-ability. The concept illuminated how various logics behind DHIS2 implementation were introduced, removed, changed, and dominant over time while influencing IT governance mechanisms and their impact on DHIS2 implementation with balancing standardization and evolvability.

Multiple Institutional Logics Underpinning DHIS2 Implementation

The research findings identified different logics during the pre-adoption and the adoption stages of implementation. Systemic, integration, and innovation logic were identified during the pre-adoption stage, influencing the IT governance mechanisms of DHIS2 adoption and its outcome. These pre-adoption logics shifted to centralized logic in the initial stage of DHIS2 configuration aimed at implementing a government-owned centralized DHIS2. However, the centralized logic focus on DHIS2 configuration for aggregated data with local IT capacity marginalized the major stakeholders, such as the DHIS2 developers, regional IT workforce, and diverse health programs. Such marginalization limited the required attention health programs required to meet their disaggregated information needs, the core of DHIS2 knowledge and skill, and the regional IT workforce at the initial stage of DHIS2 configuration. Consequently, multiple actors with systemic, and IT logic emerged and emphasized the importance of core DHIS2 knowledge, the implementation context, knowledge, and understanding of DHIS2 configuration, and requiring disaggregated data for health program information needs. These claims were converted to reality,

when the DHIS2 developer institution, the regional IT workforce, and health programs became key actors of DHIS2 implementation at different stages of the implementation. Thus, DHIS2 configuration and deployment in Ethiopia has been driven by centralized, systemic, and IT logic that competes at times, while at other times they lead to collaboration.

Institutional Logic Distance as Complemented by Inclusive IT Governance Mechanism

Research advocates the importance of the senior manager's institutional distance to accommodate new logic in the organization field. However, this study revealed this perspective is inadequate for accommodating a new logic in resource-constrained settings where multiple dominant actors who own both system and financial resources are in the field. The study illuminated the importance of the high-level official institutional distance from the prevailing institutional logic for initiating and creating a conducive environment for other actors to maintain their distance from the prevailing logic by designing inclusive governance mechanisms in these settings. The dominant system logic driven by partner organizations during the pre-adoption of DHIS2 delayed system adoption for about three years, regardless of the system's excellence, because the partner organization's competitive nature was monopolizing the systems with its required resource. For example, the MOH staff seconded by partner organizations, health institutions' managers who often received significant resources related to the system would be challenged to accept other systems. This dominant logic was eroded by the high-level official's institutional distance from the prevailing institutional logic, coupled with an inclusive governance mechanism that allowed all actors to participate in different aspects of system adoption including technical capacity, resource, and evaluation. The mechanism separated the system from resources during DHIS2 introduction and enhanced understanding of the new system, which enabled significant actors to maintain distance from the prevailing and was a key to adopting DHIS2.

Dominant Logic as Complemented by Resource-Chasing Collaboration

Of the centralized, systemic, and IT logic underlying the DHIS2 configuration and deployment stage, the centralized logic, which was facilitated by MOH, aimed for the development of a government-owned, centralized system. The centralized logic was shared by most of the stakeholders in principle. However, the central actors failing to incorporate major logic, such as

IT and systemic in the CCT, shifted the systemic logic dominance exhibited in the pre-adoption stage to the centralized logic dominance. The centralized logic determined what (i.e. aggregated data), who (i.e. local capacity), and how (i.e. centralized) to configure DHIS2, limiting standardization and evolve-ability activities due to the absence of key system development experts with core DHIS competency, health program staff who know what is needed for health service improvement, and the regional IT work-force who have local implementation context knowledge and understanding. Initially, a fragmented, low-quality DHIS2 system was deployed but was later corrected by collaborating with marginalized actors, such as HISP, health programs, and regional-level IT experts. This dynamic was labeled in this thesis as a resource-chasing collaboration. This study also revealed how implementation improved from time to time throughout the resource-chasing collaboration after realizing the importance of other logic. However, the empirical findings depicted how central actors compromised the MOH minimal standardization efforts (i.e. standardizing the health institutions' names and health data terminologies) projects for responding to frequent emergent system requirements needs of the sector.

Such resource-chasing collaboration enabled the integration of multiple logic i.e. systemic, IT, and centralized that led to achieving standardization and evolve-ability at a minimal level as the findings revealed multiple system implementation initiatives to address the disregarded disaggregated and program-specific information need.

The Inadequacy of Resource-Chasing Collaboration for Balancing

Dynamic ambidexterity to resolve conflicting issues requires continuous scanning to identify opportunities and threats to the implementation and a common vision of the collaborators of IS implementation. However, in this study, the resource-chasing collaboration was found to be inadequate for achieving standardization and evolve-ability, due to the absence of a common vision shared by stakeholders, controlling mechanisms, and continuous scanning of the implementation context to identify opportunities and threats to IS implementation. Those collaborating on DHIS2 implementation were invited to temporarily join the team on a volunteer basis to help address specific system issues instead of addressing long-term emerging issues.

Despite the resource-chasing collaboration addressing the current IS implementation resource problem, the national DHIS2 implementation team did not have a formal mechanism to receive, learn, or address the health sector's emergent information needs. Thus, multiple stakeholders at different organizational levels with IT and systemic logics have configured and deployed DHIS2 with and without the knowledge MOH to fulfill health programs' unanswered detailed, and specific information needs, leading the implementation to uncontrolled evolve-ability. The MOH organization-based DHIS2 governance did not allow them to learn and control such a decentralized DHIS2 configuration and deployment initiatives for three major reasons. First, the decentralized governance strategy to promote the partner organizations local support facilitated such initiatives at local level. Second, the DHIS2 open-source feature allows all actors to access, configure, and deploy DHIS2 for their local context. Third, the entanglement of resources with system implementation was facilitated by individuals, managers, and health institutions of the system recipients.

In general, the empirical data revealed how the centralized and decentralized organizational IT governance mechanisms supplemented by resource-chasing collaboration in a resource-constrained setting, were found to be inadequate for balancing standardization and evolve-ability of DHIS2 implementation due to four major reasons. The centralized DHIS2 governance, which was characterized by few IT experts as supplemented by resource-chasing collaboration, was inadequate to search and enact the existing and emergent major logics of DHIS2 implementation, limiting both standardization and evolvability of DHIS2 at the national level. On the other hand, the absence of controlled mechanisms for DHIS2 configuration and deployment resulted in various levels of system quality, and distinctly fragmented DHIS2 systems, which contradicted the MOH's 'One Plan, One Policy, One Budget, One report' principle.

An Integrated Implementation Framework for Dynamic Ambidextrous Organization/Managers

Based on these findings, this study recommended complementing the resource-chasing collaboration with major institutional logics that share a common vision and dynamically scanning the implementation context to identify opportunities and threats, while, enacting other logics to balance standardization and evolve-ability during IS implementation. To achieve this, I propose

an integrated implementation framework comprised of institutional logic, dynamic ambidexterity, and boundary resource concepts, which are suitable for the resource-constrained setting and digital platform technology. The framework addresses both the structural and process issues of the current IS implementation problem at institutional, organizational, and project levels with a paradoxical perspective.

9.1 Theoretical Contribution

The theoretical contributions of this study include a diversity of theoretical concepts, and uniquely combined and applied to analyzing IS implementation with IT governance practice. This study argues in this thesis that as the IT governance approach to IS research continues to be developed and applied, it could potentially benefit from contributions from a wider range of theoretical perspectives. The conceptual framework introduced in this thesis contributes to existing IS implementation and governance approaches and methodologies for studying IS implementation and its governance by emphasizing stakeholders' institutional logic, implementation context, and technology for designing governance mechanisms at multiple levels of analysis.

The study contributes to both IT governance and IS literature focused on institutional logic, governance mechanism, and their impact on resolving contradictory issues during IS implementation. The theoretical contributions of this study are four-fold.

The Role of Senior Managers' Institutional Distance to Enact Other Logics

Literature discloses the importance of senior managers' distance from prevailing institutional logic to employ collaborative strategies for successful IS implementation in complex settings (Berente & Yoo, 2012; Boonstra et al., 2017; Jones et al., 2015; Lepoutre & Valente, 2012). This study identified the inadequacy of the senior manager's distance to accommodate new logic in a resource-constrained setting where multiple dominant actors are in play. This can be exemplified by how DHIS2 adoption with senior officials' support was tiresome and took three years due to multiple dominant actors' resistance. However, this study depicted the importance of senior managers' distance to initiate and enable others to maintain their distance from prevailing logic by designing an inclusive IT governance mechanism that enabled them to accommodate other logics.

The Role of Collaboration Logic for Balancing

Regardless of the competitive logic, recent research suggests employing a collaborative approach to allow all logic to co-exist through understanding multiple IS implementation stakeholders and their logic (Asangansi, 2012; Berente & Yoo, 2012; Boonstra et al., 2017). However, these studies did not explicitly show what types of collaboration allow the co-existence of all logic. This study revealed, that the resource-chasing collaboration, which was exhibited in this case, did not allow all logics' participation. Rather the participation of actors depended on the dominant actor's or senior managers' assumptions on the absence or availability of resources for the implementation. If one or a few dominant actors can fulfill their required resources, other actors with different logic participation can be denied or limited. As a result, the IS implementation is controlled by a dominant actor in the implementation context instead of being guided by the collaborators' shared rules, norms, and structures, as seen in this case. Despite diverse organizations and their staff, collaborating in both national and multiple health program-specific DHIS2 implementation projects for resource gain, centralized logic dominates the National DHIS2 implementation and systemic logic influenced the health program-specific DHIS2 implementation. As a result, the study revealed, in addition to dominant logic-driven implementation, resource chased-collaboration diverges standardization and evolve-ability instead of achieving both simultaneously. Therefore, this study recommended complementing resource chasing-collaboration with major institutional logics collaboration for balancing which requires continuous scanning of the implementation context and technology to identify multiple actors' logics before devising the governance mechanisms.

The Role of Technology and Implementation Context for IT Governance

Platform technology implementation in a resource-constrained setting is often guided by the established hierarchical IT governance based on dominant institutional logic (Gawer, 2014; Gizaw et al., 2022; B. Lagebo et al., 2022; Sahay et al., 2010; Woldeyohannes et al., 2022) that resulted in either a fragmented (Woldeyohannes et al., 2022) or rigid (Sahay et al., 2010) system. Similarly, this study identified how organization-based governance was inadequate to govern DHIS2, an innovative digital platform. The case depicted how such governance led DHIS2 implementation towards evolvability. Research suggested the platform governance model for innovation platforms which divides the organizations into two parts, core, and periphery, and allows platforms to emerge in various stages of their lifecycle; of half-realized, not-yet-made

solutions and visions (Baldwin & Woodard, 2008; Tiwana et al., 2010). I argue that platform governance for platform technology in a resource-constrained setting is technically suitable and crucial for IS implementation context in resource-constrained settings relying on multiple international organizations' financial and technical capacity based on a decentralized governance strategy. Furthermore, the boundary resource model used for global digital platform governance is extended to local digital platform governance by emphasizing the data boundary resource design for balancing standardization and evolve-ability at national level. Finally, it provides empirical cases regarding handling contradictory issues in resource-constrained setting, which is also applicable for resource-constrained settings in general, as they are suffering from similar challenges.

Proposing an Integrated Implementation Framework for Balancing Standardization and Evolve-ability

Research describes the importance of diverse concepts, to unpack the contradictory issues of IS implementation concerning structure, process, and communication. This study integrated the institutional logic, dynamic ambidexterity, and boundary resource model and concepts to study and propose comprehensive governance mechanisms (structure, process, and communication) for IS implementation with a special focus on balancing standardization and evolve-ability in IS implementation.

9.2 Practical Contribution

The findings of this study also inform practical recommendations. First, managers should consider IS implementation as conflicting activities that require different structures, processes, and communication mechanisms. To achieve this, the study encourages employing inclusive IT governance mechanisms to enable actors to maintain institutional distance from the prevailing logic and enhance new system understanding during system adoption in cases where multiple dominant actors are in play. This first requires the managers' institutional distance from the prevailing logic to continuously navigate and enact the major logics of the implementation context and craft the common vision of HIS implementation to achieve both standardization and evolve-ability simultaneously in the implementation. Second, based on an established vision, boundary resources (i.e. data, processes, routines, procedures, capacity building) can be designed at the

national level to enable system implementation initiatives to scan, seize and reconfigure their team based on changes in the context and environment.

Structurally, the study proposed a platform governance approach that partitioned decision-making into two categories, boundary resource designing and app development. MOH and partner organizations with core system knowledge and skill are responsible for boundary resource designing, while partner organizations with periphery system knowledge and skill, resources in cooperation with health institutions, programs responsible for application, and module development, and hierarchical health institutions as end users. The study suggested the national actor, MOH, and partner organizations with core system knowledge and skill shift from involving in every activity of DHIS2 configuration and app development to designing and providing national-level boundary resources (data, procedures, capacity building) for health programs, health institutions and partner organizations with periphery system knowledge of app and module development and controlling their work to maintain the standard. Partner organizations that engage in application and module development can deliver end-user capacity building for health institutions. This directs the attention of managers from resource-chasing collaboration to fixing system issues toward major institutional logic-chasing collaboration for balancing standardization and evolvability.

With a process perspective, an integrated implementation framework based on institutional logic, dynamic ambidexterity, and the boundary resource model was proposed for national and organizational level processes. The framework guides central actors to continuously navigate and enact important institutional logic in the field before embarking on designing an IT governance mechanism for implementation. For the system-level process, given the DHIS2 platform modular architecture, the boundary resource model can address both standardization and evolvability. Accordingly, my message for policymakers, consultants, and other practitioners, it is important to consider the adopted technology architecture and the implementation context to complement the organizational governance mechanisms. For instance, DHIS2 should be understood as a platform instead of as a stand-alone system for specific health programs as seen in this case. DHIS2 can be configured to address various health program information needs in a modular form due to its modular architecture.

9.3 Limitations and Further Research Recommendations

The scope of this study is DHIS2 implementation in the public health care context of Ethiopia with a special focus in the Oromia region in the period of 2018-2021, supplemented with material going as far back as 2005. This study is limited by data from one region and a specific system which might not adequately describe the complexity of a national HIS implementation. Furthermore, the researcher's role as the external participant would miss important events such as internal meetings where technical decision and discussion was made which should have been ideal to get rich information. These are limitations and potential areas for further research.

Further research is needed to extend the scope of this study to multiple regions, and systems for a longer time to highlight new insights and to highlight the differences across regions and systems. Future research should examine multiple systems' adoption in different regions in longitudinal research to examine how multiple systems at a national level have been implemented. The study emphasizes the use of the institutional logic concept, dynamic-ambidexterity, and the boundary resource model to understand the logic behind the implementation that led to standardization and evolvability in the implementation. The study is different from the existing rare IT governance research in balancing standardization and evolvability due to its paradoxical focus in a dynamic, complex, and resource-constrained public healthcare context. To further such a paradoxical perspective, further research with comprehensive and more empirical settings is needed to generalize the findings. Although this thesis focused heavily on stakeholders' institutional logic and governance, the analysis phases of the study revealed the impact of the technology architecture in DHIS2 implementation, which was only slightly addressed in the thesis. Further, a deeper understanding of the role of technology in balancing standardization and evolvability is needed, representing another avenue for future research. The interrelationship between technology and IT governance can also be one of the future research areas. Furthermore, future studies can investigate how and why logic is changed, introduced, completed, integrated, and removed over time along with IS implementation to show its impact on balancing conflicting issues in the long term. Last but not least long-term action research might be useful to track the changes in IT governance mechanisms' impact on IS implementation over time to gain the temporal impact of governance changes. The action research enables to access confidential and pertinent information

related to the governance mechanisms and implementation which is difficult to get in other research approaches.

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APPENDICES

Appendix 1. Research Permit from AAU

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Addis Ababa University
IT Doctoral Program Office

Date /ቀን 05/06/2020
Ref. No. /ቁጥር IT-DPO-075/2012/20

To:- **Federal Ministry of Health**
Policy Plan Monitoring and Evaluation Directorate (PPMED)
Health Information Technology Directorate (HITD)
Addis Ababa

Subject: Request for Cooperation in Health Information Systems Research

Birkinesh Woldeyohanes is a PhD student in Information Systems Track of the IT Doctoral Program, Addis Ababa University. Birkinesh presented and defended her research proposal entitled "IT Governance Design for Balancing Evolve-ability and Standardization in HIS Design and Implementation in Ethiopian Health Care Context". The proposal has been approved to pursue conducting her research. Currently, she is at data collection stage. She plans to conduct data collection activities from a number of organizations including yours.

This is therefore, to kindly request your good office for cooperation and willingness to allow our student to get data for her research and render any kind of support to facilitate the research. Furthermore, we would be happy if you could invite her to attend HIS trainings, workshops and quarterly meetings as a researcher as these events are one of the major means to get rich data for the research. It is understood that such partnership will contribute for the student to gain practical experience and your organization to get important feedback from the study.

Thank you in advance for your usual cooperation and support.

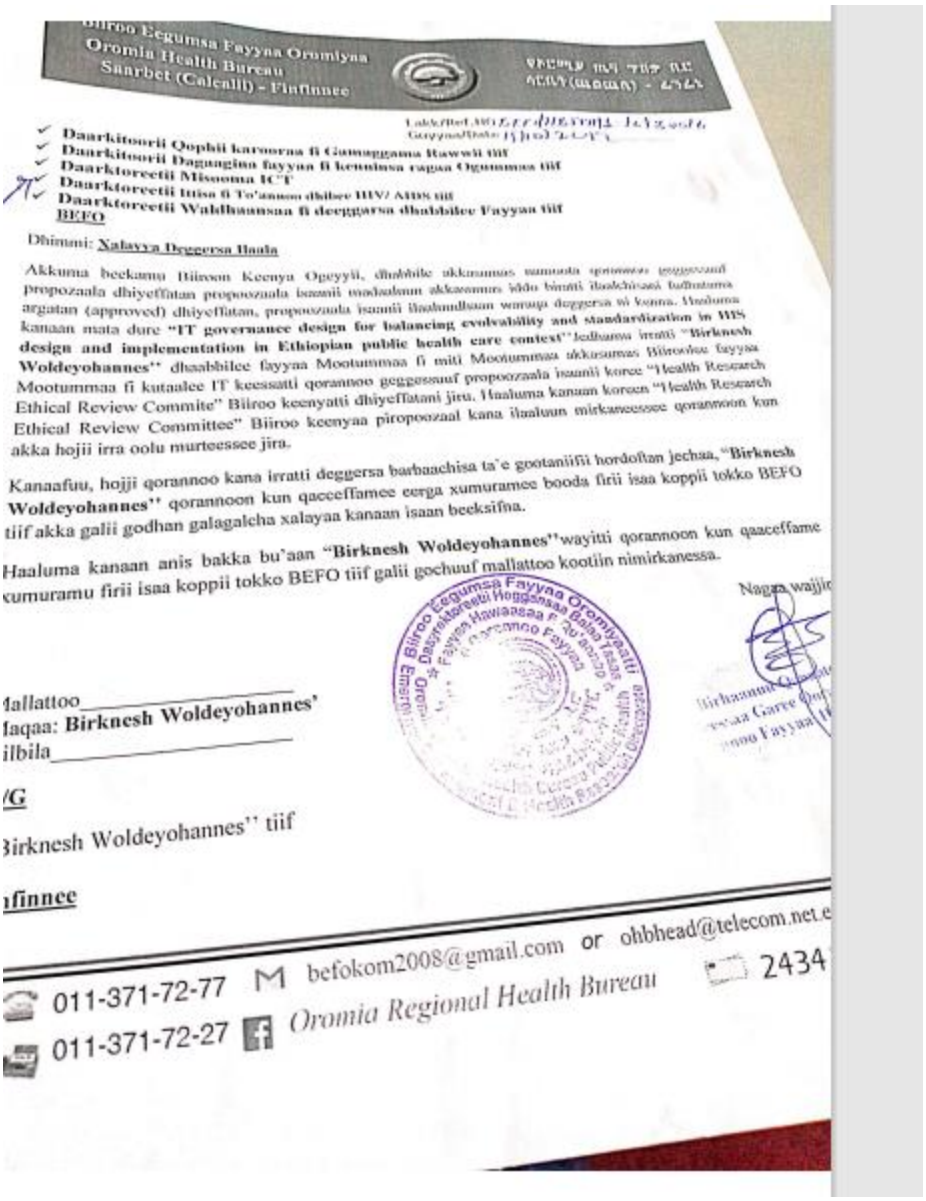
CC: Birkinesh W/Yohannes, PhD candidate
Addis Ababa University

Sincerely,

Salehu Anteneh (PhD)
Director, IT Doctoral Program
Addis Ababa University

☎ 251-11-122-91-83 Fax: 251-011-122-91-97 ✉ 1176
Address: Sidist Kilo, FBE Campus, New building 6th floor Email: ITPhD@aau.edu.et

Appendix 2. Approval of the research by Oromia Regional Health Bureau



Biiroo Eegumsa Fayyaa Oromiyaa
Oromia Health Bureau
Saarbet (Caleniil) - Finfinnee

- ✓ **Daarkitoorii Qophii karoorsa fi Gamaggama Rawwii tiif**
- ✓ **Daarkitoorii Daganginaa fayyaa fi keenuusa ragaa Ogummaa tiif**
- ✓ **Daarktoreetii Missooma ICT**
- ✓ **Daarktoreetii Iitisa fi To'annoo dhibee HIV/ AIDS tiif**
- ✓ **Daarktoreetii Waldhaansaa fi deeggarsa dhabbilee Fayyaa tiif**

BEFO

Dhimmi: **Xalayya Deggersa Haala**

Akkuma beekamu Biiroon Keenya Ogeyyii, dhabbile akkaunnaa xumuruu qorannoo geggeessuuf propozaala dhiyeffatan propoozaala isaanii madaalnnn akkaunnaa xiqqo biratti ilaalchisee hafuuruma argatan (approved) dhiyeffatan, propoozaala isaanii ilaalnudhaan warraqi deggersa isi kennu. Haaluma kanaan mata dure **"IT governance design for balancing evolvability and standardization in HIS design and implementation in Ethiopian public health care context"** jedhuurra irratti **"Birknesh Woldeyohannes"** dhaabbilee fayyaa Mootummaa fi miti Mootummaa akkaunnaa Biirookee fayyaa Mootummaa fi kutaalee IT keessatti qorannoo geggeessuuf propoozaala isaanii koree "Health Research Ethical Review Commite" Biiroo keenyatti dhiyeffatani jiru. Haaluma kanaan koreen "Health Research Ethical Review Committee" Biiroo keenyaa piropoozaal kana ilaaluun mirkaneessee qorannoon kun akka hojii irra oolu murteessee jira.

Kanaafuu, hojji qorannoo kana irratti deggersa barbaachisa ta'e gootaniifii horddoftan jechaa, **"Birknesh Woldeyohannes"** qorannoon kun qaceffamee eerga xumuramee booda firii isaa koppii tokko BEFO tiif akka galii godhan galagalcha xalayaa kanaan isaan beeksifna.

Haaluma kanaan anis bakka bu'aan **"Birknesh Woldeyohannes"** wayitii qorannoon kun qaaceffame xumuramu firii isaa koppii tokko BEFO tiif galii gochuuf mallattoo kootiin nimirkanessa.

Nagaa wajjin

Biiroo Eegumsa Fayyaa Oromiyaatti Dasgeksareetu Hoggansaa Fayyaa Hawaasaa fi Qo'annoo Fayyaa

Mallattoo_____
Maqaa: **Birknesh Woldeyohannes'**
Gilbila_____

/G

Birknesh Woldeyohannes'' tiif

afinnee

011-371-72-77 befokom2008@gmail.com or ohbhead@telecom.net.e
011-371-72-27 *Oromia Regional Health Bureau* 2434

Appendix 3. Interview Guide

I. Senior IT planners and managers

1. What is your educational background, specific experience to HIS work or to IT work and your organization and position.
2. When and how did you get involved in DHIS-2 design and implementation process?
3. What was the major reasoning behind embarking on DHIS-2 design and implementation as opposed to taking do more evolutionary approach to meeting the organization's future IT needs? Includes selection process
4. How is resources(financial, political) and organizational (rules , norms and social issues)mobilized to DHIS-2 design and implementation and is there any problem regarding this
5. How the technological resources like network and application architecture enables or constrains the design and implementation of DHIS-2 design and implementation
6. Who are the main stakeholders in DHIS-2 design and implementation and their role? Technical, financial or what, are they program or geography specific or not?
7. How partner organizations or individuals have joined and will join the DHIS-2 design and implementation process?(here I want to clarify the partners interest and how it is compromised in the process)
8. How can we explain partners' role in scaling and standardizing DHIS-2?
9. How can we explain the relationship between partners around DHIS-2?(does their motives converge or diverge and how)
10. How MOH resolve such divergence consequences?(rules, regulation, business and technical support)
11. How the informal issues interact with such tensions and its role?
12. What is each partners' contribution to DHIS-2 design and implementation-
13. What opportunities or incentives are there to participate in DHIS-2 design and implementation(standardization or evolve-ability)
14. What formal rules of conduct are partners required to obey as legitimate in participating DHIS-2 design and implementation?
15. How are these rules enforced and what are the sanctions?

16. What are the goals and objectives of the implementation of DHIS-2?
17. What tasks and roles have you fulfilled or which aspects did you focus on?(design, implementation or use)
18. What were some of the interventions and approaches in building and sustaining a community to promote the scaling up and further development of DHIS?
19. Are there informal norms or a dominant culture within the HIS design and implementation If so, how is it propagated?
20. How has DHIS-2 helped to meet the technological needs of the region?
21. Who else in their organization and across the region should be interviewed
22. Do you have any kinds of evaluative or assessment report about DHIS-2 implementation ?

II. Developers(master of ease, adaptability, leverage, evocative, open ended) it should be organized under this umbrella

1. How the DHIS-2 architecture enables you to address the current and emergent requirement-
2. How the IT governance rules, strategies and incentives helped you to standardize or to invent new module(includes institutional norms, regulation and cognition)
3. How institutional elements affects the DHIS architecture and design and also the DHIS governance regarding standardization and evolve-ability and also balance
4. How entrepreneurs play key roles to manage the tensions in DHIS architecture and design and DHIS governance to lead the implementation to purely standard, generative or to balance
5. What are the problems or new requirements faced and addressed and how?

III. Health Managers, Experts,

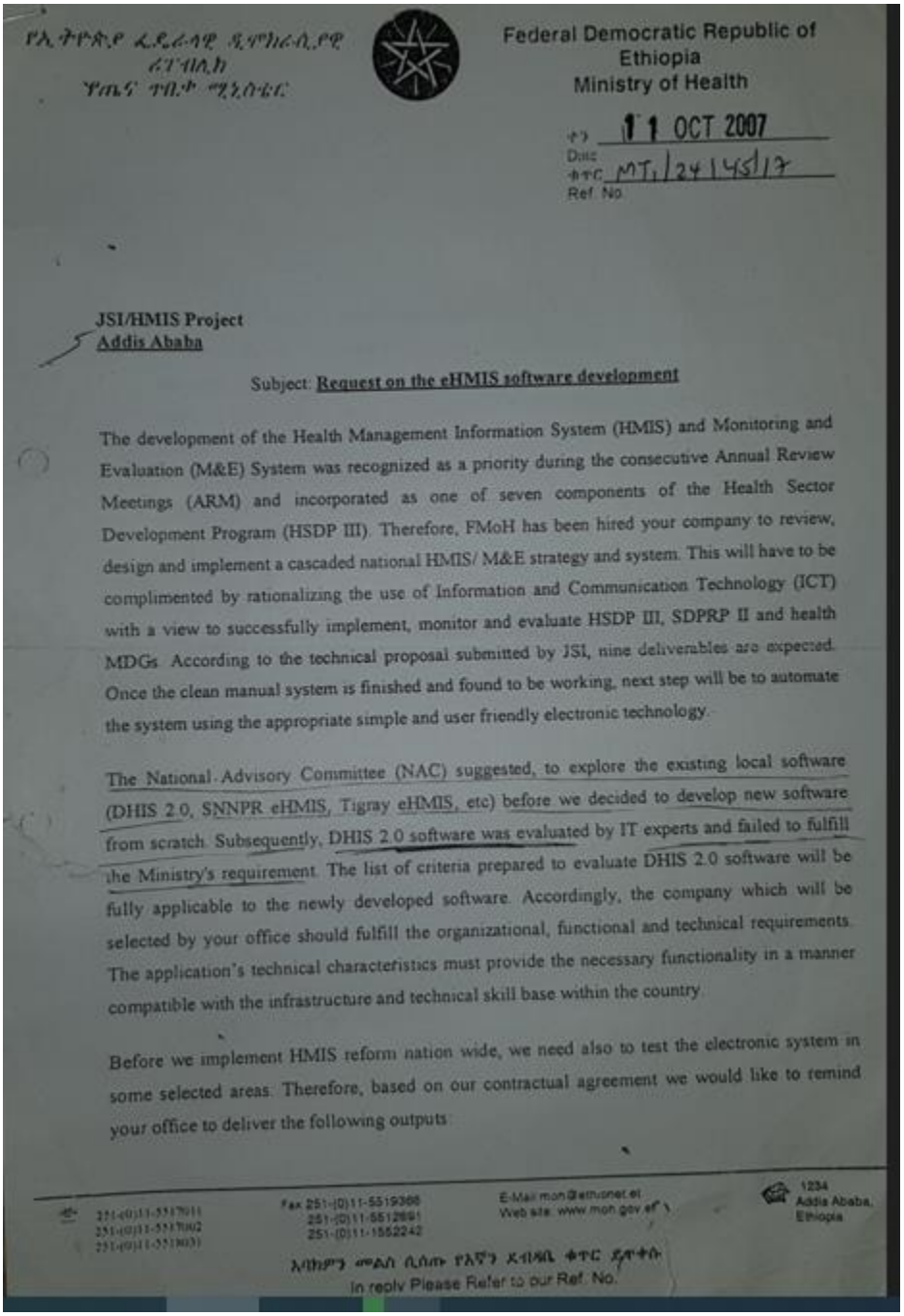
1. What is the nature of your work in relation to the use of DHIS-2.
2. Can you describe your everyday work and explain how the DHIS-2 has helped to support it?(based on the answer specific questions will follow-
3. Do you have required institutional(funding and political)support and technological support like network, computer, server, software antivirus to support DHIS-2 implementation and use
4. What do you expect from DHIS-2/
5. Who else support DHIS-2 design and implementation in your organization and how?
6. What are positive and/or negative implications of new technology use like DHIS-2

7. Who else in their organization and across the region should be interviewed
8. How will DHIS-2 be utilized in the stakeholder and constraints if any and how did you resolve the constraints

Appendix 4. Observation Check Lists

1. The MOH HIV people raised HIV data duplication issue which requires triangulation during observation
2. How the HIV data and report duplication look like and managed to avoid duplication
3. Informants resides design issues which require to check HIV data validation rules for some fields
4. What happened to Adami tule health facility when it is upgraded to the town, how long it took to address
5. Relating the HIV data elements, periods and some specific health facility includes HIV data elements, periods in DATIM, PHEM, DHIS-2, HPMT and other
6. Organizational structure definitions of DATIM, PHEM, DHIS2 and HPMT
7. Are the M&E peoples or HIT staff who enter data on DHIS-2, PHEM, DATIM, HPMT, and in others at health facility, wereda and zone level are different or the same
8. What is the DSL and 3G internet connection differences, problems, in data collection, process and how it is being solved?
9. The data completeness of PHEM, DHIS2 and HPTMT data at all levels
10. why they do not use DHIS2 and inclined to PHEM
11. Some indicators have some problems and we asked them to be corrected. Regions said that it is the software problems. For instance TB-HIV data is unexpected data is 1, the maximum ART data should be 1 but we should not have got 3. Our relation is with PPMED, we informed the PPMED, the PPMED will contact the IT people. We do not have direct relation with ITD. But it is not only the software problem , there is also a problem with data element understanding in IT staff at lower level. So we have to upgrade this understanding problem regarding the program problem and also the software will be improved by the ITD.
12. Data completeness and delaines issue should be seen from the software
13. Does PHEM data is really integrated or not with DHIS2 and used in all health facilities and problems regarding the PHEM data use

Appendix 5. Letter for selected partner organization for e-hmis implementation



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Federal Democratic Republic of
Ethiopia
Ministry of Health

ቀን Date 11 OCT 2007
ቁጥር Ref. No MT/241451/7

JSI/HMIS Project
Addis Ababa

Subject: Request on the eHMIS software development

The development of the Health Management Information System (HMIS) and Monitoring and Evaluation (M&E) System was recognized as a priority during the consecutive Annual Review Meetings (ARM) and incorporated as one of seven components of the Health Sector Development Program (HSDP III). Therefore, FMoH has been hired your company to review, design and implement a cascaded national HMIS/ M&E strategy and system. This will have to be complimented by rationalizing the use of Information and Communication Technology (ICT) with a view to successfully implement, monitor and evaluate HSDP III, SDPRP II and health MDGs. According to the technical proposal submitted by JSI, nine deliverables are expected. Once the clean manual system is finished and found to be working, next step will be to automate the system using the appropriate simple and user friendly electronic technology.

The National Advisory Committee (NAC) suggested, to explore the existing local software (DHIS 2.0, SNNPR eHMIS, Tigray eHMIS, etc) before we decided to develop new software from scratch. Subsequently, DHIS 2.0 software was evaluated by IT experts and failed to fulfill the Ministry's requirement. The list of criteria prepared to evaluate DHIS 2.0 software will be fully applicable to the newly developed software. Accordingly, the company which will be selected by your office should fulfill the organizational, functional and technical requirements. The application's technical characteristics must provide the necessary functionality in a manner compatible with the infrastructure and technical skill base within the country.

Before we implement HMIS reform nation wide, we need also to test the electronic system in some selected areas. Therefore, based on our contractual agreement we would like to remind your office to deliver the following outputs:

251-(0)11-5517011
251-(0)11-5517002
251-(0)11-551803
Fax 251-(0)11-5519366
251-(0)11-5512891
251-(0)11-1552242
E-Mail:mon@ethionet.et
Web site: www.mon.gov.et
1234
Addis Ababa,
Ethiopia

Appendix 6. Memorandum of Understanding between MOH and University of Olso

MEMORANDUM OF UNDERSTANDING

between

University of Oslo – "UiO"
c/o Department of Informatics

and

Ministry of Health, Ethiopia– "Partner"

(UiO and Partner are jointly referred to as "the Parties")

1. Introduction

Recognising the mutual benefits to be gained through a cooperative programme supporting the global HISP movement and promoting the DHIS2 software as a global public good, University of Oslo and Ministry of Health (MOH) Ethiopia enter into this cooperation agreement and agree to the following:

2. Objectives

This cooperation shall include but not be limited to:

1) DHIS2 open-source software development;
2) Country capacity building activities including hosting and arranging DHIS2 Academies and developing teaching curriculums and materials;
3) Joint research and academic activities;
4) Implementation support to Ministry of Health, and its agencies;
5) Development of integrated health information architectures in the country;
6) Development of tripartite agreements between the Parties and Ministry of Health for the strengthening of health information systems;
7) Develop a network of action, linking researchers, students, projects, Universities and health authorities in a cooperative network.

3. Principles of promoting DHIS2 as a global public good

The cooperation is based on a shared understanding and adherence to the following guiding principles:

1) Give priority to activities strengthening sustainable national health information systems;
2) Support development processes broadly and the capacity strengthening and empowerment of health staff;
3) Support country ownership of health information systems and build resilience;
4) Focus on the use of information to improve health service delivery;
5) Foster local innovation and entrepreneurship;
6) Support research by giving researchers access to data and empirical sites;
7) Promote reciprocity and sharing in the global HISP movement;
8) Promote transparency and trust in the global HISP movement;
9) Commit to free and open-source software and standards;
10) Develop software applications that are generic and reusable;
11) Adhere to the principles of hierarchy of standards;
12) Engage the users in participatory design and development;
13) Develop integrated, not stand-alone systems;
14) Software development based on global standards and best practices;
15) Design training materials for global use and as a public good;
16) Document and share best practices, case studies and knowledge as a public good;
17) Professional project management including planning, reporting, financial management etc.;
18) Professional execution of contracts, in terms of deliverables, their quality, timeliness etc.;
19) Duly acknowledge all outputs emerging from projects or research.

4. Implementation

In order to carry out and fulfil the aims of this Agreement, the Parties shall each appoint a Coordinator who shall manage the development and conduct of joint activities.

Either party may initiate proposals for activities under this Agreement. The details of terms and conditions will be determined on a case-to-case basis related to activities. The Parties shall seek financing of joint activities from sources available to them.

5. Duration and termination of the Agreement

This Agreement shall become effective on the date that it is signed by both Parties and shall be valid for a period of [5] years, but may be renewed by mutual consent. Any changes to this Agreement shall be subject to the written consent of both Parties.

This Agreement may be terminated by either party at any time provided that the terminating party gives written notice of its intention at least six months prior to termination.

Any dispute arising under the terms of this Agreement shall be referred to an independent mediator as agreed by both Parties. Nothing in the above Agreement shall be construed as being legally binding.

6. Contact persons

In order to carry out and fulfil the aims of this Memorandum, the Parties shall each designate a Coordinator who shall manage the development and conduct of joint activities:

At UiO	At the MOH
_____	_____

7. Signatures

The Agreement has been signed in two (2) originals. Each of the Parties will keep one original.

Signed on behalf of UiO [name position]	Signed on behalf of MOH [name position] Lia Tadesse (MD,MPH) Minister
_____	_____
Signature	Signature
Date: _____	Date: March 09, 2021

Appendix 7. Hermeneutics data analysis examples

First Order Data Construction Examples						
Informants	***Quotes***	***Coding***				
		Whole	***Part-Whole***	***Part-Whole***	***Part***	
Experts, PPMED	Master facility registry system is planned to be deployed in regions to send us the health facility available within the region but you have to go to each physical health facility to get the geographical coordinates using JPS and it was distracted by COVID-19 pandemic. Service management information system has many data dictionary components which is not all finished. At this time the disease data dictionary is finished the rest is at design level. The finished part is available, in mobile app and accessible for health programs, . Currently we are working on drug lists. It is new online available in MOH website, google play store is ready and it is accessible there. The rest are at working and immediately will be	**Standardizing health systems**	**Multiple unfinished standardization efforts** "MFR project was distracted by COVID-19 pandemic" "Service management information system has many data dictionary components which is not all finished." "At this time the disease data dictionary is finished the rest is at design level. " "Currently we are working on drug lists. The rest are at working and	**Accessing Standards** "The finished part is available, in mobile app and accessible for health programs" "It is online available in MOH website, google play store is ready and it is accessible there" "Currently we are working on drug lists. The rest are at working and immediately will be available. " "many manuals are difficult to access, if a person cannot access it the MOH website	**Difficult to access the available standards** "many manuals are difficult to access, if a person can not access it the MOH website or access the MOH physical , it is difficult to access but no I am not sure which one are accessible and which one are not accessible."	

	available. We are spending a lot of time in understanding what system terminology mean. ..Many manuals are difficult to access, if a person cannot access it the MOH website or access the MOH physical , it is difficult to access but I am not sure which one are accessible and which one are not accessible. We deployed it online including ARM and also distributed in a CD both the documents and training manuals.		immediately will be available. "We are spending a lot of time in understanding what is terminology system"	or access the MOH physical , it is difficult to access but I am not sure which one are accessible "I don't know which one are not accessible." " We deployed it online including ARM and also distributed in a CD both the documents and training manuals. "		
IT Directirate	"First of all we do not have the region, the zone level health information system at all we have only one national health information system. We have an agreement with regional health bureaus to deploy one system. Since our work flow is the same, as I said earlier by defining functional and non functional requirement we developed a national system and sustainable strategy will continue. Our	**One national health information system** "First of all we do not have the region, the zone level health information system at all we have only one national health	**Agreement with regions to deploy one system** "we developed a national system to avoid fragmented system and duplication of efforts"	**Challenges for one national system** "But for instance two health facilities like health center and hospitals and two different hospitals like Tikur Anbesa and Alert are different in service, the number of patients, and so on so their	**Results** "They may have more tailored system in addition to the standard in EMR"	

	health architecture standard document is considered as a standard how systems should fulfill this, the protocols should be communicated in such way. Health information system architecture document is a standard that will be used. If they wanted to add more than DHIS-2, they have to maintain the DHIS-2 requirement but it does not work at region level because we have one types of national health information systems. We have one budget, one plan and one report so we do not have more fragmented systems. That is why we developed a national system to avoid fragmented system and duplication of efforts. But for instance two health facilities like health center and hospitals and two different hospitals like Tikur Anbesa and Alert are different in service, the number of patients, and so on so their requirement is different but we EMR system we have set some	information system" "the workflow is the same" "DHIS2 does not work at region level because we have one types of national health information systems." "developed a national system to avoid fragmented system and duplication of efforts" "We have one budget, one plan and one report" "Our health information system architecture standard		requirement is different but we EMR system we have set some standard communication protocol and in this functionality then they can add more than that"		

	standard communication protocol and in this functionality then they can add more than that. They may have more tailored system in addition to the standard in EMR"	document is considered as a standard how systems should fulfill this, the protocols should be communicated in such way"				
	"Hmis has its own indicators, data elements, formulas are these requirement documents. From PPMED have a team who identified the target and baseline. That is what we automate, we do not go to lower levels. Joint steering committee have already approved the indicators"	**Indicators as standards** "HMIS has its own indicators, data elements, formulas are these requirement documents" "That is what we automate, we do not go to lower levels. "	**Key actors in indicator definition** "Joint steering committee have already approved the indicators"	**"Baseline Target"** From PPMED have a team who identified the target and baseline.		
	"It is a workflow leads us to integrate a system that will be decided by the technical working group. I might not be informed about this it is too technical. It is about the technical working group,	**Integration** "It is a workflow leads us to integrate a system that	**Key actors in system integration** "It is decided by the technical working group. I			

	they are autonomous they can do it as they need. "	will be decided by the technical working group"	might not be informed about this it is too technical. It is about the technical working group, they are autonomous they can do it as they need. "			

Second Order Data Construction Examples						
Codes	***First order Data***	***Coding***				
		Structure	***Process***	***Communication***	***Actors***	***Logics***
Standardization	**Standardizing health systems** **One Plan One Budget One Report** **Multiple unfinished standardization efforts** **Accessing Standards** **Difficult to access the available standards** **Indicators** **Master Facility Registry** **Service Terminology systems** **Drug Lists** **One national health information system** **Agreement with regions to deploy one system** **Challenges for one national system**	**Multiple unfinished standardization efforts** **Difficult to access the available standards** **One national health information system**	**Standardizing health systems** i.e. **Indicators** **Master Facility Registry** **Service Terminology systems** **Drug Lists**	**Difficult to access the available standards** **Agreement with regions to deploy one system**	**Key actors in system integration ex. TWG** **Key actors in indicator definition** PPMED	Centralized Logic

Second Order Data Construction Examples						
Codes	***First order Data***	***Coding***				
		Structure	***Process***	***Communication***	***Actors***	***Logics***
	Key actors in system integration **Key actors in indicator definition** **Baseline Target**					

Appendix 8. Papers published

1. Lagebo, Birkinesh; Lagebo, Birkinesh; Gaynor, Mark Prof.; and Assefa, Temtim dr(2022): Exploring institutional logics to dynamic ambidexterity in health information system implementation in the public health sector of Ethiopia: Electronic Journal of Information System in Developing Countries. in e12252 Version of Record online: 04 November 2022; https://doi.org/10.1002/isd2.12252
2. Lagebo, Birkinesh; Lagebo, Birkinesh; Gaynor, Mark Prof.; and Assefa, Temtim dr(2022): Inclusive Entrepreneurship in Handling Competing Institutional logics for DHIS2 Adoption in Ethiopian Public Health Care Context (2022). International Journal of Managing Information Technology(IJMIT)
3. Lagebo, Birkinesh; Lagebo, Birkinesh; Gaynor, Mark Prof.; and Assefa, Temtim dr, "IT Governance for Balancing Evolveability and Standardization in Health Information System Implementation in Ethiopian Context" (2020). African Conference on Information Systems and Technology. 12. https://digitalcommons.kennesaw.edu/acist/2020/allpapers/12
4. Birkinesh Woldeyohannes Lagebo. Development of Resilient Health Information Infrastructure in Complex, Dynamic and Resource Constrained Health Care Context International Working Conference on Transfer and Diffusion of IT (TDIT), Jun 2019, Accra, Ghana. pp.497-512, ⟨10.1007/978-3-030-20671-0_34⟩
5. Gizaw, A.A., Fossum, S.M., Lagebo, B.W. (2022). The Role of Digital Platforms in Managing Institutional Logics: Case from DHIS2 in Ethiopia. In: Zheng, Y., Abbott, P., Robles-Flores, J.A. (eds) Freedom and Social Inclusion in a Connected World. ICT4D 2022. IFIP Advances in Information and Communication Technology, vol 657, 107-119, Springer, Cham. https://doi.org/10.1007/978-3-031-19429-0_7
6. Lagebo, Birkinesh; Lagebo, Birkinesh; Gaynor, Mark Prof.; and Assefa, Temtim dr, (submitted to Journal of Health Informatics for Africa). Boundary Resource Model for Balancing Standardization and Evolve-ability of HIS implementation in Resource-constrained context