UNIVERSITY
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Master's thesis

Data Use in Rwanda HMIS

A Case Study Applying Theory of Effective Use

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Informatics: Programming and System Architecture
60 ECTS study points

Department of Informatics
Faculty of Mathematics and Natural Sciences

Spring 2023

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http://www.duo.uio.no/

Printed: Reprosentralen, University of Oslo

Abstract

A health management information system (HMIS) is a data collection system that supports planning, management, and decision-making in health facilities and organizations. A functioning HMIS is essential for health system strengthening, but the effective use of HMIS data for decision-making needs to be better documented. As such, this thesis investigates the practices of, enablers, and barriers to data use in Rwanda's HMIS. It documents data use practices across all health system levels and which factors enable and constrain local implementations. Rwanda has a well-established HMIS, building on a decade of experience with the DHIS2 platform, making it a suitable research place.

The research was a qualitative case study, based on a four-week fieldwork in Rwanda, collecting data through interviews, observations, and participating in workshops and meetings. The analysis positioned the fieldwork findings as enablers or barriers to the constructs of an adapted Theory of Effective Use framework (TEU). The TEU examines what effective system use involves and what drives it.

Rwanda HMIS supports data-driven decision-making. Stakeholders have high access to relevant health data, and the system collects comprehensive and local data that accurately represent health status and services. Decision-making heavily relies on HMIS information, facilitating program development, policy-making, and coordination. Best practices are actively shared, and significant resource adaptation is taking place. However, challenges include data fragmentation across platforms and outdated population denominators, impacting accuracy. Insufficient capacity building and limited supervision hinder the effective use of data.

The thesis offers contributions in four areas: (1) It adds to the literature on HMIS strengthening and data-driven decision-making in LMICs by providing valuable insights and empirical evidence from Rwanda HMIS. (2) This research helps advance the TEU by adapting it to a new context. Future researchers and practitioners can use this as a template to assess the effective use of an HMIS. (3) The findings help Rwanda further improve its already well-established HMIS

practices by identifying the factors driving or hindering effective data use. (4) The thesis answers the HISP project call for action to document the routine use of DHIS2 data, providing real-world examples of data use practices and the challenges faced, direct feedback from interviewees, and a framework (TEU) that can be utilized in future research projects.

Keywords: data use practices, HMIS strengthening, data-driven decision-making, Theory of Effective Use, Rwanda HMIS, DHIS2

Acknowledgements

First and foremost, I would like to thank my supervisor Johan Ivar Sæbø for guiding me through the project, providing valuable advice, encouragement, and feedback. I am also grateful for the support from my co-supervisor Silvia Masiero during preparation and meetings.

I want to thank HISP UiO and the Rwandan Ministry of Health for the opportunity to conduct this research. Thank you to HISP Rwanda for the facilitation and support during the fieldwork. The level of access we got to interact with people within HISP Rwanda and the broader health system was precious and greatly appreciated. Hamza and Jean Paul H. deserve special mentions for dedicating significant amounts of their time to support us in any requests we had. I also want to thank everyone accompanying us for excursions and interviews, and all the interviewees for their willingness to participate and provide invaluable data.

I will further thank faculty staff for insightful conversations and for providing alternative viewpoints. HISP employees giving feedback on my results and finding them relevant was a significant confidence boost and driver. My fellow students, especially those from room HB229C, have been great discussion partners and proofreaders, provided much-needed laughs, and made me a better table tennis player. Moreover, my research partners, Daniel and Ozan, were great companions during the fieldwork in Rwanda. Finally, I would like to thank friends and family for being patient and supportive throughout.

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University of Oslo

May 2023

Acronyms

CHW Community health worker.

DDM Data for Decision-Making.

DHIS2 District Health Information Software 2.

GRID3 Geo-Referenced Infrastructure and Demographic Data for Development.

HIS Health information system.

HISP Health Information Systems Program.

HISSM Health Information System Strengthening Model.

HMIS Health Management Information System.

HMN Health Metric Network.

IS Information Systems.

LMIC Low- and middle-income country.

M&E Monitoring & Evaluation.

NGO Non-governmental organization.

R-HMIS Rwanda Health Management Information System.

RBC Rwanda Biomedical Center.

RHAP Rwanda Health Analytics Platform.

RHIS Routine health information system.

SISCOM System d'Information Sanitaire Communitaire.

SOP Standard Operating Procedure.

TEU Theory of Effective Use.

UiO University of Oslo.

USAID U.S. Agency for International Development.

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Chapter 1

Introduction

This thesis addresses the knowledge gap on how DHIS2 data is routinely used for decision-making. More specifically, it will analyze and discuss how and by whom data are being used at all health system levels in Rwanda and which factors enable and constrain local use. Four-week fieldwork was conducted in Rwanda, a nation that has implemented a working Health Management Information System (HMIS) using the generic software platform DHIS2. This has improved healthcare service delivery, but there is limited research on how the platform is used and whether it facilitates data-driven decision-making. To address these problems, this thesis adapts the Theory of Effective Use, a framework that examines what effective system use involves and what drives it, to the context of the health administration situation in Rwanda. This uncovers to what extent data is: available for the users, representing the health status and services, and used to make better decisions. In addition, it highlights how adaption actions and learning actions influence the performance and decision-making processes in Rwanda HMIS.

1.1 Motivation

An HMIS is one of the six building blocks essential for health system strengthening (WHO, 2007). It is a data collection system that supports planning, management, and decision-making in health facilities and organizations. The effective use of HMIS data depends on various factors, including the practices adopted by healthcare workers at all levels of the health sector and the different challenges they face.

Data use related to HMISs is the process of preparing and carrying out decision-making for program monitoring, policy development, and resource allocation (Kumar et al., 2018; Nutley and Reynolds, 2013). It regards how health data is

used to generate health indicators, statistics, trends, and coverage (Evaluation, 2019b). According to WHO, health systems strengthening is 'everybody's business' (WHO, 2007). Various efforts have attempted to strengthen health systems through the role of information. These efforts are based on the belief that improved information systems can enhance data quality, relevance, and comprehensiveness, leading to greater data use and informed decision-making. Despite the efforts, data often remain underutilized and fail to inform program development and improvement, policy development, strategic planning, or advocacy. Literature reviews on data-driven decision-making in low- and middle-income (LMIC) countries found most capacity-building efforts to focus on training individual health workers in data analysis tools and techniques for improving quality, analysis, interpretation, and use of health information system (HIS) data (Nutley and Reynolds, 2013; Pappaioanou et al., 2003; Wilkins et al., 2008). Further, the studies emphasized the importance of organizational culture that incentivizes data use.

This thesis occurs within the Health Information Systems Program (HISP) project, an interdisciplinary center promoting research and innovation in digital global health and related areas. The project mainly emphasizes strengthening HMIS in LMICs through its DHIS2 platform. DHIS2 has been adopted in more than 100 countries worldwide and has a global footprint of 2.3 billion people. It is a trusted platform for Ministries of Health that enables monitoring and assessment of both health services and the general health of the populace. The platform enables local innovations necessary to ensure relevant systems for today's users and is flexible enough to meet tomorrow's new and changing requirements. In the HISP UiO Strategy Update for 2019-22, the focus forward is on data use and country health information system strengthening: from managing processes that enable 'data in' (to DHIS2) to focus on 'data out' concerning data quality analysis and use for strengthening health services delivery and improving health outcomes (UiO, n.d.).

DHIS2 is based on the idea that health services should be managed through a comprehensive district health system. As a geographical administration unit, the health district is optimal for managing local health (Gorgen et al., 2004). Despite the early identification of the need for building local capacity for evidence-based management (Pappaioanou et al., 2003), there is still not much evidence of improved information use at the district level (Wickremasinghe et al., 2016). A systematic review conducted by Hoxha et al. (2020) noted a disconnect between the obstacles most commonly described in the literature and those targeted for interventions. Although over half of the studies identified organizational or environmental challenges, only 13% of the strategies focused on addressing them. Challenges included resource shortages, training, feedback, and management. The authors concluded that additional research is needed to

identify effective strategies for addressing the determinants of HMIS use.

Byrne and Sæbø (2022) were the first to conduct a scoping review of how exactly DHIS2 data is routinely used for decision-making and subsequent programming of action. According to their findings, there is general utilization of DHIS2 data but limited comprehensive documentation of its usage in both peer-reviewed and grey literature. The usage pattern commonly revolves around the centralized versus decentralized use of data concerning data access and reporting 'up' in the system. Additionally, they noted that different conceptualizations of data use are not clearly expressed. The authors conclude with three suggestions for the way forward:

- The need to document in more detail and share how data are being used
- The need to investigate how data were created and who uses such data
- The need to design systems based on work practices and, in tandem, develop and promote forums in which 'conversations' around data can take place

Of the 19 papers in the scoping review, none covered Rwanda. Rwanda implemented DHIS2 nationwide in 2012 and has extensive experience with the platform. PRIMASYS, a WHO comprehensive case study of the Rwandan primary health care system, points out "promote data use to inform policy and decision-making" as a consideration for the way forward (WHO, 2017b, p. 27). Russpatrick et al. (2021) reported from an ongoing 'evaluation for improvement' action research project in Rwanda, intending to improve data use practices and the capabilities of the DHIS2 software to support data use. It was revealed at both health facility and district levels that although data was regularly employed, for example, during monthly coordination meetings, there was minimal utilization of DHIS2 dashboards and other analytical tools. In addition, several local requirements in Rwanda could not be accommodated by the generic core DHIS2 platform. Maïga et al. (2019) found data reporting high, but data analysis not trustworthy due to inaccurate target population denominator data.

This backdrop serves as the motivation for the thesis. This research is part of a larger group of students investigating data quality and data use practices in Rwanda and Tanzania. This is made possible through collaboration with the HISP UiO Centre and local HISP groups. Although the project consisted of groups conducting fieldwork together, each student wrote their thesis incorporating unique research questions and perspectives. This thesis is based on the empirical findings from a fieldwork stay in Rwanda.

1.2 Research question

This thesis will address the knowledge gap on how exactly DHIS2 data is routinely used for decision-making, adding to the literature on HIS strengthening and data-driven decision-making in LMICs. More research is essential, particularly regarding usage within and across the different health system levels. Staff in various roles and organizational levels make different decisions, e.g., front-line health workers serving patients' needs, administrators making district-wide decisions, and policy-makers operating nationally. Rwanda has a decade of experience with DHIS2, making it a well-suited place to conduct this research. Given the significant importance of the HMIS in the country's healthcare system, it is also crucial to identify data use challenges and how they cope with them. Appropriately, the thesis is centered around the following research question:

> *What are the practices of, enablers, and barriers to data use in Rwanda HMIS?*

The thesis answers these questions by presenting an interpretive, qualitative case study of the use practices of the HMIS platform DHIS2. The data collection consisted of four-week fieldwork in Rwanda, conducting interviews and observations, attending workshops, and participating in meetings. The field visits ranged from district health centers and hospitals, national implementers HISP Rwanda and Rwanda Biomedical Center (RBC), and the Rwandan Ministry of Health.

While there are well-established definitions and methods for monitoring improvements in data quality, methods for measuring data use for decision-making have been more scarce (Evaluation, 2019a). As Hoxha et al. (2020) conclude, additional research is needed to identify effective strategies for addressing the determinants of HMIS use. This thesis will position and analyze the findings of the research by adapting the Theory of Effective Use (TEU) framework by Burton-Jones and Grange (2013) to the context of the health administration situation in Rwanda. TEU is a theoretical framework that examines what effective system use involves and what drives it. Understanding the effective use of information systems is 'critically important' (Straub and Giudice, 2012), as system use alone is insufficient to meet organizational goals. Thus far, the framework has not seen high uptake, and it has yet to be applied to the context of an HMIS. By positioning the findings from the fieldwork to the constructs of TEU, the paper analyzes how routine health data is available for the users, representing the health status and services, and used to make better decisions. It will also showcase how adaption- and learning actions influence the performance and decision-making processes in Rwanda HMIS.

1.3 Thesis structure

Chapter 2 - Background and Context Provides a general background for the research. The HISP project and its DHIS2 platform are introduced. Essential information about Rwanda's history with DHIS2 and its health system structure is presented.

Chapter 3 - Related Research Introduce relevant literature to provide an understanding of 1) health information systems, 2) the challenge of data use: on a global scale, regarding the DHIS2 platform, and in the context of Rwanda, and 3) strategies to strengthen HIS in LMICs. The understanding established from this and the theoretical framework introduced in Chapter 4 provides the theoretical lens for analyzing and discussing the empirical findings.

Chapter 4 - Theoretical Framework The empirical findings will be structured using a theoretical framework called the Theory of Effective Use. In this chapter, the framework is explained, then adapted to fit the context of Rwanda's HMIS.

Chapter 5 - Research Approach Outlines and justifies the selected methodology, methods, and data collection and analysis techniques. In addition, there are accounts of the philosophical underpinning of the research, methodological limitations, and ethical considerations.

Chapter 6 - Findings Results from the data collection are presented: 1) practices of data use and 2) challenges regarding data use.

Chapter 7 - Analysis Draws on the results of the empirical findings and the adaptation of the TEU framework to position and analyze enablers and barriers to data use in Rwanda HMIS.

Chapter 8 - Discussion The analysis results are matched with relevant literature on HIS strengthening and data-driven decision-making in LMICs, the application of the TEU framework is discussed, and so are the research's implications for practice, regarding both Rwanda HMIS and the HISP project.

Chapter 9 - Conclusion This chapter provides a summary and conclusion of the thesis, utilizing the findings and discussion to answer the research question. The research contributions are explained, and pointers for future research are given.

Chapter 2

Background and Context

This chapter provides an overview of the study's contextual background. It begins with an introduction to the HISP program and its primary project, DHIS2. Standardized WHO metadata packages for DHIS2 are also explained, as certain findings are related to them. It then presents the structure of health in Rwanda, which serves as a way to structure the fieldwork findings and facilitate the discussion later. Finally, the chapter presents the local HISP group in Rwanda, and the history and various applications of DHIS2 in the country.

2.1 HISP

HISP, or the Health Information Systems Program, is a global action research project considered one of UiO's greatest international achievements. It all started in post-apartheid South Africa in 1994, where UiO aimed to provide a health management system that could centralize health data and bring together a fragmented health sector (Braa and Hedberg, 2002). From 1996 to 1998, there was a prototyping and implementation pilot project in a single province, and from 1999 the software was rolled out nationally. By 2001 a nationwide health information system named DHIS was established.

After 2001, similar projects would take place, first in Mozambique and India, then expanding worldwide over time. This required an extensive overhaul of the entire architecture, transitioning from standalone installations to a client-server (or cloud-based) platform architecture. This new platform was called DHIS2.

Since then, HISP has grown tremendously and is now an interdisciplinary center promoting research and innovation in digital global health and related areas. The greatest emphasis is on helping LMICs deploy comprehensive HMISs. The HISP core development team is still implementing, customizing, providing

capacity building, and promoting software. The project has gained support from prominent organizations and funds such as Norad, UNICEF, CDC, The Bill and Melinda Gates Foundation, and The Global Fund (Adu-Gyamfi et al., 2019). In 2017 HISP UiO was designated as a WHO Collaboration Centre for Innovation and Implementation Research for strengthening health information systems[1]. In addition to HISP UiO, there is a network of local HISP groups and regional partners worldwide.

2.2 DHIS2

DHIS2 was designed as a flexible, configurable HMIS platform for collecting, storing, visualizing, and analyzing data. The software has advanced from handling aggregate health data to encompassing patient management, individual records, and more (Adu-Gyamfi et al., 2019). It is a trusted platform for Ministries of Health, enabling monitoring and assessment of both health services and the population's general health. Countries can monitor public health, combat and prevent pandemics, and manage treatment programs for severe illnesses. DHIS2 is open-source, web-based, with user interfaces and metadata available in various languages. It enables local innovations necessary to ensure relevant systems for the users of today and is flexible enough to meet the new and changing requirements of tomorrow, both within the health sector and for new use cases. Recent examples include agriculture, education, e-government, and logistics management[2].

DHIS2 has a core database and API developed and maintained by the HISP UiO team. The team also develops and maintains "core" generic applications. These tools include data capture, analytics such as dashboards, pivot tables, charts, and maps, as well as data quality and user management applications. These share standard components built on top of a stable API, resulting in a layered and modular architecture. In addition to the core, various locally developed applications are created with little or no involvement from HISP UiO. The platform is rooted in a philosophy of decentralized adaptation and contextualized utilization (Braa and Hedberg, 2002). When the software was first created twenty years ago, it was explicitly designed to allow for local health variations and actively promote and facilitate their incorporation. These boundary applications can be generic and reusable across different countries and contexts or highly specialized for a particular user or function (Roland et al., 2017). DHIS2 is an example of an innovation platform that provides the foundation upon which applications or components can be built, much like the Android operating system or the Chromium browser project from Google.

[1] https://www.mn.uio.no/hisp/english/about/history/index.html
[2] www.dhis2.org/user-stories

Figure 2.1: A DHIS2 dashboard showcasing various visualizations

Today the platform has a global footprint of 2.3 billion people and is implemented in more than 100 countries worldwide. The success lies in sustainable and scalable software and a thriving community. DHIS2 is seen as a leading example of a Global Public Good. Public goods are 'those that are available to all and that can be enjoyed over and over again by anyone without diminishing the benefits they deliver to others' (Chin, 2021). The HISP UiO Strategy Update for 2019-2022 (n.d.) presents a new shift in focus, where data use and country HIS strengthening are the main themes.

2.3 Standardized WHO metadata packages

Since its inception in 1948, WHO has been instrumental in setting standards for monitoring and evaluating public health. In 2016, influential organizations working within global health formed the Health Data Collaborative (HDC), led by WHO, to enhance country-level capacity to monitor progress towards sustainable development goals. There was a need for more standards regarding information systems supporting health programs. Standardization would mean software components and other materials could more easily be re-used and shared across actors (Poppe et al., 2018). The solution became the DHIS2 platform, with its flexible metadata model and architecture supporting custom application development. In DHIS2, metadata gives information about other data, such as indicators, data elements, and dashboards[3]. The proposed approach

[3]https://dhis2.org/metadata/

combined the knowledge and legitimacy of the WHO with the installed base of countries using DHIS2.

Poppe, Sæbø, and Braa (2019) found that a pervasive challenge with the initiative had been the limited penetration and use of these standards by countries. While there had been an improvement in the ability to gather data, there were instances where pertinent data was not consistently obtained, and the overall data quality frequently fell short. They found a lack of clearly defined procedures by the WHO to facilitate the implementation of standards and the perceived use value concerning the cost of implementation in countries. On the other hand, the COVID-19 pandemic gave the concept time to shine. The pandemic highlighted the need for quality data and structures that could be implemented in a few days or weeks. Poppe et al. (2020) argue that the rapid development and deployment of COVID-19 health packages worldwide is an example of the successful dissemination of global standards.

Representatives from UiO analyzed the WHO initiative in a multi-year case study, in which they participated in developing, implementing, and evaluating the standardized packages (Poppe et al., 2021). While the initiative had successfully supported the implementation of tools and analytics, information about the impact packages had on the performance of HISs was lacking. Further research was necessary to assess to what extent standardization of health packages had led to improved data use practices.

2.4 The structure of health in Rwanda

Health services in Rwanda are provided through the public sector, government-assisted health facilities, private health facilities, and some traditional healers. The hierarchy of health services provision in Rwanda can be divided into the central level and five additional levels underneath: the province, district, sector, cell, and village levels (WHO, 2017b).

Starting on top, the central-level agencies are developing, coordinating, evaluating, and disseminating health policies, strategies, programs, and human resource capacities (WHO, 2017b). In the case of the HMIS platform, the primary stakeholders are the Rwandan MoH, HISP Rwanda, and the Rwanda Biomedical Center (RBC), Rwanda's national health implementation agency.

At the province level tertiary hospitals focus on providing specialized health service provision, teaching, and research in health-related fields. This level of the hierarchy was not covered during the fieldwork, but it does not offer general healthcare services like the rest of the levels do.

At the district level, district hospitals provide a government-defined comple-

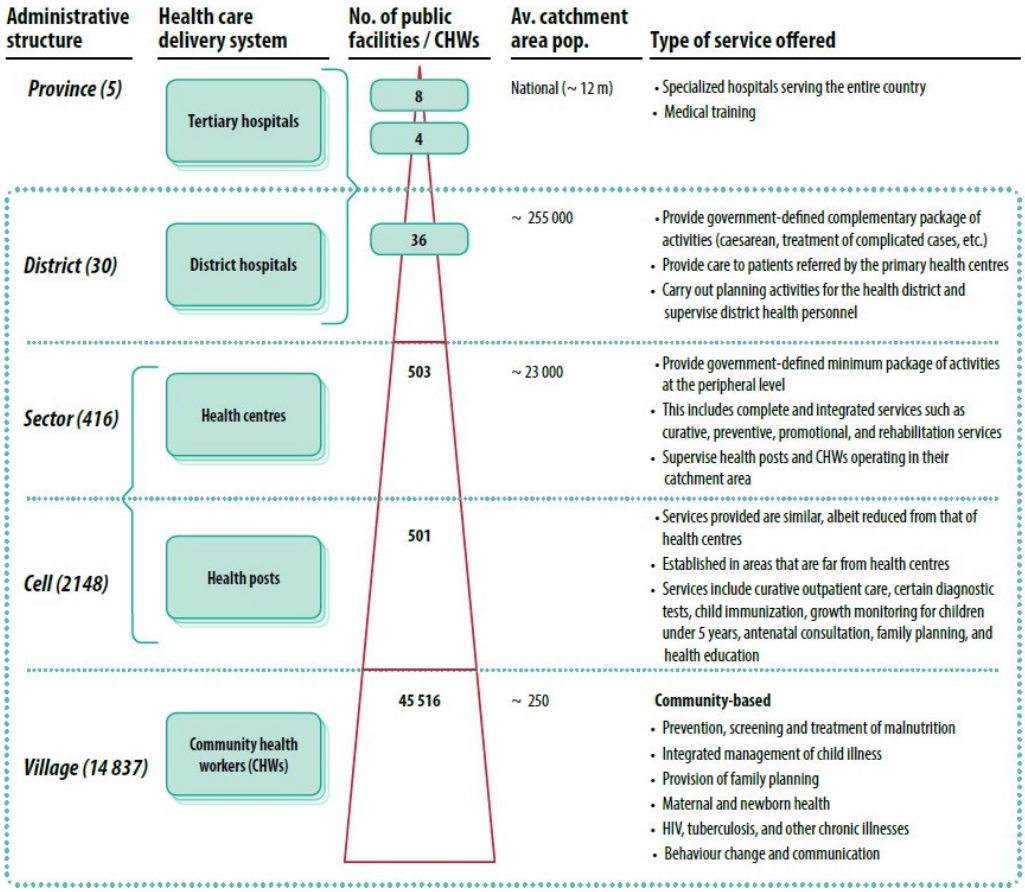


Figure 2.2: Representation of the structure of health care in Rwanda (Rwanda Ministry of Health, 2017)

mentary package of activities (e.g., treatment of complicated cases) and provision of care to patients that the health centers in the district have referred. These hospitals also supervise health personnel within the district.

At the sector level, health centers provide a government-defined minimum package of activities at the peripheral level. The peripheral level is represented by an administrative office, a district hospital, and a collection of health centers, health posts, and community health workers (CHWs) (WHO, 2017b). The health centers provide complete, integrated services, such as preventive, promotional, curative, and rehabilitation services. Like district hospitals, these facilities supervise health posts and CHWs operating in their catchment area.

At the cell level, health posts provide primary healthcare, including preventive, promotional, and curative services. They can offer basic diagnostics with rapid testing and a basic package of services for areas far from health centers. The health posts work as an outreach, serving the population living in remote areas of the country. With support from administrative districts, communities, and partners, the MoH has established over 1000 health posts that provide basic

health services nationwide.

At the village level, more than 50 000 community health workers are deployed as an outreach to provide health services outside of clinics and in remote areas. These people are the first line of defense against diseases, preventing possible outbreaks, treating diseases, and educating the public. This includes the management of child illness, malnutrition, maternal and newborn health, provision of family planning, and more. CHWs are one of the main driving forces that helped transform the health of Rwandans, as Dr. Gashumba said in the Global Fund article 'Rwanda: A nation reborn' [4]:

> *We have a health system built from the community level, from the household level, a health system that focuses more on the preventive element as opposed to the curative side. We have decentralized everything to make sure that services are close to the people.*

2.5 HISP Rwanda

HISP Rwanda is a program that aims to improve healthcare quality by strengthening Rwanda's HIS. The program offers a range of expertise that develops and deploys information systems that support both government and community[5]. This includes evaluation and performance assessments, project planning, designing Monitoring & Evaluation (M&E) systems, and capacity building. The efforts primarily concern the DHIS2 platform, where they have over ten years of experience. HISP Rwanda also supports the governments of 9 other African countries in complementing their priority health areas: Burundi, Central African Republic, Chad, Comoros, Congo Brazzaville, Djibouti, Gabon, Madagascar, and Sudan. They aim to assist countries and organizations implement customizable, innovative, and sustainable solutions that leverage healthcare delivery in low-resource settings (Rwanda, 2022). While HISP Rwanda provides technical expertise and capacity building, the goal is for the different programs to take ownership of the solutions as much as possible.

2.6 DHIS2 in Rwanda

Prior to 2008, the Rwanda HMIS relied predominantly on paper-based forms (Nisingizwe et al., 2014). In 2008 the country implemented an electronic HMIS to capture facility healthcare data. Care providers recorded patient-level data in paper-based registers, and each facility aggregated this data monthly to submit reports for the district team. Before 2012, these reports were transferred to an

[4]https://www.theglobalfund.org/en/stories/2019/2019-09-20-rwanda-a-nation-reborn/
[5]https://hisprwanda.org/

electronic system that the central MoH office had access to (Jolliffe et al., 2015). That year, the MoH introduced the Rwanda Health Management Information System (R-HMIS), in collaboration with WHO and UiO. R-HMIS is just another word for their DHIS2 solution. The former minister of health disliked the name DHIS2 as it implied the platform was limited to district-level usage. Instead, they wanted the platform referred to as (R)-HMIS, as it better suited the range of topics covered by the platform. The HMIS collects data from over 700 health facilities, both public and private. Additional modules and a national data warehouse were later introduced using the same software. All health facilities were equipped with computers for data management. Each facility assigned at least one person to act as the data manager, handling data- capture, maintenance, dissemination, and presentation. The introduction of R-HMIS improved reporting timeliness, completeness, and accuracy (Jolliffe et al., 2015). Previously, it could take months to receive reports from remote health areas, but with R-HMIS the reports from all facilities could be viewed and analyzed immediately.

As time progressed, Rwanda kept expanding its HMIS platform to incorporate the functionality of other systems. In 2014, a performance-based financing (PBF) module was introduced to the platform, allowing data to be analyzed using existing DHIS2 tools. In short, PBF means the health workers do not have a set monthly salary but receive payments based on accomplishing predefined goals. Integrated Disease Surveillance and Response (IDSR) was also introduced, a strategy adopted by nations within the WHO African Region to establish all-encompassing public health surveillance and response systems that address high-priority diseases, conditions, and events at every level of healthcare systems[6]. Implementing the Tracker application enabled Rwanda to collect, manage and analyze individual data records. Introducing the Android app for DHIS2 expanded the platform's reach even more, allowing front-line workers to collect data at the community level through mobile phones, even without an internet connection. When the COVID-19 pandemic hit in 2019, Rwanda had DHIS2 solutions for case reporting and vaccination management up and running by the time the first batch of vaccines arrived. The project used a range of functionality the DHIS2 platform offers, from case-based surveillance to aggregate data analysis and setting up client SMS reminders.

The Rwanda MoH, HISP Rwanda, and RBC have the technical skills for DHIS2 system sustainability, implementation, and further development. In addition to modules developed domestically, the country has a range of DHIS2 packages in use: disease surveillance; HIV; HMIS; EMIS (Education Management IS); LMIS (Logistics Management IS); Malaria; Tuberculosis; case-based surveillance; cause of death & mortality surveillance; COVID-19 surveillance and vaccines; and

[6]https://openwho.org/channels/idsr

more[7]. To put the rapid development into perspective, I end the chapter with major health-related milestones, as reported by The Global Fund[8]:

- Between 1990 and 2017, life expectancy in Rwanda increased by 33 years, a faster gain than any other African country.
- Under-5 mortality has decreased by two-thirds and maternal mortality by three-quarters.
- Percentage of women giving birth in health facilities has climbed from less than 40% to well over 90%.
- New HIV infections declined from 13000 in 2004 to 7400 in 2018. The number of people living with HIV receiving antiretroviral treatment rose from just 3% in 2004 to 83% by 2017

2.7 Chapter summary

The chapter presents the contextual background for the thesis, which is based on the HISP program and its main project DHIS2. HISP started as a health management system pilot project in post-apartheid South Africa in 1994. Based on this prototype, DHIS2 was developed and implemented in several countries worldwide. DHIS2 is a flexible, configurable HMIS platform that can handle individual and aggregate health data. It is open-source and web-based, enabling local innovations to meet changing requirements within and outside the health sector. Standardized WHO metadata packages for DHIS2, aimed at improving global health monitoring, see limited adoption by countries. While the initiative has successfully supported the implementation of tools and analytics, information about the impact packages had on the performance of HISs was lacking. Further research is necessary to assess to what extent standardization of health packages had led to improved data use practices.

The structure of health in Rwanda is then explained. Health services are provided through the public sector, government-assisted health facilities, private health facilities, and some traditional healers. The hierarchy of health service provision can be divided into the central, province, district, sector, cell, and village levels. HISP Rwanda is a program that aims to improve healthcare quality by strengthening the country's health information systems. The program offers a range of expertise that develops and deploys information systems that support both government and the community. Finally, the chapter displays the history and various applications of DHIS2 in the country. The platform was introduced in 2012 and has expanded in scope ever since.

[7]https://hisprwanda.org/dhis2-2/overview-2/
[8]https://www.theglobalfund.org/en/stories/2019/2019-09-20-rwanda-a-nation-reborn/

Chapter 3

Related Research

This chapter introduces the fundamental concepts of HIS, HMIS, and RHIS. Then it builds an understanding of data use and data-driven decision-making and their importance in improving health outcomes. Next, literature on data use practices in LMICs globally, regarding DHIS2, and in the context of Rwanda, are reviewed. Finally, impactful research into HIS strengthening in LMICs is presented.

The chapter lays the foundation for understanding the significance of an HMIS and the obstacles encountered in utilizing data for decision-making. It sets the stage for subsequent discussions on improving data use practices and enhancing the performance of an HMIS.

3.1 Health information systems

Health information is, according to WHO, one of the six core functions (see Figure 3.1) of the health system (2007). The motivation behind a health information system (HIS) is to produce high-quality information used at all health system levels for decision-making about program monitoring and review; program planning and improvement; and health strategy planning, advocacy, and policy-making. Each of the six core functions is important for improving a health system and better health outcomes, but high-quality and timely data from the HIS lays the foundation for the overall system. Health data inform decision-making in the other five core functions: service delivery; health workforce; access to essential medicines; financing; leadership, and governance (Abouzahr and Ties, 2005). Enhancing the health system is a primary focus in numerous global and national health agendas to improve health outcomes. This involves strengthening the six fundamental building blocks and effectively managing their interactions to attain more equitable and sustainable enhancements across health services and overall health outcomes. It requires technical and political knowledge and action (Sæbø

et al., 2011; WHO, 2007).

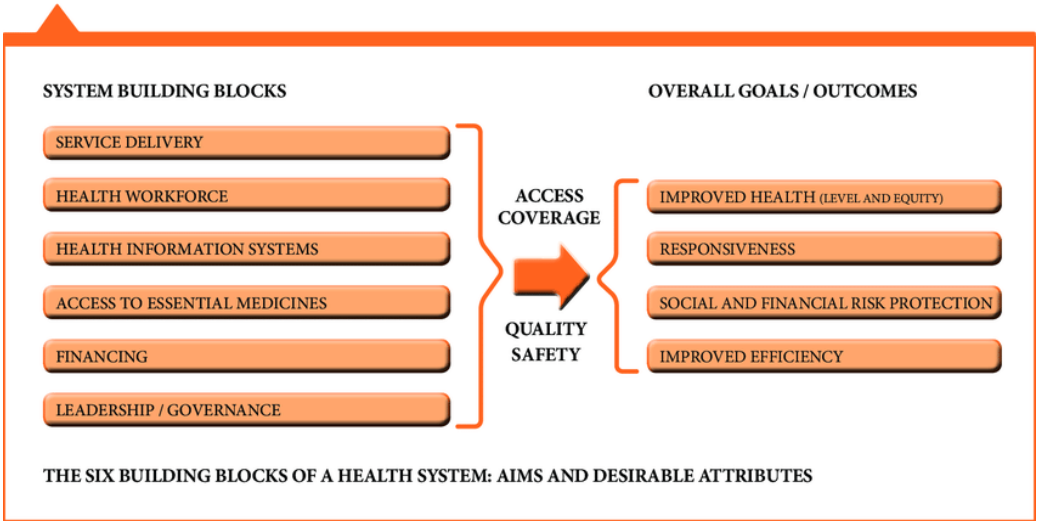


Figure 3.1: The WHO Health Systems Framework (WHO, 2010)

HMIS describes a subset of HIS that collects aggregate, routine data for managerial and administrative processes. This thesis primarily centers around the HMIS subset, as the Rwanda HMIS platform DHIS2 is the focal point. While DHIS2 provides additional features related to HIS, such as logistics management or individual patient records, this thesis focuses on its utilization within the HMIS context.

HMIS is sometimes referred to as a Routine Health Information System RHIS in literature, two terms that can be considered synonymous (Aqil et al., 2009). The term RHIS will sometimes be utilized to preserve original quotations and statements.

3.2 The challenge of data use

This section first conceptualizes data use and data-driven decision-making. It then explores the state of data-driven decision-making in LMICs HMIS: (1) on a global scale, (2) regarding the DHIS2 platform, and (3) in the context of Rwanda.

3.2.1 Understanding data use and data-driven decision-making

Data use is an area of HIS performance measured by the use of health data to generate health indicators, statistics, trends, and coverage and for data-informed decision-making (Evaluation, 2019b). Put another way, it is the analysis, synthesis, interpretation, and review of data as part of decision-making processes such as program monitoring, policy development, and resource allocation

(Kumar et al., 2018; Nutley and Reynolds, 2013). Data utilization occurs across all health system levels, both in formal and informal settings and in planned and ad hoc decision-making (Evaluation, 2019b).

Data-driven decision-making refers to the proactive and interactive processes that consider data during program monitoring, review, planning, and improvement; advocacy; and policy development and review (Walker, 1989). Data-driven decision-making is the practice of basing decisions on the analysis of the data rather than purely on intuition (Provost and Fawcett, 2013). Put another way, decision-making in health systems administration is the process by which a group reaches a collective understanding of a topic, which helps build consensus on a particular course of action to address a health service challenge (Wickremasinghe et al., 2016). A lack of demand for and use of data limits the health system's ability to respond to priority needs throughout its many levels (Nutley, 2012). Ideally, decision-making is based on a full assessment of all the available data that meet accepted quality criteria. Despite efforts to strengthen HISs, data often remain underutilized and fail to inform program development and improvement, policy development, strategic planning, or advocacy (Pappaioanou et al., 2003; Walshe and Rundall, 2001).

The ability of LMICs to monitor and measure their progress toward sustainable health-related development goals depends on the ability of national HMISs to capture, store, manage, and share both individual and population-level health data (Kumar et al., 2018; Network and WHO, 2008). Routine data is recorded consistently without being directly linked to any explicit research question. Various national and local routine data such as deaths, hospital admissions, disease prevention data, diagnostics, demographic data, and geographic data are widely available.

Structured decision-making processes are considered to be those that contain predefined steps, include a consensus-building process, and incorporate the use of locally generated data. The process moves a data-informed recommendation to an implemented action, often involving engaging decision-makers with competing priorities, biases, and values. Regardless of the quality of health data, this type of decision-making is directly influenced by factors that have nothing to do with data, such as the availability of funds to implement a data-informed decision, the political will to advocate a decision, and the general complexity of decision-making processes and structure (Evaluation, 2019b). The actual use of data for making decisions should occur at all levels of the health system and within each of the six health-system building blocks.

Measuring the outputs of data quality and data use is crucial to assess the effectiveness of interventions to strengthen the HMIS. While there are well-established definitions and methods for monitoring improvements in data

quality, such as accuracy, reliability, precision, completeness, timeliness, integrity, and confidentiality (Evaluation, 2019a), monitoring and measuring data use has been more challenging. Different types of data users and producers contribute to and employ the HMIS in complex ways, and there is not always consensus about the actions that constitute data use. For example, data sharing, visualization, dissemination, and review are often considered data use cases. In the literature, measures of data use have included such dimensions as transparency, timeliness, visibility, accessibility, dissemination of information, calculation of key indicators, preparation of information products, and presentation of the achievement of targets (Abajebel et al., 2011; Mwencha et al., 2017). Data use measurement is complicated by various factors, including decision-making procedures, ongoing HMIS strengthening activities to improve the availability and quality of data, stakeholders at different healthcare system levels, and information dissemination. Lack of documentation and accessibility, time-lags between the formulation of recommendations and implementation, and between decisions and outcomes at the service delivery level can hinder retrospective analysis (Nutley and Harrison, 2010).

3.2.2 The state of data use practices in LMICs HMIS

Studies in LMICs have shown how data use positively impacts the quality of care and helps strengthen health systems (Kimaro and Nhampossa, 2004; Wagenaar et al., 2017). Despite agreement that rational, data-based decisions will lead to improved health outcomes (White and Henderson, 1978), many public health decisions appear to be made intuitively or politically (Davis, 2002). There have been limited efforts to synthesize the knowledge across the currently available intervention studies in improving HMIS data quality and use for decision-making in LMICs. Thus, Lemma et al. (2020) scoping review synthesized published results from interventions, identifying 20 articles on data quality and 16 articles on data use. Research conducted in these contexts indicates a restricted or insufficient utilization of data, particularly concerning routinely generated data (Biruk et al., 2014; Etamesor et al., 2018; Nicol et al., 2017). Studies on data use have primarily included combined interventions that can be divided into three groups (WHO, 2007):

- Interventions utilizing decision-making tools or models, which can present information in a logical and meaningful manner to aid decision-making
- Interventions employing technology to enhance data quality and availability for decision-making
- Capacity-building interventions, ensuring that a combination of the tools, skills, staff, and support systems required for chosen functions are available and operational

Improvement in data use was reported in 11 of the 16 studies on data use (Lemma et al., 2020). These studies showed that combining interventions addressing behavioral and technical factors improved data quality and utilization. No interventions were found to specifically address organizational factors, despite reports that these presented obstacles to the implementation and success of the interventions. Certain papers discussed drivers and barriers influencing the interventions. The most prominent were related to staff, resources, and infrastructure. Staff-related factors comprised a lack of knowledge, skills, or training and low commitment or motivation. Leadership issues, such as variation in leadership quality, lack of guidelines or protocols, limited resources, and inadequate technological infrastructure, were reported as barriers. Additionally, limited user acceptance, restricted capacity to access and utilize interventions, and a prevalent culture that does not prioritize data utilization were identified. Resource constraints included a lack of access to computers and internet connectivity. Only three articles covering capacity-building efforts were found.

Hoxha et al. (2020) systematically reviewed technical, behavioral, and organizational challenges that hinder the use of RHIS data in LMICs and the strategies implemented to overcome these challenges. The paper concluded:

> *Additional research is needed to identify effective strategies for addressing the determinants of RHIS use, particularly given the disconnect between the type of challenge most commonly described in the literature and the type of challenge most commonly targeted for interventions.*

The examined studies showed that a mere 13% of RHIS strategies tackled organizational or environmental challenges such as limited resources, training gaps, feedback mechanisms, and management concerns, despite more than half of the studies acknowledging these challenges. The majority of strategies addressed technical challenges.

Similarly, Wickremasinghe et al. (2016) conducted a systematic literature review exploring how administrators and health managers in LMICs used health data to make decisions. The goal was to describe the decision-making tools used and identify challenges encountered when using these tools. Out of 14 papers included, they found 12 examples of tools to assist district-level decision-making, all of which consisted of two key stages: the identification of priorities; and the development of an action plan to address them. Four tools with more steps included measures to review or monitor the agreed-upon action plan using HMIS data. In eight papers, HMIS data were used for prioritization. Challenges to decision-making processes fell into three main categories: the availability and quality of health- and health facility data, human dynamics, and financial constraints.

In an evaluation of surveillance systems aimed at enhancing access to timely and high-quality public health information in five developing nations, Wilkins et al. (2008) discovered that the most common challenges were related to personnel (such as inadequate numbers of skilled and motivated workers and inadequate supervision) and dissemination. The systems evaluated in the study identified six inadequacies, which included lack of timeliness, accuracy, simplicity, flexibility, acceptability, and usefulness. The presence of one or more of these inadequacies hindered the utilization of data for making informed decisions.

Braa et al. (2007) found most research into HIS in developing countries to focus on the current process of collecting health data, how that data is used by managers in the upper levels of the health system, and how that process can be improved. In addition, many developing nations suffered from fragmentation due to differing infrastructure, inadequate data quality, and donors funding only specific areas. This led to Non-governmental Organizations (NGOs) developing information systems to meet unique requirements without integrating these into the existing HIS. Additionally, health programs typically collect different data types in different ways, with no standards for data elements or data collection methods between them. This led to duplicates in data reporting, information gaps, and burdening health workers with inconsistent data reporting methods (Stansfield et al., 2008).

Finally, the centralization of health management is another barrier. Local health data are usually collected and merged into national HMIS, from which reports are mainly created for central use but may also be cascaded back to the district level (Nutley and Li, 2018; Stansfield et al., 2008). This process is time-consuming, delaying local data utilization and leading to outdated data by the time it is utilized (Wickremasinghe et al., 2016). The granularity of the data is lost in national reports, compromising the detail required by local users. Consequently, there needs to be more utilization of information at the district level, where most public health intervention decisions are planned, executed, and monitored.

3.2.3 Routine use of DHIS2 data

The fundamental principle behind the DHIS2 software is that health services should be overseen through a comprehensive district health system. It is considered the ideal unit for managing local health (Gorgen et al., 2004). A district's size depends on balancing resources, autonomy, and closeness to the health service provision (Chrysantina and Sæbø, 2019). Local use of the information is a consistent challenge in managing public health services. Despite the early identification of the need for building local capacity for evidence-based management (Pappaioanou et al., 2003), there is still not much evidence of improved information use at the district level (Wickremasinghe et

al., 2016).

Despite the significant global deployment of DHIS2, there has not been a corresponding enhancement of data utilization to support national HMIS improvements in LMICs. This is primarily due to a focus on central-level systems and the support being technical in nature. UiO researchers identified these factors by systematically assessing DHIS2-supported data use in four countries in East Africa, Mozambique, and an Indian state. These assessments revealed a lack of use of dashboards and other information products from DHIS2, weak maintenance of data and metadata, capacity-related problems, and weak governance. Consequently, the results prompted a twofold shift in focus for HISP. The HISP UiO Strategy Update for 2019-22 states (n.d.):

- From managing processes that enable 'data in' (to DHIS2) to focus on 'data out' concerning data quality analysis and use for strengthening health services delivery and improving health outcomes.
- Increasing district-level support and integrating concurrent review systems to identify gaps and address them to continuously improve 'data out' processes.

There have been examples of countries and development partners investing in improving data generation and use through their HMIS (Braa et al., 2012; Etamesor et al., 2018). Maïga et al. (2019) found the introduction of DHIS2 a notable milestone in improving the standardization of data collection and gradually enhancing data quality. Among 14 countries studied, 13 relied on DHIS2 for most of their programs (South Sudan still uses DHIS V.1). DHIS2 had operated for at least five years in 8 countries. The use of scorecards and dashboards, tools specifically designed to visually present health facility data, gained popularity (Etamesor et al., 2018). Six countries used the DHIS2 WHO Data Quality module to identify outliers and assess internal and external consistency (WHO, 2017a).

Byrne and Sæbø (2022) were the first to conduct a scoping review of how exactly DHIS2 data is routinely used for decision-making and subsequent programming of action. Over 500 documents were reviewed, and data from 19 were extracted. The findings suggest that, in general, there is the utilization of DHIS2 data but limited comprehensive documentation of its employment in either peer-reviewed or grey literature. A typical pattern of usage revolved around centralized versus decentralized use in terms of access to data and the reporting of data 'up' in the system. Moreover, different conceptualizations of data use were not clearly articulated.

Byrne and Sæbø concluded with three suggestions for the way forward:

- The need to document in more detail and share how data are being used
- The need to investigate how data were created and who uses such data
- The need to design systems based on work practices and, in tandem, develop and promote forums in which 'conversations' around data can take place

3.2.4 Data use practices in Rwanda

None of the 19 papers in the scoping review on DHIS2 data use for decision-making covered Rwanda (Byrne and Sæbø, 2022). PRIMASYS, a comprehensive case study of the Rwandan primary health care system in 2017 by the WHO, pointed out "promote data use to inform policy and decision making" as a consideration for the way forward (2017b, p. 27). The study states:

> *Data-driven decision-making and policy formulation has increased the efficiency of health program management and enhanced the government's capacity to monitor the quality of health care.* (p. 25)

And that:

> *All government institutions at central and local levels use the collected data to inform planning and budgeting. However, all levels should ensure appropriate infrastructure, skilled personnel, and accountability. Routine health data are sent from health facilities and the community by data managers and community health workers. Reports are sent regularly (quarterly, monthly, or weekly) or on a case-by-case basis through the web-based Rwandan HMIS.* (p. 25)

Russpatrick et al. (2021) reported from an 'evaluation for improvement' action research and participatory design project in Rwanda. The aim was to improve data use practices and the capabilities of the DHIS2 software to support data use. The project identified shortcomings, with the ultimate goal of proposing, designing, and implementing changes to address them. Suggested improvements involved many system design and participation levels, from the global core DHIS2 software team to the country DHIS2 team and local app development, the Rwanda MoH, and health workers at the local level.

Regarding data use, both health facility and district levels regularly employed data, for instance, during monthly coordination meetings, but there was minimal utilization of DHIS2 dashboards and other analytical tools. This was primarily due to users' preference for using Microsoft Excel for data analysis and to bypass DHIS2 limitations. In addition, target population denominator data were unavailable in DHIS2 for sub-units like health posts under the health centers.

Local users knew the rough figures, and entering them directly in Excel was more accessible.

When analyzing health facility data from 14 countries in Eastern and Southern Africa, Maïga et al. (2019) also uncovered denominator-related issues. Rwanda had a 96% reporting rate, with 88% of districts boasting over 90% reporting rates. At the same time, over 80% of districts reported ANC1 (antenatal care) coverage above 100%. 93% of districts reported DPT1 (Diphtheria, Tetanus, and Pertussis) coverage above 100%. These were clear signs the estimates of the target population were off. A national population census provides data on the population by age and sex, which are projected using assumptions about fertility, mortality, and migration. The longer ago the census, the less accurate the projections. The median year of the most recent census used for the population projections in the 14 countries was 2009 (data from 2018). None of the countries applied subnational birth rates to estimate target populations. In addition, people may seek care from health facilities outside their district of residence, further skewing the numbers. This has been referred to as a numerator/denominator mismatch.

Russpatrick et al. also found that many of the local requirements in Rwanda could not be accommodated by the generic core DHIS2 platform. Those requirements could be addressed in two other ways: (1) by adding needed new features to the roadmap for core DHIS2 development, or (2) use DHIS2 as a platform and develop apps to address new features (locally, regionally, or shared between countries. The local HISP Rwanda team is capable of optimally configuring and customizing the DHIS2 platform, but some requirements go beyond the current customization capabilities of the DHIS2.

3.3 Strategies to strengthen HIS in LMICs

Several efforts have been made to develop calls to action, consortia, and guiding frameworks to direct the role of information in strengthening health systems. These efforts include the commitment in 2005 to the Paris Declaration, the creation of the Health Metrics Network in 2005, the crafting of the World Health Organization's Framework for Action, the Strengthening Health Systems to Improve Outcomes in 2007, and the restructuring of the U.S. response to global health with the U.S. Global Health Initiative. The Global Health Initiative calls for "strengthening existing public health surveillance and other data collection systems for monitoring diseases, conditions, health service provision, and health outcomes" (2011, p. 21) as part of an integrated approach to strengthen health systems. These efforts are based on the belief that improved information systems can enhance data quality, relevance, and comprehensiveness, leading to greater

data use and informed decision-making. As a result, positive experiences with data can stimulate demand for additional data and promote a continued commitment to enhancing data quality and utilization. This interplay between improved information, demand for data, and continued data use can create a cycle that leads to improved health programs and policies (Foreit et al., 2006).

Studies confirm that to strengthen evidence-based public health, it is necessary to bring together principles and elements from all relevant disciplines in a problem-solving approach (Higginbotham et al., 2001; Pappaioanou et al., 2003; Rosenfield, 1992). The US Centers for Disease Control and Prevention carried out the Data for Decision-Making (DDM) Project between 1991 and 1996 (Pappaioanou et al., 2003). The DDM Project aimed to achieve three goals:

- Strengthening decision makers' ability to identify data requirements for solving problems and to interpret and use data effectively for public health decisions
- Improving the capacity of technical advisors to provide timely and valid data to decision-makers clearly and efficiently
- Enhancing HISs to support the collection, analysis, reporting, presentation, and use of data at all levels, from local to national

The project implemented various strategies, including assessing critical health problems, developing implementation plans with data-based solutions, and providing interdisciplinary in-service training programs. The strategy was successfully tested in Bolivia, Cameroon, Mexico, and the Philippines, leading to the integration of DDM concepts and practices into the institutional frameworks of participating countries. However, sustained efforts were required to promote behavioral change and foster a broader culture of data utilization in the long term. Teaching decision-makers basic quantitative skills requires long-term and concerted efforts (Pappaioanou et al., 2003), and providing post-workshop assistance is crucial for participants to apply their skills and materials to on-the-job problem-solving. Participants may revert to old work practices without supportive follow-up and supervised application of skills. However, conducting targeted follow-up of data-informed decision-making can be lengthy, costly, and labor-intensive (Nutley and Li, 2018).

Similar efforts to assess and strengthen HISs have been observed in Brazil, Mexico, Honduras, Paraguay, Dominican Republic, Peru, and Ecuador (Plaza et al., 2012). These countries faced challenges related to resource adequacy, data sources, information products, and data dissemination and use. To address these challenges, regional strategies were developed, including securing stakeholder buy-in and funding for strategic health plans, creating databases at sub-national

and health facility levels, and implementing capacity-building and training programs focused on data and information. Establishing the Latin American Network to Strengthen HIS (RELACSIS)[1] further facilitated information exchange and learning among countries.

Braa, Heywood, and Sahay applied data-use workshops to improve data quality and utilization in Zanzibar, Tanzania (2012). The workshops broke the vicious cycle caused by parallel data collection systems and low data use due to poor quality by encouraging use in small incremental steps. The approach was later adopted in Kenya and Rwanda, becoming a standardized part of their quarterly review processes.

Integrating isolated systems has become a priority for many developing countries, NGOs, and research communities (Stansfield et al., 2008). The fragmentation of HISs is a multifaceted issue that needs to be approached from different angles. There have been different strategies to integrate HIS following a data warehouse approach. A study conducted in four African countries found fragmentation of health information in partly overlapping subsystems run by different vertical health programs (Sæbø et al., 2011). South Africa followed a data for the decision-making approach, only including the most important data from each area. More areas and data were added over time, easily accommodated through the flexible database structure. In this way, national standards for essential data were developed 'on top of' other existing systems. The three other countries, Botswana, Sierra Leone, and Zanzibar, followed different all-encompassing strategies:

- Botswana: included all data 'as they are,' without solving inconsistencies between them
- Zanzibar: started with revising the data collection tools and solved the inconsistencies before setting up the data warehouse
- Sierra Leone: solved inconsistencies regarding overlapping data collection forms in the metadata structure of the database

Users often work around inadequate information systems by using manual or duplicate systems, rather than changing their systems via maintenance or enhancement (Gasser, 1986). Gasser argues there are three types of adaption work: fitting, augmenting, and working around. Fitting work is changing a system or work structure to accommodate misfits. Augmenting work is undertaking additional work to make up for the misfit. Working around means intentionally using a system in ways for which it was not designed or avoiding its use and relying on an alternative means of accomplishing work.

[1] https://www.paho.org/en/relacsis

In his foundational article, Lomas (1997) promoted improved communication between those that generate research data and those that use research data in decision-making. Researchers must engage with stakeholders, including policy-makers, healthcare providers, and patients, to ensure that research is relevant to their needs and interests. An overemphasis on changing health practitioners' behavior fails to consider other stakeholders in the data use processes. The paper emphasized the importance of clear and accessible communication, using understandable language to non-experts, considering the broader context in which their findings will be implemented, and working to build relationships with those responsible for implementing recommendations. In addition, robust coordination mechanisms and feedback loops are necessary to ensure that relevant data are available to meet the information needs of decision-makers from various sectors (Nutley and Li, 2018).

Finally, standardizing the decision-making process to ensure replicability is crucial (Wickremasinghe et al., 2016). By following a structured process, decision-makers can make more informed priority decisions and increase the demand for, availability, and quality of data (Nutley and Li, 2018). While the technical aspects of a standardized process are likely to be similar across sub-national levels, local socio-political priorities within a district can influence the interpretation and application of the process. It is important to openly acknowledge these elements' interplay to ensure decision-makers' transparency and accountability to their local population. Involving the community in the process helps to identify local health priorities and encourage uptake and monitoring of health services, enhancing a sense of ownership and improving accountability (Israr and Islam, 2006).

3.4 Chapter summary

The chapter introduces the fundamental concepts of HIS, HMIS, and RHIS. HMIS is a subset of HIS that collects aggregate, routine data for managerial and administrative processes. It highlights the role of high-quality and timely data in supporting decision-making across all health system levels.

The section on the challenge of data use delves into the concepts of data use and data-driven decision-making. It explains that data use involves analyzing, synthesizing, interpreting, and reviewing data. Data-driven decision-making refers to basing decisions on data analysis rather than intuition. The section elaborates on data utilization in LMICs HMIS: globally, on the DHIS2 platform, and in the context of Rwanda. It also highlights the complexities and challenges associated with measuring data use for decision-making.

The chapter concludes by summarizing the findings from literature reviews

on strategies to strengthen HIS in LMICs. It discusses the different types of interventions and the challenges encountered. Enhancing data use and strengthening HISs require a multidisciplinary approach, engaging stakeholders, and promoting clear communication. Incremental steps, capacity-building, and supportive follow-up are essential to encourage data use and improve data quality. Standardizing decision-making processes while acknowledging local socio-political priorities ensures transparency, accountability, and community involvement. The review also highlights the fragmented nature of health information systems in developing countries and the need for better integration and standardization.

This chapter provides a comprehensive overview of related research on HMIS, data use, and data-driven decision-making. It sets the stage for further exploration of strategies to enhance data use practices and strengthen HMISs in LMICs.

Chapter 4

Theoretical Framework

This chapter opens by showcasing various frameworks that have attempted to address HIS strengthening in LMICs: the PRISM framework covering HMISs and the Health Metrics Network (HMN) addressing whole HISs. Together they build the foundation for a logic model by MEASURE Evaluation, the HISSM, and its supporting data use continuum model. While HMN and HISSM touch on the use of data in their own ways, the time and resources required to apply the frameworks go above the scope of this research. The PRISM framework could be a good fit as it has already seen use in similar contexts. However, a new framework could bring new perspectives to the findings and related literature. Instead, it was decided to refine the Theory of Effective Use (TEU), a theoretical framework that examines what effective system use involves and what drives it. The generalized framework is adapted into Rwanda's health administration situation context to position and analyze the fieldwork findings later.

4.1 Existing frameworks for addressing HIS performance

The PRISM framework

Aqil et al.Aqil et al., 2009 developed the PRISM framework to improve HMIS by emphasizing the three interrelated determinants of HMIS processes: technical, behavioral, and organizational. The assessment captures data quality and information use as performance outputs, leading to improved health system performance and health status. If done right, it can provide a comprehensive overview of the barriers impacting data use. The framework measures the extent to which data are employed in decision-making processes, conceptualized as whether HMIS information is discussed during meetings, whether decisions evolved from these discussions, and whether decisions are referred to upper management for action (Nutley and Reynolds, 2013). Implementing a complete PRISM framework

is a resource-intensive activity that requires sampling multiple units across facility, district, and central levels.

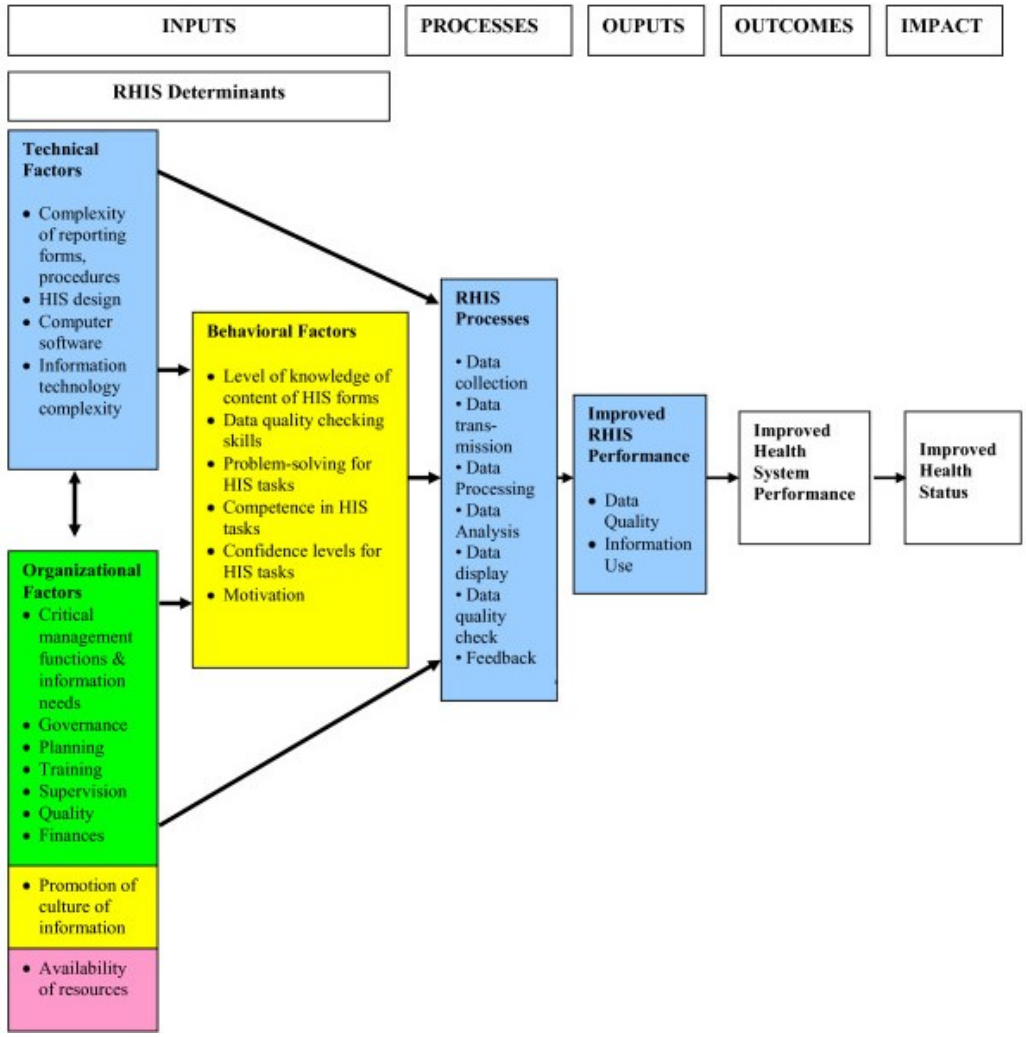


Figure 4.1: The PRISM framework (Hotchkiss et al., 2010)

The Health Metrics Network framework

The Health Metrics Network (HMN), established in 2005, has been instrumental in addressing the problem of fragmentation in health information systems through its technical framework (Network and WHO, 2008; WHO, 2007). The framework promotes a data warehouse approach to information system integration (Braa, 2005). It approaches the strengthening of the entire HIS, which among many other things, includes improving the use of data in decision-making. The framework lays out a standard for guiding the collection, reporting, and use of health information by all developing countries and global agencies. The goal is to increase the availability, accessibility, quality, and use of health information vital for decision-making at country and international levels.

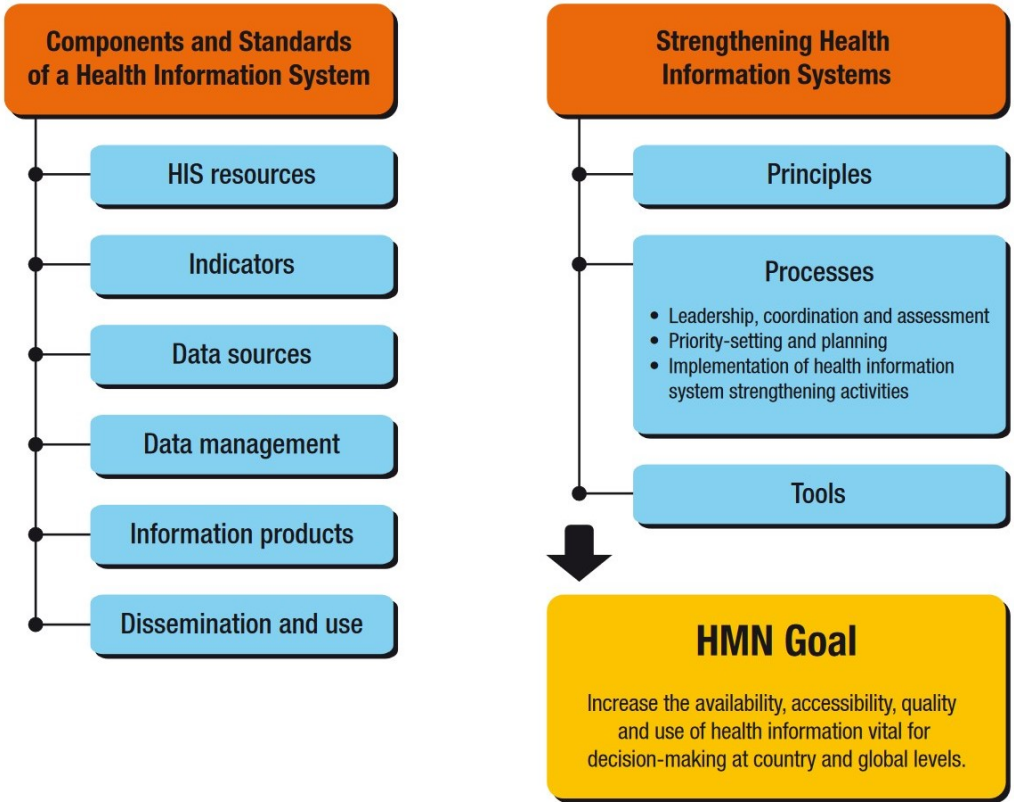


Figure 4.2: Components and standards of HIS strengthening in the HMN framework (Health Metrics Network and WHO, 2008)

HISSM and the data use continuum

Drawing on insights from previous models such as PRISM and HMN, MEASURE Evaluation developed the Health Information System Strengthening Model (HISSM). The HISSM has three main areas: the enabling environment (the foundation for planning, implementing, and maintaining the HIS); information generation (the collection, analysis, and dissemination of health information); and HIS performance (measurement of HIS performance such as data quality and data use) (Evaluation, 2019b). Since the HISSM encompasses a much broader range of topics than the data use practices relevant to this thesis, only the aspects relating to HIS performance will be expounded upon.

MEASURE Evaluation presents a data use continuum (Figure 4.3) as a part of the HISSM that covers HIS performance. It identifies the stages of data use for improving the functioning of the HIS and driving informed decision-making. It covers two objectives of data use: the use of data to improve the functioning of the HIS; and the use of data for improved health program performance. The second objective is particularly challenging to measure because its actual utilization is an aspect of other health system functions such as governance. Furthermore,

data may only sometimes inform decision-making due to factors beyond the health sector, such as political ideology and preference, culture, and competing priorities. The ultimate goal of the continuum is to improve the health system's functioning and health outcomes over time. It is an interactive and proactive process involving data producers and users utilized to review and interpret the products for program performance.

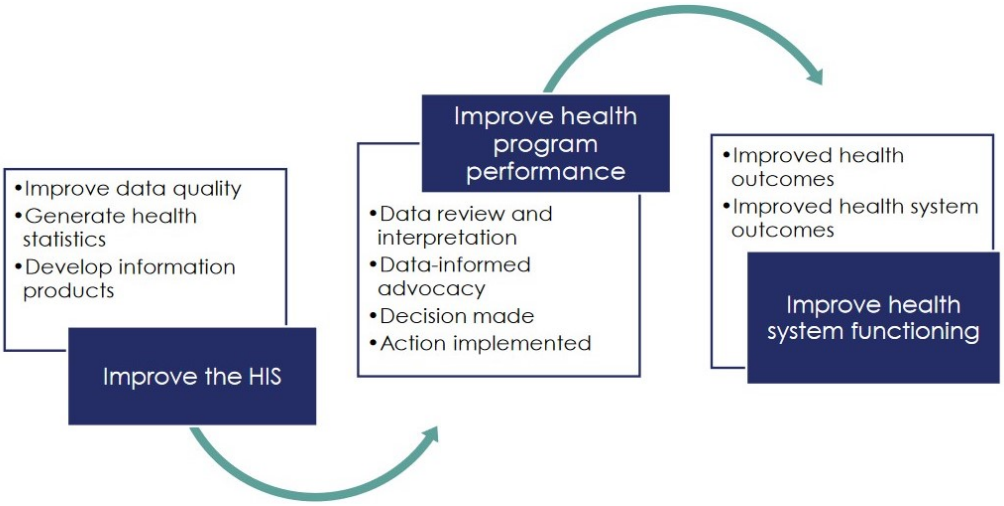


Figure 4.3: The data use continuum (MEASURE Evaluation, 2017)

The frameworks effectively model distinct approaches to enhancing the performance of HIS in LMICs. Unfortunately, the scope of the HMN and HISSM frameworks makes them unfit for addressing data use practices, as performance-strengthening efforts are only components of the entire framework. In a master thesis with limited time and resources available, the scope needs to be reduced drastically. Limiting the scope of the HISSM to the data use continuum would be appropriate, as it concentrates explicitly on improving HIS performance. However, a continuum is not fitting for a one-time case study. Continuums are ongoing processes that evolve gradually over time. Given that this research cannot monitor this process, the model is also unsuitable.

MEASURE Evaluation stated that PRISM is the only standardized tool that measures the full spectrum of the use of data to enhance decision-making (Nutley and Li, 2018). PRISM could be adapted for this thesis as its scope can be modified to fit, and its focus mirrors that of this research. It has already been applied in similar contexts (Hotchkiss et al., 2010; Hoxha et al., 2020). Nevertheless, it was decided to use a framework that has yet to be applied to the context. Introducing a new approach might add new perspectives to the findings and related literature. The Theory of Effective Use became the framework of choice.

4.2 The Theory of Effective Use

To examine data use practices and challenges in Rwanda HMIS, the Theory of Effective Use by Burton-Jones and Grange (2013) will be applied. Understanding the effective use of information systems is 'critically important' (Straub and Giudice, 2012), as system use alone is insufficient to meet organizational goals. According to Burton-Jones and Straub (2006), system use is defined as an activity involving a user, a system, and a task, with a task defined as a 'goal-directed activity.' Therefore, effective use at an individual level is defined as "using a system in a way that helps attain the goals for using the system" (Burton-Jones and Grange, 2013, p. 633). The TEU proposes two levels of effective use, focusing firstly on the nature of effective use and its impact on performance and secondly on drivers of effective use.

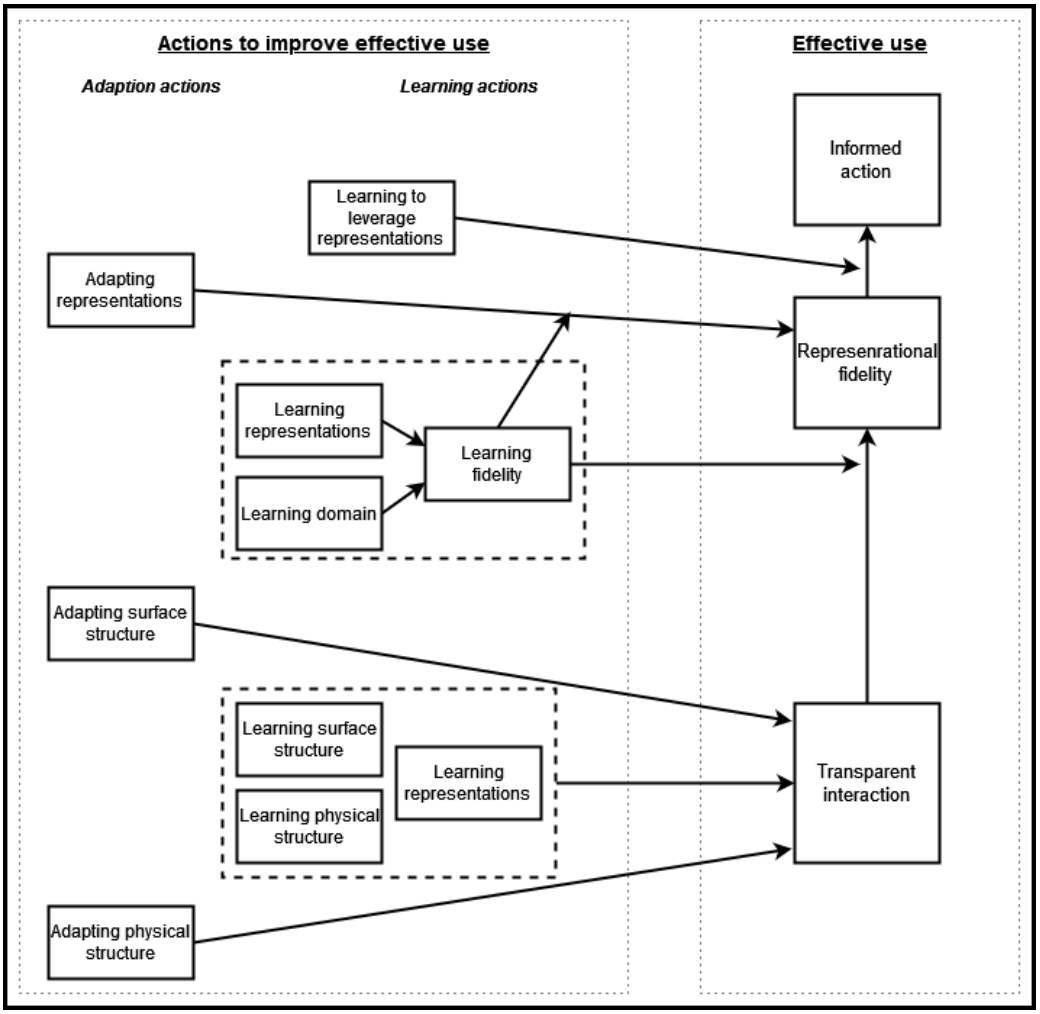


Figure 4.4: The simplified Theory of Effective Use

Figure 4.4 is a simplified depiction of the TEU framework. It presents transparent interaction, representational fidelity, and informed actions as the three dimen-

sions of effective use that impact performance. Adaption- and learning actions are identified as significant precursors, or drivers, of effective use.

In conceptualizing effective use, TEU drew upon representation theory (see: Wand and Weber, 1995, Wand and Weber, 1990). Representation theory proposes that an information system (IS) primarily aims to represent certain real-world phenomena faithfully (Recker et al., 2019). The IS should allow users to reason about the phenomena more cost-effectively than if observed directly. Representation theory has spawned a comprehensive program of research, primarily on the modeling of IS but also on other phenomena such as data quality, system alignment, security, and effective system use (Burton-Jones et al., 2017). The theory asserts that any information system consists of physical, surface, and deep structures. Surface structures refer to the facilities that allow users to access and interact with the representations, such as the user interface, including screens, menus, and report layouts. The physical structures are the machinery that supports other structures, such as input, output, storage, transportation, and computation devices. Deep structures represent the phenomenon that the system is designed to model.

The TEU defines the dimensions, or nature, of effective use as follows. *Transparent interaction* refers to "the extent to which a user is accessing the system's representations unimpeded by the system's surface and physical structures." (Burton-Jones and Grange, 2013, p. 642) When using a HMIS, an effective user can seamlessly access the HMIS's representations; for example, they can easily query and analyze the data they need. *Representational fidelity* refers to "the extent to which a user obtains representations from the system that faithfully reflects the domain being represented by its surface and physical structures." (2013, p. 642) When using the HMIS, an effective HMIS user can find that the system's content is sufficiently complete, clear, correct, and meaningful. *Informed action* refers to "the extent to which a user acts upon the faithful representations they obtain from the system to improve their state." (2013, p. 642) When an HMIS user obtains information from the system that faithfully presents a complete picture of the domain it describes, they can act upon it to make better organizational decisions. In short, transparent interaction activates the information potential of an IS, representational fidelity ensures that this potential is positive, and informed action leverages it.

The framework additionally defines the drivers of effective use. *Adaption actions* refer to any action a user takes to improve (1) a system's representation of the domain of interest; or (2) their access to them through a system's surface and physical structures (2013, p. 644). Users can conduct these actions in the system, i.e., by changing data or programs directly or sending change requests to their supervisors or the IT department. *Learning actions* refer to any action a user takes

to know: 1) the system with its representations, surface, or physical structure; 2) the domain it represents; 3) the extent to which it faithfully represents the domain (fidelity); or 4) how to leverage representations obtained from the system (how to engage in more informed actions) (2013, p. 644).

To summarize, the two levels of effective use focus firstly on nature, and secondly on drivers, of effective use. This paper draws on the constructs of the TEU to further understand the data use practices in Rwanda's HMIS. In the context of Rwanda HMIS, to what extent is data: available for the users, representing the health status and services, and used to make better decisions? How do adaption and learning actions influence the performance and decision-making processes in Rwanda HMIS?

Burton-Jones and Grange analysis suggests that users are more likely to take actions to improve effective use and performance when: (1) users are more knowledgeable, experienced, motivated, and supported; (2) systems and tasks are simple, flexible, familiar, and independent of other systems/tasks; and (3) users can take actions, and see their consequences, quickly (Burton-Jones and Grange, 2013). In addition, users are more likely to make informed decisions through adaption- and learning actions. They can improve access to representations and their fidelity by conducting adaptations. Learning the components of an IS can improve how well a person can access its representations through its other structures. The framework and its components prove central in understanding the data use practices in Rwanda and will be a principal tool for the analysis and discussion of this thesis. Discovering what effective use involves in this context is essential. In fact, it is among the most urgent inquiries in healthcare management.

4.2.1 Example applications and adaptations

The Theory of Effective Use has seen increased uptake over the last years. Burton-Jones and Volkoff (2017) conceptualized effective use to consist of the dimensions of accuracy, consistency, and reflection-in-action. Their paper offers an approach for developing context-specific theories of effective use, highlighting the value of a new, more IS-specific form of multilevel thinking. The paper proposes two underlying assumptions for effective use. First, effective use is measurable in some sense, from "ineffective" to "as effective as possible." Second, effective use helps attain desired outcomes but does not guarantee them. Effective use is one potential mechanism, but a desired result could occur without effective use through alternate mechanisms (Burton-Jones and Volkoff, 2017). Effective use simply increases the chance of attaining the outcome.

Eden, Fielt, and Murphy (2020) sought to understand how effective use can be operationalized and measured. Despite rigorous conceptualizations, they

found quantitative investigations of effective use largely lacking. The paper drew upon the primary research on effective use and refined a survey tool for measuring it. In the context of emergency management, Bonaretti and Piccoli (2019) conceptualized effective use to instead consist of the dimensions of promptness, currency, and responsiveness. Literature on Business Intelligence (BI), the process of collecting, analyzing, and presenting business information to support decision-making, is fragmented and lacks an overarching framework to integrate findings and systematically guide research. Trieu (2016) implemented a modified TEU approach and identified many opportunities for researchers to provide a complete picture of how organizations can and do obtain value from BI.

Surbakti et al. (2020) considered effective use in the context of big data. They saw a need for rigorous academic guidance on what factors enable the effective use of big data and performed a comprehensive literature review. The paper categorized the findings into seven themes: data quality; data privacy and security and governance; perceived organizational benefit; process management; people aspects; systems, tools, and technologies; and organizational aspects.

Further application of the global framework in diverse contexts is required to gain additional experience about its utility. This is because the factors that influence the use and demand for data are contingent on the specific needs and local contexts.

4.2.2 Adapting the Theory of Effective Use to the context of Rwanda HMIS

Burton-Jones and Grange (2013) proposed a model they argue could apply to any information system in any task. To position and analyze the fieldwork findings later, the generalized framework is adapted to the context of the health administration situation in Rwanda.

For the adaption, inspiration was taken from Burton-Jones and Volkoff's (2017) approach for developing context-specific theories of effective use. While this thesis focuses on the nature (transparent interaction, representational fidelity, and informed action) and drivers (adaption, learning) of effective use, Burton-Jones and Volkoff aimed to study accuracy, consistency, and reflection-in-action. However, their work still served as inspiration on how to adapt the constructs of effective use from generic to context-specific definitions.

The real-world context in this paper is routine data on health status and service provision in Rwanda's HMIS. The generalized definition of representation is that it is enabling in some sense, at the most general level, enabling users to act in the world (Weber, 2003, p. viii). In the context of Rwanda HMIS specifically, I

define representation as routine data on health services provided at clinics and hospitals. Table 4.1 provide the context-specific definitions for the constructs of effective use theory. This table will be revisited in Chapter 7, to position and analyze the fieldwork findings.

4.3 Chapter summary

This chapter provides an overview of frameworks developed to strengthen HIS in LMICs. These frameworks include the PRISM, Health Metrics Network, and HISSM models. While HMN and HISSM address data use in their own ways, they fall outside the scope of this thesis. PRISM could be a good fit, but it was decided to rather implement a framework that has yet to be applied to the context as it will add new perspectives to the findings and related literature. The Theory of Effective Use became the framework of choice, adapted to the context of data use practices in Rwanda's HMIS. The TEU framework examines what effective system use involves and what drives it. It presents transparent interaction, representational fidelity, and informed actions as the three dimensions of effective use that impact performance. Additionally, adaption- and learning actions are identified as significant drivers. The chapter provides examples of how research projects have applied and customized the TEU framework for various contexts.

Construct	Generalized definition	Context-specific definition for Rwanda HMIS
Transparent interaction	The extent to which a user is accessing the system's representations unimpeded by its surface and physical structures	To what extent users can access relevant health data
Representational fidelity	The extent to which a user is obtaining representations from the system that faithfully reflect the domain being represented	To what extent do the data in the HMIS systems represent the health status and services
Informed action	The extent to which a user acts upon the faithful representations they obtain from the system to improve their state	To what extent decisions are made based on the information obtained from the HMIS
Adaptation	Any action a user takes to improve a system's representation of the domain of interest, or their access to them, through a system's surface and physical structures	Any action a user takes to improve data use representation in the HMIS or the use of alternative solutions where the DHIS2 platform is not meeting their needs
Learning	Any action a user takes to learn the system (its representations, or its surface or physical structures), the domain it represents, the extent to which it faithfully represents the domain (i.e., its fidelity), or how to leverage representations obtained from the system (i.e., how to engage in more informed actions)	Any action a user takes to learn DHIS2, data use practices, the way DHIS2 faithfully represents data use practices, or how to engage in more informed actions

Table 4.1: Theory of Effective Use constructs: The generalized definitions versus context-specific definitions for Rwanda HMIS

Chapter 5

Research Approach

This chapter begins by outlining the philosophical foundations that provide the basis for the study. It then describes and rationalizes the chosen methodology, methods, and data collection and analysis techniques. The chapter concludes with reflections on the ethical considerations and methodological limitations surrounding the research. Overall, this chapter will provide a comprehensive understanding of the approach and considerations that inform the study.

5.1 Philosophical underpinning

This thesis utilizes interpretive methodology and methods based on the epistemological assumptions of the interpretive research paradigm (Walsham, 2006). According to interpretivism, "access to reality (given or socially constructed) is only through social constructions such as language, consciousness, shared meanings, and instruments" (Myers, 2008, p. 45). This approach aims to capture social and organizational phenomena and the subjective understandings of humans. Ontologically, interpretive research views reality as an "intersubjective construction of the shared human cognitive apparatus" (Walsham, 1995, p. 75), in contrast to positivist research, which views reality as objective and independent of human understanding. In summary, interpretivism asserts that researching social phenomena involves interpreting the meaning of other humans' interpretations through what they say and do (Myers, 2008).

Data collection for this thesis primarily involved conducting interviews, engaging in participant observations, and partaking in meetings or workshops. The process and methods have been guided by principles from the interpretive tradition, including sensitivity to participants and contexts, and acknowledging subjectivity in understanding the context and constructing knowledge (Klein and Myers, 1999). The resulting findings and subsequent analysis are mainly based

on the perspectives and interpretations of individuals and may not necessarily represent a universal view. This thesis presents my personal understanding of the subject matter, which may differ from that of other researchers.

The main drawbacks of interpretivism include its subjective nature and the potential for bias on the researcher's part. A central issue for researchers of the interpretive paradigm concerns the generalizability of the results. The researcher's viewpoint and values might heavily influence the data collected through qualitative methods. This can lead to questions about the reliability and representativeness of the data. However, this is only partially true. According to Walsham (1995), one can draw four types of generalization from a single study: the development of concepts, generation of theory, drawing of specific implications, and the contribution of rich insight. In addition, interpretive research offers great depth in studying qualitative research areas such as cross-cultural differences in organizations, ethical issues, leadership, and the factors that impact leadership. The data collected through interpretive methods can be considered highly valid as it is often perceived as trustworthy and honest.

5.2 Methodology

This research uses a qualitative case study methodology (Walsham, 1995). A case study can be explained as a bounded study of a phenomenon in its real-life context (Verne and Bratteteig, 2018). Case studies can be used in the exploratory phase of a research topic to discover relevant features, factors, or issues that might apply to similar situations (Myers, 2019). The researcher seeks to understand how and why a process or decision works the way it does. Instead of deliberately intervening in a situation like in action research, a case study seeks to describe it. However, the factors and issues uncovered can be used to implement changes later.

This thesis has looked closely at practices and challenges to data use in the HMIS of Rwanda. A case study is suitable to answer this question since it supports empirical investigation of a phenomenon in its real-life context. The study aims not to provide proof or debunk a hypothesis but to learn from the different stakeholders interacting with the system. The study's scope is the different kinds of users interacting with the HMIS system in Rwanda: community health workers, facility data managers, district specialists, and stakeholders on a national level. The data collection and analysis draw from multiple sources of evidence, triangulating these data and using a theoretical framework to guide the research.

5.3 Data collection

Data collection was conducted through fieldwork, with a team of three students spending four weeks in Rwanda. In preparation for the fieldwork, the group met with a HISP Rwanda employee in Norway, set up the trip, and read up on the literature. In addition, I completed three DHIS2 Academy courses for an upcoming data quality workshop: Introduction to DHIS2, Aggregate Data Analysis Fundamentals, and Data Quality Level 2 Academy.

In the first couple of days in Rwanda, we got introduced to HISP Rwanda and Rwanda MoH, establishing a foundation for the fieldwork. These meetings helped organize aspects of the stay and answered questions and uncertainties. Throughout the stay, we collaborated closely with HISP Rwanda and were provided with office space in their facilities to work from. They assisted in arranging interviews and accompanied us during the process. Most days were spent in and around the capital Kigali. In addition, there were expeditions to two other districts: Musanze and Bugesera. The week in Musanze consisted of a national bi-annual data quality review workshop and interviews at local hospitals and health centers. This included participant observation, allowing us to observe firsthand how different individuals and stakeholders (HISP Rwanda, Rwanda MoH, USAID, WHO, RBC) interacted with the platform and what challenges they faced. The fieldwork ended with a debrief at the HISP Rwanda offices, where we presented our findings and received final feedback.

Figure 5.1 highlights the main events of the stay. Days without scheduled arrangements or those that were postponed or canceled were spent working on the data already collected, such as transcribing interviews or further investigating findings.

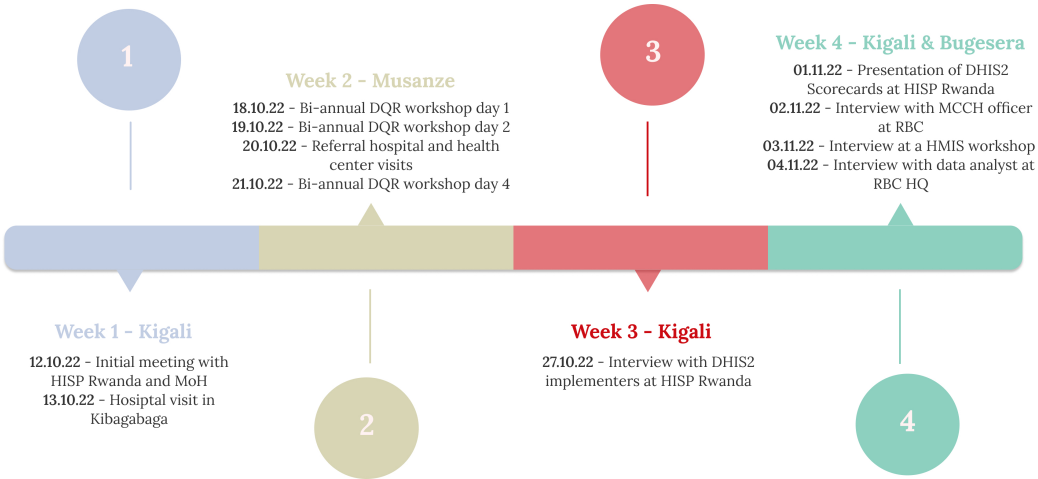


Figure 5.1: A timeline consisting of the main events from the fieldwork in Rwanda

(a) Introductory meeting with MoH

(b) DQR workshop

(c) Interview with a data manager

(d) DQR workshop

Figure 5.2: Examples of data gathering conducted during the fieldwork

We interacted with and interviewed several people working on national and facility levels. It could be problematic that discussions among locals were almost exclusively in the native tongue, Kinyarwanda. For the workshop in Musanze and during interviews, we were typically given verbal summaries of the conversations we did not understand. Informants would sometimes give short and lacking answers to us in English, clearly uncomfortable about how to express themselves. By letting interviewees discuss with our accompanies in their native tongue instead, it was easier for them to get their message through. Afterward, we were given summaries of the discussions and findings. This will naturally lead to a lack of details, and representativeness will suffer, but it was a worthy sacrifice.

The interviews were either semi-structured or unstructured in form, typically lasting between 45 minutes and 1.5 hours. As the initial focus of the fieldwork was less prevalent than expected, it was fitting to go in with an open mind and let the conversations flow more naturally. We prepared general topics to cover during the interview, and when topics of particular interest popped up, we let those conversations run their course. Consent to collect and use the data

for research purposes were given, and some interviews were recorded if the interviewees agreed to it. All interviews were conducted on-site, either at health facilities, in offices, or at workshops. A representative from HISP Rwanda or RBC always accompanied us for the interviews. The interview material was later processed by filling in notes, writing short summaries, or transcribing audio recordings.

In total, 12 interviews were conducted, detailed in Table 5.1. Informants during the fieldwork consisted of: HISP Rwanda staff, mainly their DHIS2 implementers; district hospital and health center staff, namely the data managers and the Head of Facility at the facilities; representatives from Rwanda MoH; and program specialists, managers, and data analysts from RBC. The goal was to cover all levels of the health system, from community health workers, health posts, health centers, district hospitals, and different stakeholders on a national level, but this did not come to fruition.

Informant role/position	Number of informants
Data manager at a district hospital	2
Head of Facility - health center	1
HISP Rwanda coordinator	1
HISP Rwanda implementer	3
HISP Rwanda software developer	1
MoH representative	2
RBC representative	1

Table 5.1: Interviews held during the fieldwork

Going into the fieldwork, the thesis focused on standardized WHO metadata packages made for DHIS2 (see Chapter 2.3), and not data use practices as a whole. After immediately realizing the packages were barely used, the research context was reconsidered. Instead of a narrow focus, I conducted an open data collection, accumulating as much information as possible on all forms of data use practices through DHIS2 or alternative platforms. If platforms other than DHIS2 were preferred, the reasons for how and why were noted. Although the metadata packages were no longer the main focus of the research, the findings still warranted inclusion in analysis and discussion.

5.4 Data analysis

The analysis was an ongoing process of reviewing literature and analyzing empirical data to shape the final contributions iteratively. The approach was based on thematic analysis, a flexible approach to analyzing qualitative data (Braun and Victoria Clarke, 2006). The first data analysis phase involved familiarizing, transcribing, and rewriting data collected during the fieldwork. The data com-

prised interview transcripts, field notes, observations, and meeting summaries. In addition, interviewees provided further documents such as Standard Operating Procedures (SOPs), empty patient registers, Excel reporting forms, and PowerPoint presentations. The online whiteboarding and collaboration tool FigJam[1] was used to generate initial codes and collate codes into potential themes. Over time it evolved into a thematic mind map that included different themes, challenges, and possible solutions.

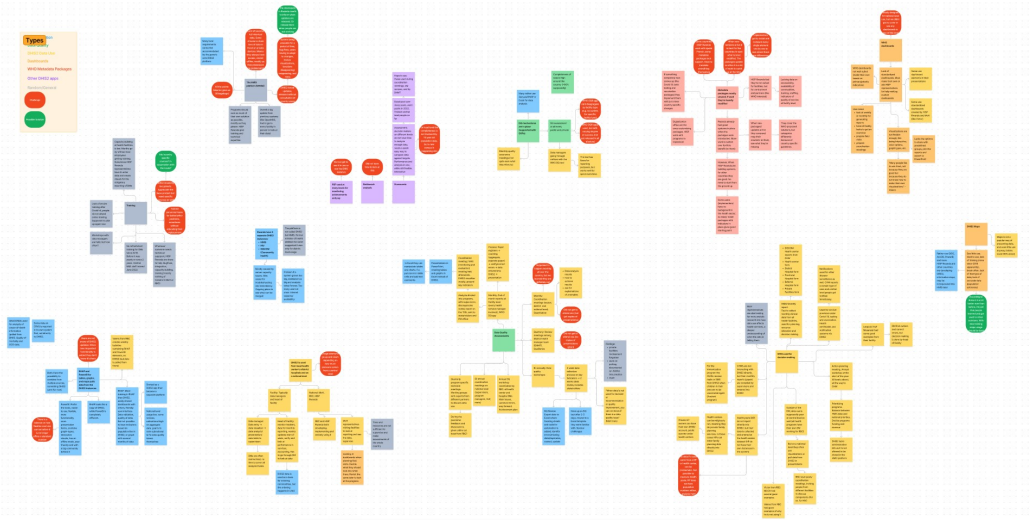


Figure 5.3: Mindmap with colors representing different topics (e.g., data use, data quality, fragmentation)

Discussing raw data, findings, and analysis with co-students throughout the research process was beneficial. By developing different representations of the findings and engaging others in reading and commenting, researchers stimulate the creative process and facilitate convergence toward a publishable and defensible outcome (Maxwell, 2012). Findings may be misinterpreted and used to support wrong theories, so it was advantageous to look at the same data with different sets of eyes that come to different conclusions. As a researcher, I have to accept that not everyone thinks and feels the same way I do and that I have an obligation in the analysis to acknowledge the multiple perspectives encountered (Miles et al., 2019).

Upon organizing all the findings and presenting them as a coherent text (see Chapter 6), I shared the result with colleagues at HISP UiO and an external HISP staff member based in Spain. These individuals were investigating information use and found several findings interesting. First, a digital meeting took place, followed by subsequent email correspondence, which initiated a discussion on the topics that captured the interest of HISP. This led to additional inquiries

[1]https://www.figma.com/figjam/

about the findings, and recommendations for future research in the domain. The information gathered reinforced the trends HISP had discovered in previous research, and consolidated their arguments for a conference in Athens they were scheduled to participate in. This process enabled me to acquire a new stance on the data by taking into account the perspectives of others, which is a crucial element in conducting interpretive research.

After the fieldwork, I also compiled a document for the core DHIS2 developer team containing the technical feedback provided by the informants. Although the analysis and discussion in this thesis primarily revolve around organizational, environmental, and behavioral factors, it would be unfortunate to disregard the valuable technical feedback. Thus, the feedback was shared with the core team for analysis and potential implementation of changes. This served as a gesture of giving back to the informants and the community, hoping it would contribute to positive improvements.

The final analysis phase involved categorizing and integrating the takeaways from the mindmap into the theoretical framework. Each point was carefully assigned to a corresponding construct, classified as a driver or a barrier. The subsequent discussion compared the analysis outcomes with the existing literature. Certain results aligned with the literature, while others presented new or contrasting perspectives.

5.5 Methodological limitations and ethical considerations

The study gave rise to several limitations and ethical considerations that affected data collection and interpretation of the empirical data. This section presents three areas in which ethical considerations have been made, along with examinations of the limitations associated with the selected research approach.

First, my role and biases as a researcher. The framing of this research is limited by my knowledge of the information systems field and doing interpretive research. It is crucial to reflect on how I may introduce bias and influence in the thesis through my status as a junior researcher. To begin with, there is my lack of experience, and the learning curve is steep. This affected how interviews and observations were conducted, or data analyzed. How well we introduced and presented ourselves to people we interacted with affected the quality of information we were given in return. When people understood our position as student researchers, the responses were more in line with the information we sought.

Additionally, researchers must be careful jumping into the data collection process with too many expectations of what to find. If one is actively looking for something, it will be found in one way or another. It is crucial to have an open mindset if the results are to be presentable and trustworthy. During the fieldwork, it quickly became apparent that the initial focus point for the research, WHO metadata packages, were barely used. This meant most presumptions going into the fieldwork were discarded, and approaching the research with an open mindset was more straightforward. It became a process of gathering all kinds of information on data use practices during the fieldwork, then conducting a selection process later, framing the most relevant data.

There is also a balance to be found regarding honesty and trust in believing what informants are telling us. It is important not to put words into someone's mouth, judge all alike, or base a statement from a single individual as the truth. As an example, multiple informants stated there were monthly coordination meetings taking place all across the country. We wanted to partake in a meeting to understand how they take place and what is discussed. After countless attempts to locate meetings (with good help from HISP Rwanda), we failed. Still, multiple informants assured us they occur almost every month, but matters of higher priority sometimes get in the way. Ultimately, we must take their word for it and assume meetings are occurring.

Secondly, relationships with the participants. Despite the participants' helpfulness and willingness to devote a considerable amount of time to us, it is crucial not to consume an excessive amount of their valuable time. Throughout the stay, it was clear most participants had hectic schedules, and spending an hour with us would mean working an additional hour that day. As J.A. Maxwell put it: 'conducting qualitative research with human participants is always, to a certain extent, an intrusion into their lives' (2012). We tried to keep things short when conducting interviews in health facilities or working with HISP representatives.

It is essential to reflect on how the study contributes significantly to a domain broader than one's funding, publication, and career (Miles et al., 2019). The contributions of this paper should help Rwanda further improve its already well-established HMIS practices by identifying the factors driving or hindering effective data use. In addition to the data relevant to this paper, I combined participants' feedback for the core developer team and shared it with them. The goal was to give the participants more in return for their generosity. As students, we may not be responsible for implementing changes, but we can provide feedback to the relevant parties to ensure that the participants' time was not spent in vain.

There were always representatives from HISP Rwanda or RBC by our side

when conducting interviews. The interviews and meetings where high-ranking representatives were present seemed more formal, and participants seemed more reserved in their responses. Understandably, most staff would not be willing to point out negative things about their work or criticize the DHIS2 platform when the people behind it are present. On the other hand, HISP Rwanda seemed to have a casual, friendly tone with most of the people interviewed. This led to less formal conversations, where informants seemed comfortable speaking their minds.

Lastly, caution must be exercised while working within the health sector. The field consists of considerable amounts of personal data, any information relating to an identified or identifiable natural person (Schulz, 2022), and sensitive data, a set of special categories that must be treated with extra security (racial or ethnic origin, religious beliefs, biometric data, etc.). The harm or risk of this type of data ending up in the hands of bad actors or being presented without consent is to be taken very seriously. Privacy, confidentiality, and anonymity are all key terms.

No informants will be mentioned by name or in ways they can be easily recognized. Pictures containing individuals who have not provided consent will undergo blurring. Tables or graphs showing potentially confidential data will be blurred. Before the data collection process began, a notification form for personal data was filled out for NSD, the Norwegian center for research data. Interviewees filled out a consent form.

The intent of this research has never been to collect, store, or present personal or sensitive data. During the fieldwork, people had varying degrees of concern regarding confidentiality. Some willingly shared dashboards, data analysis, presentations, or reporting forms. These did not contain personal or sensitive data of any kind. If any of this material was included in the paper, identifiable information such as facility names was blurred. Other participants were clear they did not want to share with us data of any kind. As researchers, we got to respect both stands. If we stumble upon sensitive data, we mustn't use, save, or share that kind of data anywhere.

5.6 Chapter summary

This chapter provides the philosophical foundation, methodology, and ethical considerations that have informed the study. It begins by outlining the philosophical underpinnings guiding the research: the advantages and drawbacks of working within the interpretive research paradigm. The choice of case study as methodology and the data collection methods involved are justified: interviews, observations, and participating in meetings or workshops. Data analysis con-

sisted of multiple stages, from transcribing and writing up data collected through the fieldwork, categorizing the data in a mindmap, sharing the findings with other researchers, and placing the findings in a theoretical framework. The chapter concludes with a reflection on the limitations of the chosen methodology and the ethical considerations surrounding the study. In particular, the role and biases of a researcher, the relationship with participants, and the importance of treading carefully working within the health sector. Overall, this chapter provides a comprehensive understanding of the approach and considerations that inform the study.

Chapter 6

Findings

The purpose of this chapter is to present the findings of the fieldwork, first by presenting data use and decision-making practices at each health level, then the challenges faced. DHIS2 is used by community health workers, local health centers, district hospitals, and nationally for reporting, analysis, meetings, and more. Three primary forms of challenges were identified, and these were 1) Fragmentation, there are multiple alternative solutions to DHIS2 being used in several cases; 2) A general lack of capacity building, which constrains the users' ability to make effective use of the platform; 3) The lack of WHO metadata packages and standardized dashboards. The findings provided in this chapter will be analyzed in Chapter 7.

6.1 Practices of data use

DHIS2 is used to some degree at all levels of the health system in Rwanda, from CHWs in remote locations to ministries on a national level. Regarding DHIS2 platform use, the district hospitals and health centers operate similarly and are therefore collectively referred to as 'facility level' in this thesis.

6.1.1 National level

On a national level, several entities interact with the system: Rwanda MoH, HISP Rwanda, Rwanda Biomedical Center (RBC), and other government factions. HISP Rwanda and RBC develop, implement, and actively use the platform. In addition, stakeholders like the Global Fund and WHO monitor routine data. The MoH continuously oversees the various programs and bases its supervision on the data gathered. A typical use case is looking at the reporting from a facility when planning a field visit. The MoH representatives or other supervisors will review the dashboards and decide which topics deserve a closer look during

the next facility visit. They will revisit the same dashboards later to review the progress since the last visit. Time and resources are insufficient to supervise and assess all facilities nationwide, but this way of handling outliers through the dashboards is a good compromise. One MoH representative notes:

> *Before, we would go on field visits without knowing what the problems were in the health facility. Now we know the biggest problems beforehand and can look at the overall situation before the visit. We go on the visits with analyzed information. This allows the identification of problems and the discussion of solutions.*

The platform is used for advocacy (public support or recommendation for a particular cause) and policy development. A massive action planning meeting is held at the beginning of each year. This workshop has participants from all levels of the health system in attendance. The goal is to determine how to prioritize the funding and revenue of the various health programs for the upcoming year. Decisions are based on both HMIS data and national priorities from the ministries. With the exception of administrative information, which is prohibited from being stored on the DHIS2 platform, most data-driven decisions rely on information extracted from the platform. The MoH is also looking for more analytic research into how data use affects health services to understand better what the data tells them.

All the health programs have a data manager working for RBC. Routine data is used for decision-making through bi-annual coordination meetings held by RBC. Representatives from different facilities are invited to discuss the data and indicators from programs like HIV or Maternal, Child, and Community Health (MCCH). A diverse range of individuals, including supervisors, program managers, heads of facilities, and more, are in attendance.

RBC data managers also host quarterly program-specific presentations called technical meetings. These are common across all programs. The meetings consist of technical working groups, gathering experts from various stakeholders to discuss data use. Figure 6.1 is a slide from an RBC presentation on community-based maternal & newborn health across all districts. The graph illustrates how many home deliveries were accompanied by postnatal care (PNC), the care given to the mother and her newborn baby immediately after birth, and for the first six weeks of life. PNC should, in reality, never exceed 100% coverage, which explains why all districts with over 100% coverage are marked in red. Districts exceeding 100% are asked to explain these numbers. On the other side of the scale, the districts with the lowest PNC provision might also have to elaborate on the poor performance.

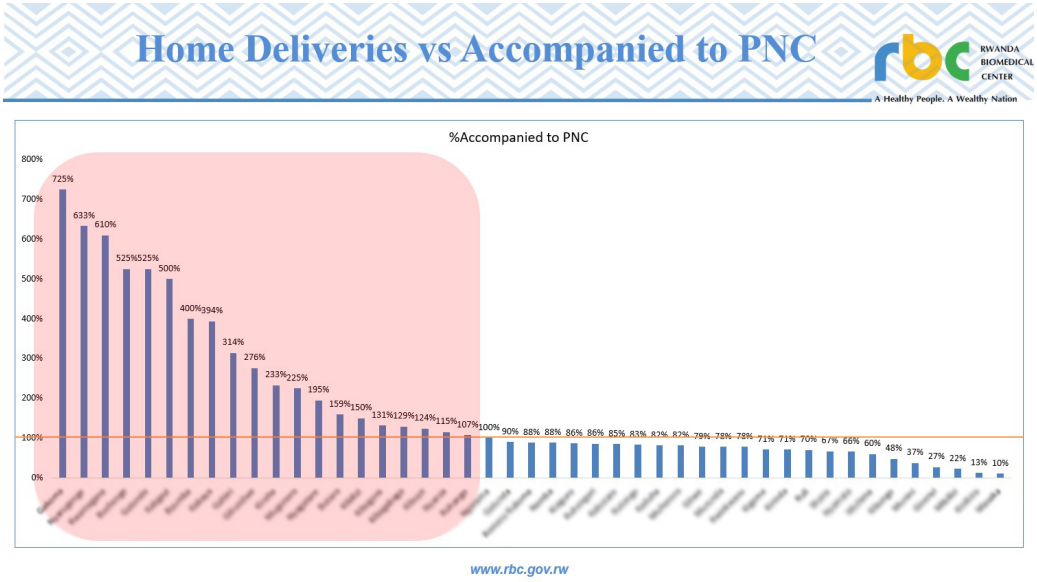


Figure 6.1: Percentage of home deliveries accompanied by PNC (RBC presentation on community health)

When asked how DHIS2 helped their decision-making, one RBC data manager replied: "I want to promote data use culture first and foremost." The person highlighted the dashboards and presented three cases in which interventions were based on routine data:

- Some facilities had been experiencing a decline in vaccine reporting, evident from the lack of data entry in the databases. In response, the data manager contacted the facilities to inquire about the reasons behind this decline. After discussions, it became apparent that the decline could be attributed to forgetfulness, delays, typographical errors, or stockouts. In the event of a stockout, immediate conversations would be initiated with relevant stakeholders to rectify the situation, restore normal operations, and replenish the stock.
- The dashboards provide insights into the treatment of various diseases by health workers, and a specific type of infection drew the attention of the data manager. In the middle of 2022, the data manager examined the corresponding dashboard and observed a consistent downward trend in reporting. Determined to identify the underlying cause, they collaborated with the MoH to intensify their efforts and advocate for improvement in this activity. Additionally, a review of the supply chain was conducted. These measures proved effective, as the reporting trend has progressively increased.
- As previously mentioned, dashboards serve as valuable tools for preparing

for field visits. During these visits, the primary emphasis lies in examining key topics based on reported data, mainly on trends. In the subsequent follow-up meeting after the field visit, the data manager at RBC prefers to revisit the same tables and graphs to analyze any changes that have occurred, whether they are positive, nonexistent, or potentially even worse than before. The same practice is extended to coordination meetings.

The DHIS2 Scorecards have proven to be as valuable as dashboards in providing facility feedback and as a useful preparation tool for field visits or meetings. The scorecard app is a performance monitoring tool that allows users to track the comparative performance of indicators over time and against different organization units or levels. With easy-to-use color-coded outputs (traffic light principle), the scorecard allows users to make data-driven decisions using the performance outlined via the scorecard app's outputs[1]. The solution has been developed as a collaboration between Rwanda, Uganda, and Tanzania, having its public release in 2022. The assessment was that decision-makers on several levels did not have time to analyze enough data and needed a quick and easy way to compare data against targets. Scorecards offered both performance and analysis in one while still being flexible.

The solution is decentralized and integrated into the routine supervision of health facilities. Figures 6.2, 6.3, and 6.4 illustrate a typical use case. Figure 6.2 presents the performance of the five regions of Rwanda. Kigali City has noticeably lower coverage than the other regions, as the yellow and blue (invalid data) cards indicate. A user can then click on that region to see how each district holds up, as seen in figure 6.3. Users can delve deeper by clicking on a district, presenting data from each health facility. Figure 6.4 showcases multiple anomalies and shortcomings regarding the reporting within that district. There is a complete lack of reporting from one facility, a few with low coverage, and invalid data in many others (grey and blue colors). Supervisors can approach these facilities to locate the root causes based on these quick observations. Some might have forgotten to report, some must be told to improve their efforts, while others need updated denominator data to achieve valid results. Ten years have passed since the last population census, so the denominators are not representative. Fortunately, a new census is being conducted in 2022, and updated population figures will soon be available.

It should be noted that scorecard data is most accurate nationally. The further down the hierarchy one operates, the less reliable the data. Population estimates are hard to calculate on lower levels, and the current estimates are based on annual growth rates from the 10-year-old census. The national statistical office provides the projections based on assumptions about fertility, mortality, and

[1]https://apps.dhis2.org/app/6e3af2e6-6dac-49b8-baa1-40019a684252

migration, and a constant population growth rate for all years is used (Maïga et al., 2019). Projections can deviate substantially from reality, especially in areas of significant migration. These regions will struggle to reach their goals if people emigrate in large numbers. On the other hand, if more people are moving into a region, coverage may exceed 100%. Thus, scorecard data is more precise at the national than district or facility levels.

HISP Rwanda envisions using scorecards during coordination meetings, data quality reviews, and by the District Health Management Team. Comprising individuals with diverse backgrounds and capabilities, this team meets every quarter and is tasked with planning, monitoring, and coordinating district health activities. HISP Rwanda is actively exploring implementation strategies for introducing the system in the countries they provide support to as well. In Rwanda, all districts are trained on using the tool to enhance data-driven decision-making further. It has improved data quality, increased frequency and regularity of reporting performance data, and service delivery improvements. An example of this is family planning:

> *The scorecard identified multiple districts in red, and after review meetings and bottleneck analysis, a new approach was implemented in districts with low coverage. Instead of delivering family planning only through health facilities, people (CHWs) went door to door to mobilize the population, provide services, and refer clients to health facilities.*

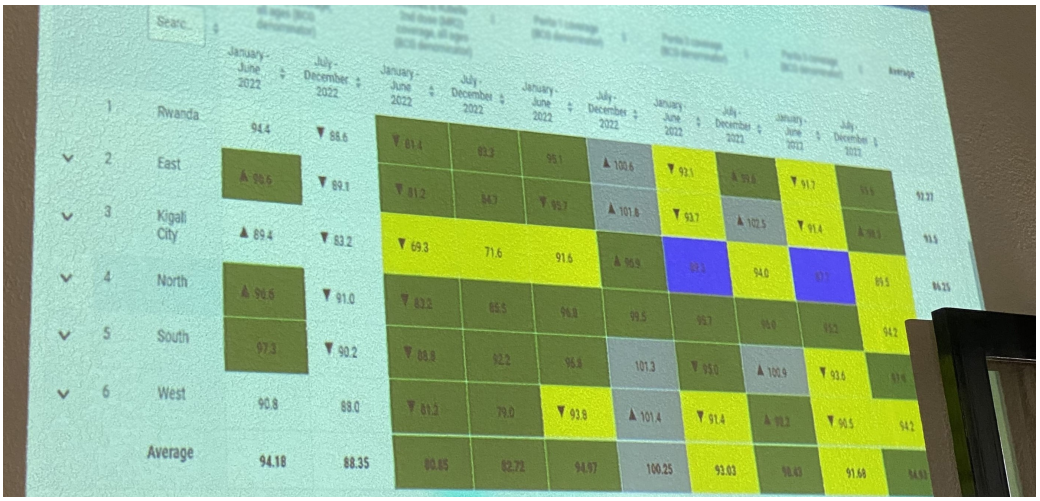


Figure 6.2: Scorecard showcasing the reporting of all regions

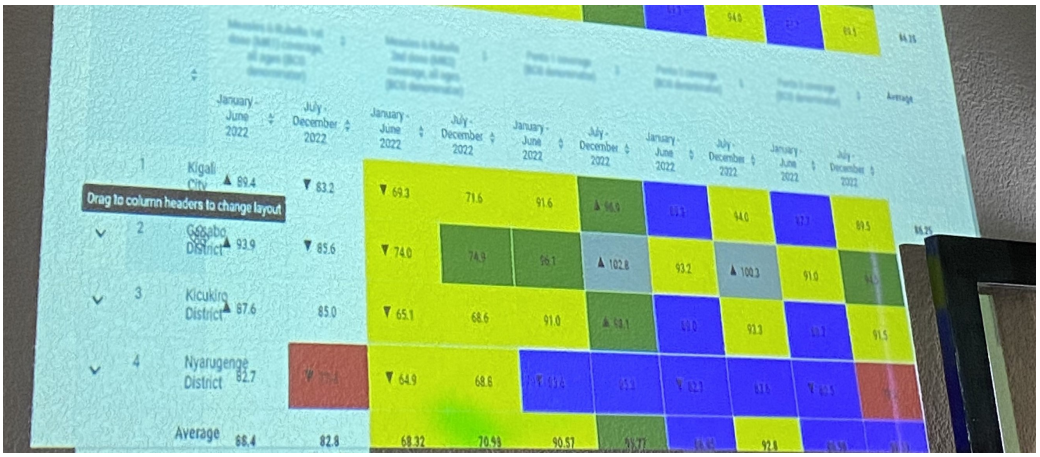


Figure 6.3: Scorecard showcasing the reporting of districts in a region

Figure 6.4: Scorecard showcasing the reporting of facilities in a district

6.1.2 Facility level

In health centers and district hospitals, data managers interact directly with the platform through data entry, generating visualizations, observing dashboards, performing data analysis, and creating reports or presentations for their facility, supervisors, or the ministry. CHWs deliver paper-based monthly summaries that data managers enter into the database. Subsequently, data managers create visualizations, perform data analysis, create presentations, and report the data to their supervisors. These tasks require a significant amount of time, and several sources indicated that data managers are overwhelmed and unable to adequately fulfill their assigned responsibilities. Certain facilities have alleviated the workload by assigning multiple staff to divide the burden, while others have only one person handling the entire workload.

The Head of the Facility can also be an avid platform user. Use cases range from monitoring trackers, verifying and looking at service performance, accounting, or getting daily, weekly, or monthly updates on facility services. While data managers are the ones locating outliers and correcting errors, the decision-making is performed by the Head of the Facility. They typically have to go through the data manager to gain access to specific data. One Head of the Facility told us they liked to begin every week by getting an overview of the previous week's registered disease and treatment numbers. This way, they had an idea of the current trends for morbidity, service delivery, and health facility resources.

Possibly the most central use case for DHIS2 at the facility level are the monthly HMIS reports, a tool to collect monthly clinical data from all programs and for planning, resource allocation, and decision-making. These forms come in many configurations: private facility-, referral hospital-, provincial hospital-, district hospital-, and health center forms. In addition, there are health center reports from CHWs for the SISCOM instance (explained further in subsection 6.2.1). Routine health data forms the basis for monthly coordination meetings, in which key indicators are presented and discussed. During these meetings, the results of data analysis are presented, discussions take place to explore strategies for achieving goals, and individuals responsible for specific data anomalies are asked to provide explanations. Monthly coordination meetings are supposed to be held at all facilities, but it has been observed that this is not always the case. Despite making efforts to attend a coordination meeting, no such arrangements were found to be taking place.

Health data were used to adapt approaches and strategies for service delivery. For example, a review of data from a DHIS2 dashboard identified poor performance on immunization-related indicators at a health center. This prompted follow-up analysis and interpretation of the data during a supervision visit, in-

dicating that the number of vaccination sessions conducted each month was insufficient to reach targets. Based on the recommendations from the supervisors, a decision was made to increase the number of vaccination sessions at the health facility. DHIS2 data is also used as a base for ordering commodities to facilities, but the ordering happens in a separate platform.

6.1.3 Health posts

Like health centers, health posts should conduct an active monthly data review and validation meeting and deliver monthly reports to the central level. Health posts do generally not report directly into DHIS2, but their data is collected and entered at their related health center data set. Health posts are thus not individually represented in the HMIS. This means there is no way of knowing if a case or outpatient came from a health post or the health center it is connected to. Some health centers have asked for separate accounts for each health post, allowing them to analyze posts separately. However, this is hard to manage in practice, as denominators required for analysis are absent at the health post level. Health posts do not have specific target population numbers for their area of operations, so it is impossible to produce an accurate analysis.

Although most health posts do not report data directly into DHIS2, some exceptions exist. While public health posts report under health centers, privately owned facilities can operate DHIS2 accounts. Health posts located near health centers managed by faith-based organizations may also report their data directly. Various religious beliefs run health centers that do not provide family planning services. Consequently, family planning data are not reported to the HMIS in those areas. As such, health posts near these facilities are allowed DHIS2 accounts to enter family planning data. That is typically the sole reason health posts exist near health centers. The typical use case for health posts is to serve as outreach for health centers in the country's most remote areas.

6.1.4 Community health workers

Community health workers are typically not interacting directly with the platform. However, their monthly paper-based reports are compiled by health center supervisors, then entered into the databases in collaboration with the data manager. This report is a standardized document offered in both Kinyarwanda and English. Parts of it can be seen in figure 6.5.

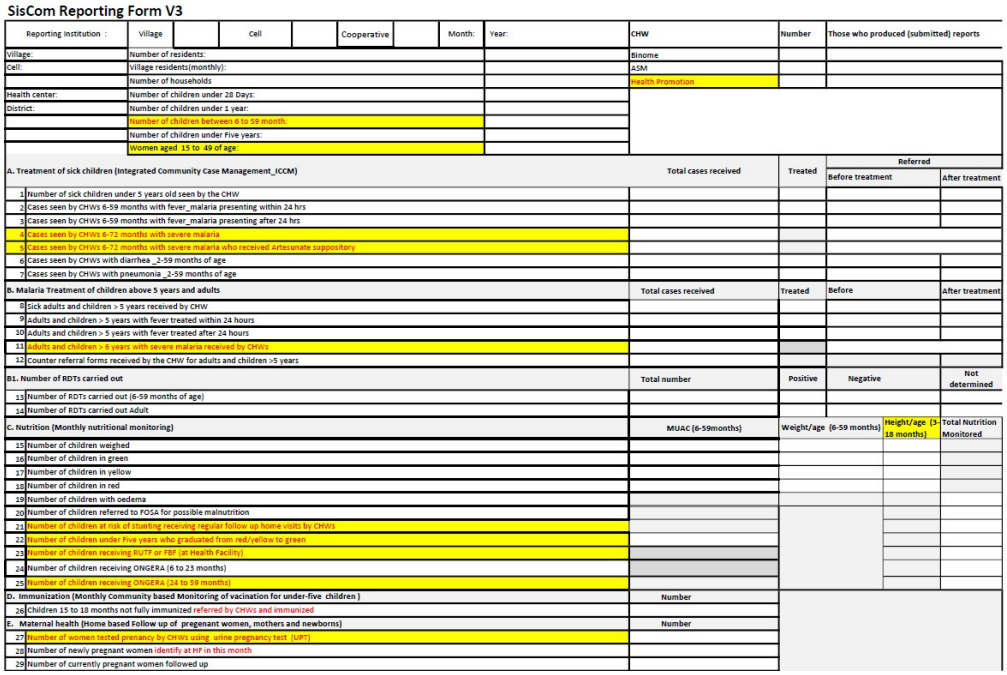
DHIS2 was used for service provision during the COVID-19 pandemic. Rwanda used tablet- and mobile devices for the COVID-19 sample collection, reception, and results distribution, an entirely paperless process from start to finish. The tablets used the Android Capture App and were distributed nationwide to

sample collectors, quarantine sites, drive-through testing centers, and health facilities. Once the tests were processed, results were automatically delivered by DHIS2 via SMS. Health certificates for vaccination and testing were also distributed through DHIS2.

As a side note, we had the opportunity to experience the system personally. Negative COVID-19 test results were required before a trip. Upon registration at the reception desk at a health center, we provided our phone numbers. Within 20-30 minutes the test results came through via SMS. The messages were sent by the Rwanda Biomedical Centre (RBC) in both Kinyarwanda and English.

An instance of upward reporting by CHWs is the community-based surveillance system through DHIS2. CHWs are empowered to send alerts to the system for early warning/notification of potential disease outbreaks. When a health worker enters a specific type of case, such as a suspected case of Ebola, instant notifications are transmitted to the central-level staff. Within minutes, a response team can be mobilized, initiating further investigations. This highly efficient system caters to both public and private healthcare facilities. Additionally, efforts are underway to expand the scope of outbreak detection to encompass all case-based diseases, as well as seasonal and non-seasonal illnesses.

The notification system can also be used the other way around, where higher levels notify health workers of urgent matters. For the immunization tracker, CHWs receive an email or SMS when children in their assigned area are due for a follow-up on their vaccination schedule. Upon receiving the notifications, the CHWs can contact the respective families and ensure the children receive the necessary vaccines. For the tuberculosis program, indicators measure the activities the health workers have reported. For instance, one indicator could be the number of health workers involved in assisting individual TB cases. This data is utilized by the central level to make informed decisions regarding resource management, ensuring that resources are allocated effectively and efficiently to address the tuberculosis program's needs.



SisCom Reporting Form V3

Reporting institution :	Village		Cell		Cooperative		Month:	Year:	CHW	Number	Those who produced (submitted) reports
Village:	Number of residents:								Binome		
Cell:	Village residents(monthly):								ASM		
	Number of households								Health Promotion		
Health center:	Number of children under 28 Days:										
District:	Number of children under 1 year:										
	Number of children between 6 to 59 month:										
	Number of children under Five years:										
	Women aged 15 to 49 of age:										

	A. Treatment of sick children (Integrated Community Case Management_ICCM)	Total cases received	Treated	Referred	
				Before treatment	After treatment
1	Number of sick children under 5 years old seen by the CHW				
2	Cases seen by CHWs 6-59 months with fever_malaria presenting within 24 hrs				
3	Cases seen by CHWs 6-59 months with fever_malaria presenting after 24 hrs				
4	Cases seen by CHWs 6-72 months with severe malaria				
5	Cases seen by CHWs 6-72 months with severe malaria who received Artesunate suppository				
6	Cases seen by CHWs with diarrhea _2-59 months of age				
7	Cases seen by CHWs with pneumonia _2-59 months of age				

	B. Malaria Treatment of children above 5 years and adults	Total cases received	Treated	Before	After treatment
8	Sick adults and children > 5 years received by CHW				
9	Adults and children > 5 years with fever treated within 24 hours				
10	Adults and children > 5 years with fever treated after 24 hours				
11	Adults and children > 6 years with severe malaria received by CHWs				
12	Counter referral forms received by the CHW for adults and children >5 years				

	B1. Number of RDTs carried out	Total number	Positive	Negative	Not determined
13	Number of RDTs carried out (6-59 months of age)				
14	Number of RDTs carried out Adult				

	C. Nutrition (Monthly nutritional monitoring)	MUAC (6-59months)	Weight/age (6-59 months)	Height/age (3-18 months)	Total Nutrition Monitored
15	Number of children weighed				
16	Number of children in green				
17	Number of children in yellow				
18	Number of children in red				
19	Number of children with oedema				
20	Number of children referred to POSA for possible malnutrition				
21	Number of children at risk of stunting receiving regular follow up home visits by CHWs				
22	Number of children under Five years who graduated from red/yellow to green				
23	Number of children receiving RUTF or FBF (at Health Facility)				
24	Number of children receiving ONGERA (6 to 23 months)				
25	Number of children receiving ONGERA (24 to 59 months)				

	D. Immunization (Monthly Community based Monitoring of vacination for under-five children)	Number
26	Children 15 to 18 months not fully immunized referred by CHWs and immunized	

	E. Maternal health (Home based Follow up of pregenant women, mothers and newborns)	Number
27	Number of women tested prenancy by CHWs using urine pregnancy test (UPT)	
28	Number of newly pregnant women identify at HF in this month	
29	Number of currently pregnant women followed up	

Figure 6.5: Parts of the monthly reporting form for community health workers

6.2 Challenges regarding data use

6.2.1 Fragmentation

Throughout the fieldwork, multiple instances of fragmentation were identified, wherein alternative solutions were favored over the capabilities provided by DHIS2. This subsection will highlight isolated DHIS2 implementations, the DHIS2 clone RHAP, Microsoft Power BI for visualizations, and several alternatives to DHIS2 maps.

Rwanda has three isolated implementations of health datasets

Rwanda has three isolated DHIS2 implementations in operation: HMIS, HIV, and SISCOM. The HMIS collects data on service provision from health centers, district hospitals, and referrals. A separate DHIS2 instance is dedicated to service provision related to HIV. The système d'information sanitaire des communautés, or SISCOM, is the CHW information system. It collects, stores, retrieves, and disseminates critical community-level information affiliated with care and treatment.

The main reason for platform fragmentation was the saturation of server capacity. New programs would be allocated dedicated servers to accommodate additional data and resolve space constraints effectively. Introducing further

packages would exceed the original servers' capacity, necessitating even more dedicated servers. This pattern continued as new packages were introduced. This operational approach facilitated easier troubleshooting, as any issues or breakdowns in one instance would not impact the functioning of the others. Initially, this system worked seamlessly, but managing multiple distinct systems became increasingly challenging and burdensome over time.

The HMIS serves as a facility registry; other systems (even outside DHIS2) retrieves information from it. The HMIS contains so much data that there were ten separate instances of it operating concurrently, in which users from separate health programs use distinct instances. Additionally, there are separate DHIS2 instances for PBF and IDSR (Integrated Disease Surveillance and Response).

There was an ongoing plan to evaluate the feasibility of merging the separated systems. The merging process considered factors such as the number of users and data points across the systems. The concern was that data analysis would become time-consuming if the database grew significantly and the number of users within a single system increased substantially. Retrieving and analyzing data could take minutes or even hours, mainly due to many facilities' poor or unstable internet connections. DHIS2 version 2.39 was to be released after the fieldwork was conducted, introducing a new API for data exchange HISP Rwanda intended to explore further when it arrived.

RHAP - A DHIS2 clone

We first stumbled upon this DHIS2-lookalike at our first interview with a data manager. They said a software called RHAP was preferred for data analysis over DHIS2, and it was revealed throughout the fieldwork that they were not alone in that sentiment. The Rwanda Health Analytics Platform (RHAP) is a rapid data integration and advanced analytics platform developed by Zenysis Technologies alongside RBC. Zenysis is a big data and artificial intelligence startup that helps countries improve health programs by building a platform that can integrate data from any number of fragmented systems, with the end goal of improving decision making[2]. The platform enables data triangulation, processing, and visualization of fragmented data. It resolves critical differences in datasets by harmonizing location naming, data collection cadence, indicators, names, and more.

[2]https://www.theglobalfund.org/en/private-ngo-partners/delivery-innovation/zenysis-technologies/

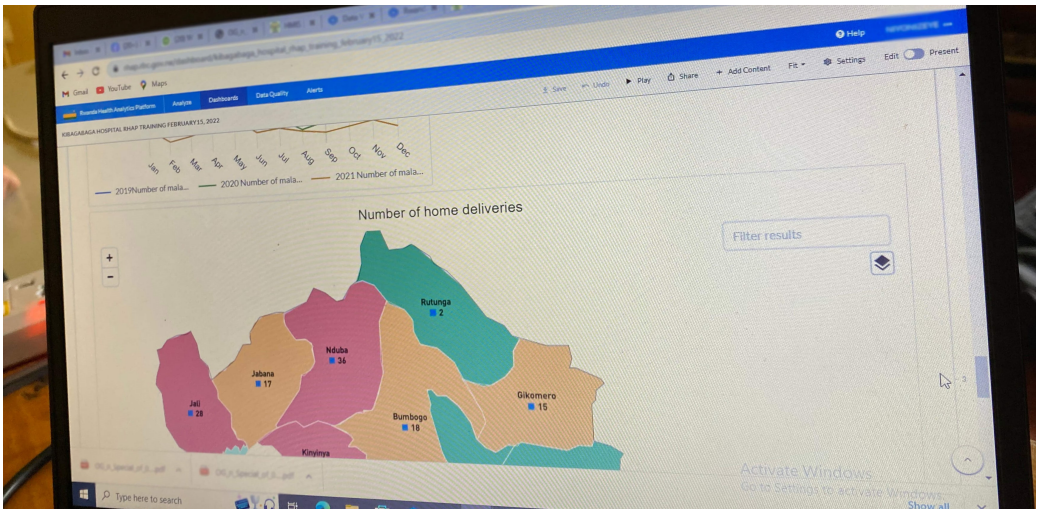


Figure 6.6: RHAP dashboard

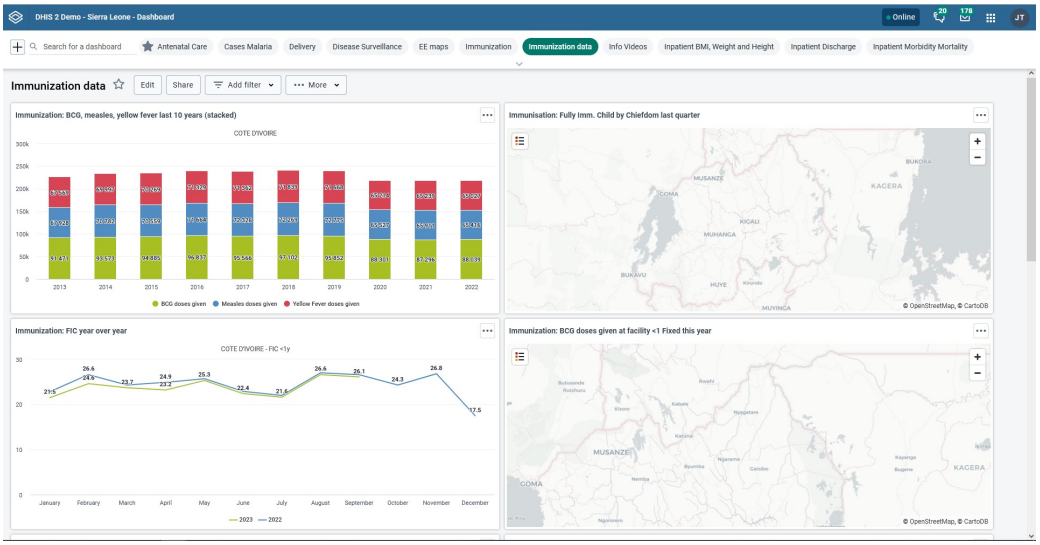


Figure 6.7: DHIS2 dashboard

The goal of RHAP was to integrate data from multiple fragmented HISs into a single unified platform for holistic analysis. It solved the issues of Rwanda HISs being divided between separate instances and that DHIS2 analysis tools could only pull data from a single instance. With RHAP, users could combine data from multiple instances, even outside of DHIS2, but thus far, there were no other big platforms they pulled data from. The current database is extracted from the DHIS2 HMIS. RHAP started in 2018 as a custom application in DHIS2, then became a separate platform. Zenysis began to provide training in 2021, and the platform got its nationwide rollout in 2022. According to the 2022 Health Research and Policy Symposium[3]:

[3]https://rbc.gov.rw/abstract/book/mobile/index.html#p=11

> *By April 2022, over 85 staff from central and district levels across the country were actively using RHAP, performing side-by-side, triangulated analysis and data visualization allowing them to improve data quality, strengthen data analysis, and guide data-driven decision-making.*

A brief glimpse into the platform revealed a design that closely resembled DHIS2 in appearance, bordering on being a clear copy. As figures 6.6 and 6.7 illustrate, the layout, colors, and visualizations look similar. HISP Rwanda staff said Zenysis had not informed its users that data is pulled from DHIS2. They believed this knowledge would incentivize users to revert to using DHIS2 again.

Microsoft Power BI - Visualizations

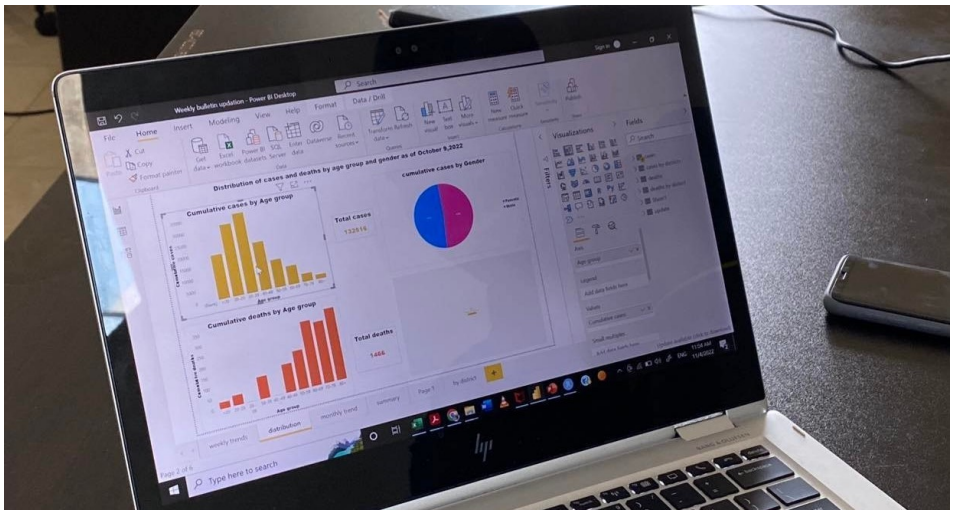
In addition to RHAP, Microsofts Power BI was preferred over DHIS2 visualization. Several data analysts used Power BI, a scalable platform for self-service and enterprise business intelligence (BI)[4]. The platform can connect and visualize any data and seamlessly infuse the visuals into everyday apps, reputedly bridging the gap between data and decision-making. The software aims to create a data-driven culture with business intelligence for all.

It was already known from previous research that many users in Rwanda preferred to download HMIS data to Excel and produce visualizations there instead. Users preferred Excel to the DHIS2 dashboards, data visualizer, and analysis tools. The phenomenon had now evolved to HMIS data being transferred to Power BI, bypassing DHIS2 limitations and design choices. Like RHAP, it could combine data from multiple instances/sources. When asked why interviewees preferred Power BI, they said it was more user-friendly and flexible, with better functionality and forms of presentations. Different graph types could be combined into a single visual, and visuals were interactive. Additionally, the platform has a big community behind it. Resources were available through forums, guides, videos, and more. Power BI also offered offline solutions that allowed users to work on data locally, which proved beneficial in areas with unreliable internet connectivity.

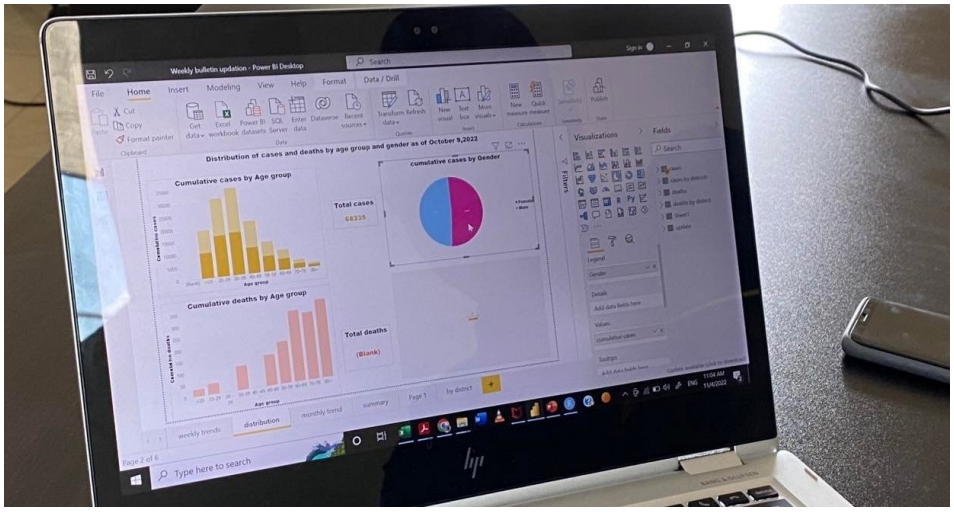
One data analyst presented their graphs from DHIS2 and Power BI. They felt the DHIS2 graphs were not flexible enough, looked ugly, and were sometimes a hassle to work with. Power BI they learned mostly by themselves via Youtube tutorials or making use of the big community, allowing them to ask questions and get replies quickly:

> *It (Power BI) doesn't require much programming knowledge and is easier to use. People like to use them (DHIS2 visualizations) not because they are good but because they do not know how to make their own visualizations.*

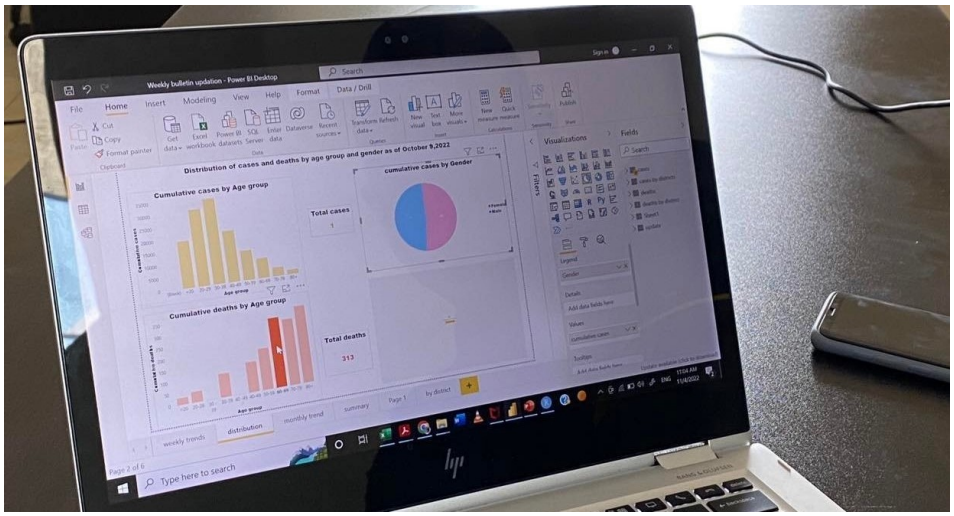
[4]https://powerbi.microsoft.com/en-us/what-is-power-bi/



(a) No data highlighted



(b) Data for a gender highlighted in the graphs



(c) Data for an age-group highlighted in the graphs

Figure 6.8: Examples of interactive graphs in Microsoft Power BI

Especially one thing from the person's Power BI dashboard caught our attention, interactive visuals. As seen in figure 6.8, graphs highlight data based on how a user has interacted with other charts in the dashboard. For example, in 6.8 (b), a gender (women) has been clicked in the pie chart, leading to the line graph alongside it highlighting how many of the cases in each age group were women. The line graph in the bottom left of the screen does not contain gender data and is therefore not highlighting anything. In 6.8 (c), data for a single age group is highlighted.

Several alternatives to DHIS2 maps

Map visualizations exhibited an even higher fragmentation level than other types of visualizations. Alternative solutions such as Microsoft Power BI, RHAP, ArcGIS, and QGIS were uncovered. Barely any use of the DHIS2 Maps was found, and usage analytics data from HISP Rwanda supported this. When interviewees were asked why they preferred other solutions, two recurring reasons were: 1)Lack of training and 2) DHIS2 maps didn't work. Several people found them challenging to set up, and when new updates arrived, solutions tended to break down. There was also a general lack of data that could be presented as maps. The population denominator being ten years old did not help either, as it led to inaccurate representations. HISP Rwanda said they were aware of these issues.

Furthermore, it is worth noting that utilizing maps to present data has never been a widely favored option. Based on HISP Rwanda usage analytics, approximately 80% of the data visualizations consist of tables. Other than tables, there are various types of graphs encompassing a significant portion. Maps represent only a small fraction of the visualizations, comprising a few percentage points.

In addition, HISP Rwanda is collaborating with several African countries developing GRID3(Geo-Referenced Infrastructure and Demographic Data for Development), a platform featuring a range of innovative visualization tools through geospatial data. Use cases range from boundaries and population to infrastructure, settlements, and risk analysis. GRID3 works with dedicated humanitarian workers, government officials, NGOs, and communities, with partners such as United Nations, UKaid, and the Bill & Melinda Gates Foundation[5]. In the case of Rwanda, the goal is to get the general population more informed about the locations of health facilities, particularly combating the fact kids are not getting vaccinated. GRID3 is based on ArcGIS, but HISP Rwanda is working together with DHIS2 developers to incorporate something similar for the Rwanda HMIS at a later stage.

[5]https://grid3.org/

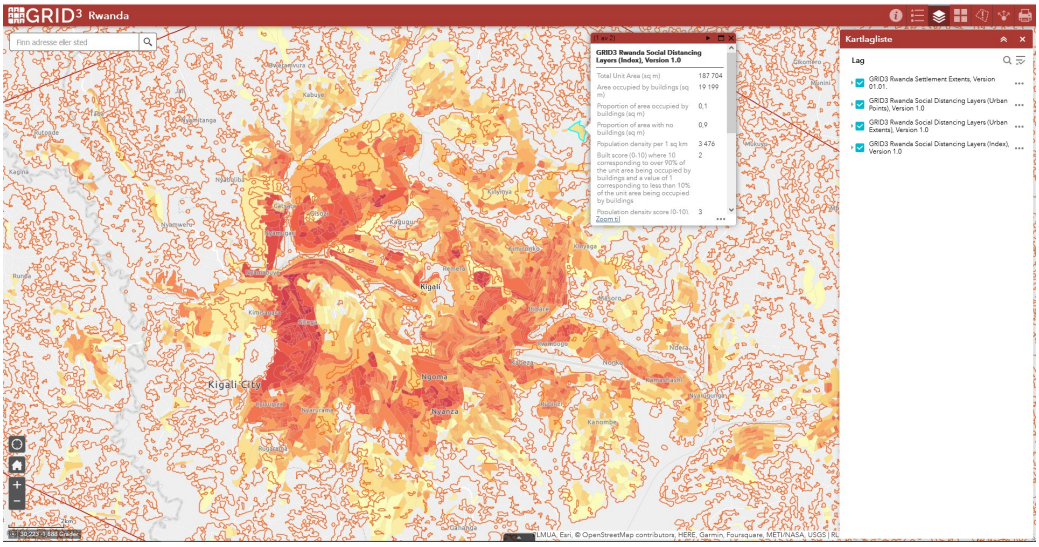


Figure 6.9: Example usage of GRID3 - Settlement data in Kigali, the capital of Rwanda

6.2.2 Capacity building

When interviewees were asked to elaborate on the challenges associated with DHIS2, the issue of insufficient training emerged as a recurring concern. Several interviewees highlighted a capacity-building deficiency, encompassing training, skill development, and coaching across various domains. The lack of adequate capacity building was particularly evident at healthcare facilities, where newly hired personnel often experienced significant delays in receiving DHIS2 training, sometimes waiting for months. On certain occasions, HISP Rwanda representatives had to perform data entry and visualization creation for data managers to ensure compliance with mandatory reporting. Whenever individuals need technical support, encompassing bug fixes, integration, capacity building, or training (particularly for the training of trainers within the MoH or RBC), the staff members of HISP Rwanda are readily available to provide assistance.

The lack of on-site training could primarily be associated with the arrival of the COVID-19 pandemic. There has been no refreshment training for data managers since 2019. Before 2020, these refresher educations were conducted annually or once every two years. Central M&E staff was trained in June 2022, after a long break due to the pandemic. Workshops with data managers are held, but it is unclear how often. A data analyst told us that there used to be physical DHIS2 academies in Rwanda before the pandemic. Since then, all academies have been held online, with attendance limited to those who expressed interest. While everyone was invited to participate, many individuals did not perceive it as a priority or lacked the inclination to attend due to the virtual nature of the event. The data analyst felt it was harder to focus and derive some benefit and wanted

the physical academies back. Nevertheless, the DHIS2 Academy is highly valued as a great way to strengthen national and regional capacity in DHIS2 systems. While participants appreciate the fundamental content covered, they also desire more specialized courses that cater to local needs. The current courses were considered too generic.

However, it would be unfair to attribute all the shortcomings solely to the onset of the COVID-19 pandemic. Discussing DHIS2 maps as an illustration, a coordinator from HISP Rwanda informed us that the usability and stability of the maps tool had significantly improved over the years. The challenge lay in the fact that users had become accustomed to and familiarized themselves with alternative solutions like Power BI or QGIS during that time. While these claims were difficult to verify, we received information from multiple sources indicating a lack of maps training dating back to 2015. Consequently, most users would have likely forgotten how to work with the tool effectively, and individuals hired after 2015 would have had no experience with DHIS2 maps beyond self-guided learning.

There was a recurring pattern observed where trained data managers, equipped with the necessary knowledge and skills, would leave for other job opportunities. Unfortunately, they often failed to adequately mentor their successors before leaving, resulting in a significant knowledge and skills gap in those positions. This issue was further compounded by the lengthy duration, sometimes spanning months or even years (especially during the pandemic-affected period), for new data managers to undergo a comprehensive training program. Although HISP Rwanda and RBC provided extensive support, their capacity was constrained by limited time and resources, making it impossible to address every issue instantaneously. As a consequence, numerous data managers were left overworked, as they had to shoulder a multitude of tasks without possessing the required skills.

It was clear that more training had been offered for RHAP in recent years, which might have added to its rise in popularity. This training was conducted by Zenysis and RBC and funded by the Global Fund.

6.2.3 WHO metadata packages

The initial research to be addressed in this thesis was about (1) how standardized WHO metadata packages for DHIS2 had contributed to more and better information use in Rwanda, and (2) how they shape and are shaped by the context in which they are deployed. It was anticipated this would lead to a better understanding of how the development and dissemination of metadata packages could be improved to foster local impact. It didn't take long for us to realize that these packages were barely implemented in Rwanda, and the underlying reasons

for this were apparent. Rwanda already had years of experience with DHIS2 development as the standardized metadata packages were rolled out in 2017. Given the effective functionality of the existing system, the Rwanda digitization office found no compelling reason to transition to an entirely new system. Rwanda's set of unique indicators would need to be completely overhauled to fit the WHO metadata packages, resulting in substantial work with minimum returns on investment. In addition, new data would not be comparable to the previous years. Although metadata packages did not become the focus of this thesis, the findings surrounding them remain relevant and warrant inclusion.

Rwanda has policy guidelines and protocols to follow when choosing indicators. A selection of national representatives sits down with specific programs to discuss which key indicators should be included (what to ask the health facilities to report in DHIS2). It is a delicate balance between the global WHO guidelines and country-specific needs.

The implementations of the WHO and Rwanda systems encompass numerous shared indicators. Whenever new WHO packages or updates are introduced, Rwanda closely examines them, identifies any disparities or missing elements in its system, and discusses the potential inclusion of these elements in its domestic solution. An example is the installation and modification of the Vaccine Preventable Diseases (VPDs) case-based surveillance tracker package. The existing system and the WHO package were almost identical. Instead of creating a duplicate system, Rwanda added the vaccine information lacking from their domestic implementation. Implementing the WHO package instead would necessitate additional resources, training for all staff, and the development of new reporting forms. However, the WHO metadata packages would be employed in the event of a unique disease outbreak where no system is already in place. One such instance was the advent of the COVID-19 pandemic. The WHO packages were utilized for COVID-19 testing and vaccination efforts, albeit with minor modifications to align with local practices, such as adjusting age groupings.

Although the WHO metadata packages find little use in Rwanda, HISP Rwanda supports numerous other African countries in implementing their HMISs. Countries like Sudan or Burundi do not have HISP centers, but HISP Rwanda helps develop and disseminate solutions. Introducing new solutions in a country begins with evaluating and comparing DHIS2 packages to the system in place. The nation must decide what solution they want, but HISP centers will advise using DHIS2. If the country lands on DHIS2, the WHO metadata packages will be used, modified to fit country-specific indicators. Most countries HISP Rwanda support now have trackers up and running, although still in their early phases

(from DHIS2 version 2.35). A plan is in place to ensure that most implementations adhere to WHO packages.

One significant challenge emerged concerning the release of metadata packages. When new versions of metadata packages were introduced, it posed difficulties for countries to discern the modifications or additions. Lacking good documentation on what content was new or modified meant the implementers had to play catchup constantly. Updates were also seemingly imposed on users without clear information regarding their arrival. Consequently, systems occasionally experience temporary service disruptions, and local implementers must invest considerable time in identifying and resolving the issues. These problems were associated with updates released by both national ministries and the core DHIS2 development team.

When inquired about the impact of the packages regarding development and implementation, representatives from HISP Rwanda acknowledged that standardized solutions make their life easier. They emphasized that certain users, particularly the implementers without a health sector background, benefit significantly from the pre-configured packages with pre-defined indicators. Paraphrasing one representative:

> *Information systems can be big and complicated when they are made from scratch and continuously developed in different directions over a long period of time. Metadata packages tone this phenomenon down to smaller, easier-to-use systems split into different use cases.*

HISP Rwanda thinks the WHO packages are not suited for facility-level implementation but for the central level and partners. This aligns with the original intention of the WHO when developing these packages. HISP Rwanda could see the packages being applicable at the facility level if indicators on accessibility, availability of commodities, training, staffing, and quality of service were added. In addition, HISP Rwanda supports both French- and English-speaking countries, and it can take a long time for the metadata packages to be released in French. Sometimes, HISP Rwanda must undertake the entire package translation, which demands considerable time and effort.

The fact that WHO metadata packages and standardized dashboards see limited utilization and that some users prefer RHAP or Power BI does not mean that DHIS2 dashboards are not used. In addition to what's been presented in section 6.1, data managers create and use self-made dashboards determined by primary indicators most relevant to their facility. Some will also utilize dashboards made by HISP Rwanda or the MoH. Users at national and facility levels confirmed that they utilize the dashboards regularly. Common use cases for the dashboards include:

- Used weekly or monthly for generating reports.
- The Head of the Facility will study them at the beginning of each week to get an overview of the service provision and health status.
- Representatives from MoH, RBC, or HISP Rwanda will study them to prepare for facility visits. Facility users will study them to prepare for field visits.
- Study the data in preparation for coordination meetings. Some use dashboard elements in their presentations.

6.3 Chapter summary

This chapter provides an overview of the practices and challenges of HMIS data use in Rwanda's healthcare system. DHIS2 is utilized at all health levels, from the national MoH to CHWs in remote areas. At the national level, DHIS2 is used for advocacy and policy development, to monitor health programs, identify interventions, and promote a culture of data use. At the facility level, data managers enter data into DHIS2, generate visualizations, perform data analysis, and create reports. DHIS2 is also crucial for monthly HMIS reports that aid decision-making and planning. CHWs interact through community-based surveillance systems. The chapter also notes challenges in managing health post data and the absence of specific target population numbers.

The second part of the chapter presents challenges related to data use in Rwanda's HMIS. The main issues are fragmentation, capacity building, and lack of WHO metadata packages and standardized dashboards. Fragmentation was due to server capacity saturation or alternative platforms offering new or better functionality. The lack of training and skill development for DHIS2 was a recurring concern, made worse by the COVID-19 pandemic. WHO metadata packages were rarely implemented (except for COVID-19 service provision) due to already functioning systems and unique indicators. While the utilization of metadata packages may be limited in Rwanda, they are well-suited when supporting other countries in implementing their own HMIS.

Chapter 7

Analysis

In this chapter, the fieldwork findings are contextualized by matching them to the constructs of the adapted Theory of Effective Use framework outlined in Chapter 4. Table 7.1 illustrates the integration of various findings with their corresponding construct, based on the context-specific definitions produced in Table 4.1. Each construct's contents are presented in distinct sections.

7.1 Transparent interaction

Transparent interaction refers to how users can access relevant health data. The enablers of transparent interaction in Rwanda HMIS include a high level of system integration, where almost all health data is available within one platform, DHIS2. Stakeholders such as the Global Fund and WHO are highly involved in monitoring the information within the HMIS. The involvement of health facility management also plays a crucial role, where positions such as the Head of the Facility can ask for access to data through the data managers at the facility.

However, there are also barriers to transparent interaction, such as limiting physical structures that can prevent health data sharing and analysis, including network problems and capacity issues. The health system comprises three distinct implementations of health datasets: isolated HMIS, HIV, and SISCOM instances. Each of these implementations operates on multiple separate servers. This can hinder access to information across programs.

Table 7.1: Theory of Effective Use constructs: Findings from Rwanda

Construct	**Context-specific definition for Rwanda HMIS**	**Findings**
Transparent interaction	To what extent users can access relevant health data	Enablers: • High level of system integration • High involvement of stakeholders • Involvement of health facility management Barriers: • Certain limiting physical structures • 3 separated implementations of health datasets
Representational fidelity	To what extent do the data in the HMIS systems represent the health status and services	Enablers: • High data reporting • All levels of the health system included • Several entities interact with the platform • Monthly reports, data reviews, and validation meetings • Developing custom DHIS2 apps Barriers: • Fragmentation across platforms • Outdated population denominators • No DHIS2 instances for most health posts • Data visualizations almost exclusively tables

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Table 7.1 – continued from previous page

Construct	Context-specific definition for Rwanda HMIS	Findings
Informed action	To what extent decisions are made based on the information obtained from the HMIS	Enablers: • Advocacy and policy-making • MoH monitor and base field visits on HMIS information • Coordination- and technical meetings at multiple levels • Health facility management base decision on HMIS data • CHW surveillance and notification systems Barriers: • Insufficient time and resources for sufficient facility supervision • Monthly coordination meetings not upheld
Adaptation	Any action a user takes to improve data use representation in the HMIS or the use of alternative solutions where the DHIS2 platform is not meeting their needs	Enablers: • Develop and implement new features domestically • Adapt domestic solutions to international standards • Reuse solutions in new settings • Data informs service delivery adaptation • A new approach to map visualizations with the GRID3 project Barriers: • Adapted solutions are outside the DHIS2 platform: RHAP, Power BI, Excel, ArcGIS, QGIS

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Table 7.1 – continued from previous page

Construct	Context-specific definition for Rwanda HMIS	Findings
Learning	Any action a user takes to learn DHIS2, data use practices, the way DHIS2 faithfully represents data use practices, or how to engage in more informed actions	Enablers: • Staff create and use self-made dashboards • DHIS2 used for COVID-19 service provision within weeks • Adopt WHO metadata standards: add relevant missing elements to their system Barriers: • Capacity building lacking in multiple fields • Low attendance for DHIS2 academies held online due to pandemic • Trained personnel leave without transferring knowledge to their successors

7.2 Representational fidelity

Representational fidelity refers to how the data in the HMIS represent the health status and services the healthcare system provides. There are several enablers of representational fidelity, including a high level of data reporting in which data is collected and reported from all health system levels. CHWs deliver data-based monthly summaries that data managers enter into the database, where visualizations and data analysis are performed. Health posts conduct monthly data review and validation meetings. Health facilities conduct monthly HMIS reports in which data from all programs are used for planning, resource allocation, and decision-making later. Several national and governmental entities interact with the system: Rwanda MoH, HISP Rwanda, RBC, and other government factions. In areas where the platform did not sufficiently cover healthcare status and services, new DHIS2 apps have been developed domestically. Examples include PBF and Scorecards systems, further enhancing data representation in the HMIS.

Despite these efforts, there are still barriers to representational fidelity. Data fragmentation occurs across various platforms, where the raw data stored within DHIS2 is represented and analyzed on alternative platforms such as Excel. This can result in inconsistent data representation. Outdated population denominators have led to gradually worsening accuracy of representations, especially noticeable at the lower reporting levels, such as villages. Ten-year-old denominators are far from accurate in areas of high migration, making it impossible to represent health status and services faithfully. The lack of DHIS2 instances for most health posts means their data gets aggregated with their affiliated health center, making it impossible to do separate monitoring and analysis for the facilities. Additionally, usage analytics indicate that data visualizations are almost exclusively tables. Tables are not well suited to present many forms of data and can paint a wrong picture of healthcare performance.

7.3 Informed action

Informed action refers to the extent to which decisions are made based on the information obtained from the HMIS. A primary driver in Rwanda is the use of HMIS data for advocacy and policy-making, highlighted by an annual large-scale action planning meeting. Representatives from all factions of the health system meet to prioritize funding and resources for the different health programs, a balancing act between HMIS data and national priorities. The MoH monitors health programs and bases its supervision and field visits on the data gathered. Coordination- and technical meetings are held at multiple levels, providing

opportunities for data review and informed decision-making. Health facility management base their decisions on HMIS data, monitoring trackers, verifying service performance, performing accounting, or getting daily, weekly, or monthly updates on facility activity. Introducing CHW surveillance and notification systems at the community level further supports informed action.

There are also constraining factors to informed action, such as insufficient time and resources for sufficient facility supervision, although tools such as DHIS2 dashboards have increased efficiency. Additionally, monthly coordination meetings may not be upheld, leading to a lack of communication and informed action based on HMIS data.

7.4 Adaptation

Adaptation refers to any action a user takes to improve the use and representation of data in the HMIS or the use of alternative solutions where the DHIS2 platform is not meeting their needs. HISP Rwanda and RBC develop and implement new features domestically to improve data use within the DHIS2 platform. They also adapt domestic solutions to meet international standards like those of the WHO. Well-established solutions are reused in new settings allowing for efficient development and implementation, as demonstrated by the introduction of COVID-19 packages within weeks. Health data are also used to adapt approaches and strategies for service delivery. Finally, the GRID3 project has introduced a new system for map visualizations, which offers a more comprehensive and detailed representation of health data compared to the maps generated through DHIS2.

A significant barrier to effective use is platform fragmentation, where adapted solutions outside the DHIS2 platform are preferred. This problem comes in many forms: RHAP offers data triangulation and (according to some) better visualizations; Microsoft Power BI provides more advanced visualizations, data triangulation, flexibility, and user-friendliness; Excel is used for visualizations and analysis; and there are several alternatives to DHIS2 maps (Power BI, RHAP, GRID3, ArcGIS, and QGIS). This leads to a lack of standardization across different healthcare settings and could limit the ability to compare and analyze data across platforms.

7.5 Learning

Learning involves any initiative a user takes to acquire knowledge about DHIS2, data use practices, the accurate representation of data use practices by DHIS2, or how to take better-informed actions based on the data. Enablers of learning

include individuals creating and using self-made dashboards and the rapid adoption of DHIS2 for COVID-19 service provision within weeks. Regarding metadata package implementations, Rwanda adopts the WHO standards and incorporates any relevant or missing elements into its domestic system.

Insufficient capacity building in various fields and forms, such as training, skills, and coaching, presents a significant barrier to learning. Alternative platforms such as RHAP and Power BI had more to offer than DHIS2, with RHAP receiving more capacity building and Power BI having more resources and a larger community behind it. Low attendance for DHIS2 academies held online due to the pandemic can limit individual learning opportunities. Finally, trained personnel leave for other jobs without transferring knowledge to their successors. Months or even years can pass before the successor completes a training program. This can lead to a lack of continuity in using and interpreting DHIS2 data.

7.6 Chapter summary

The analysis chapter presents the fieldwork findings through the context of the adapted Theory of Effective Use framework, demonstrating how the various findings align with the constructs of the framework. This chapter provides a comprehensive understanding of the enablers and barriers to the effective use of HMIS data in the Rwandan healthcare system.

Chapter 8

Discussion

Practices of, enablers, and barriers to data use in Rwanda HMIS have been addressed through the analysis by matching the findings from the fieldwork with the constructs of the Theory of Effective Use. By contextualizing data use practices across all health system levels and the challenges faced, the analysis provides a comprehensive understanding of the enablers and barriers to the effective use of HMIS data in Rwanda.

This chapter consists of three sections. The analysis results, as presented in Table 7.1, are matched with relevant literature on HIS strengthening and data-driven decision-making in LMICs. Secondly, to what degree the application of the TEU framework was fitting for the research is discussed. Finally, the research's implications for practice regarding Rwanda HMIS and the HISP project are presented. For reflections on the methodological approach, see Chapter 5.5.

8.1 Practices of data use in Rwanda HMIS

Below, the findings, as presented in Table 7.1, are compared to relevant literature on HIS strengthening and data-driven decision-making in LMICs.

8.1.1 Transparent interaction

The various users can access relevant health data in Rwanda's HMIS to a large degree. Lomas (1997) promotes improved communication between those that generate data and those that use data in decision-making. The platform must engage with stakeholders, including policymakers, healthcare providers, and patients, to ensure that data is relevant to their needs and interests (Kumar et al., 2018; Nutley and Reynolds, 2013). In addition to the entire healthcare hierarchy of Rwanda, stakeholders such as the Global Fund and WHO are highly involved in monitoring information within the system. There is a high level of

system integration, where most health data is available within one platform, DHIS2.

One significant barrier to a complete unified system architecture is that Rwanda's solution is based on three separate implementations of health datasets (isolated HMIS, HIV, and SISCOM instances), each consisting of multiple separated servers. It has followed the approach of South Africa, where more areas and data were added to the system over time, easily accommodated through the flexible database structure (Sæbø et al., 2011). In this way, national standards for essential data were developed 'on top of' other existing systems. Braa et al. (2007) state how the presence of various health programs that address specific diseases within the health sector can hinder access to information across programs. Data reporting forms are standardized across programs in Rwanda, but the separated databases have led to a lack of data triangulation, hindering cross-platform data visualization or analysis. Physical structures, such as unstable internet and scaling problems regarding software and large databases, only seem to affect service delivery and health outcomes to a limited degree.

8.1.2 Representational fidelity

The data in the Rwanda HMIS represent the health status and services the healthcare system provides well. Data reporting is conducted extensively across all health system levels (Evaluation, 2019b). CHWs, health centers, hospitals, and several national and governmental entities report to the system. Involving the community in the decision-making process helps to identify local health priorities and encourage uptake and monitoring of health services, enhancing a sense of ownership and improving accountability (Israr and Islam, 2006). Usually, countries' local health data are collected and merged into national HMIS from which reports are mainly created for central use (Stansfield et al., 2008; Wickremasinghe et al., 2016).

In areas where the platform coverage of healthcare status and services was insufficient, new DHIS2 apps were developed domestically, further enhancing data representation in the HMIS. Russpatrick et al. (2021) found that local requirements in Rwanda could be partly addressed by developing DHIS2 apps to address new features. Platform stakeholders have continued to expand on this with app developments locally, regionally, or shared between countries.

Stansfield (2008) suggested a practice of more utilization of information at the district level, where most decisions for public health interventions are planned, executed, and monitored. The granularity of the data is thus kept intact, not compromising the detail required by local users (Wickremasinghe et al., 2016). District-level utilization is well-established in Rwanda, but not without its challenges. Outdated population denominators have led to gradually worsening

accuracy of representations, particularly evident at the lower reporting levels. Ten-year-old denominators will be inaccurate in areas of high migration, making it impossible to represent health status and services faithfully. Further, the fact most health posts still do not have a dedicated HMIS account leads to a lack of health post representation in the HMIS (Russpatrick et al., 2021). Their data will be aggregated with an affiliated health center, making it impossible to do separate monitoring and analysis for these facilities.

A more significant issue in Rwanda is data fragmentation across different platforms. While raw data is stored in DHIS2, substantial representation and analysis are carried out on alternative platforms such as Excel. This can result in inconsistent data representation. Braa et al. (2007) found fragmentation attributed to various factors, such as donors funding only specific areas and NGOs creating separate information systems to meet unique requirements without integrating them into the existing HIS. This description matches the situation in Rwanda. DHIS2 did not offer data triangulation, so a new platform called RHAP was developed, funded by an external source. Users found Power BI visualizations more advanced, flexible, and better looking. The same can be said for Excel and several alternatives to DHIS2 maps. Also of note was that data visualizations in Rwanda HMIS were almost exclusively tables (according to HISP Rwanda usage analytics). Tables are not well-suited to present many forms of data and can paint a wrong picture of healthcare performance.

8.1.3 Informed action

In Rwanda, health-related decisions are primarily based on the information obtained from the HMIS. Despite agreement that data-based decisions will lead to improved health outcomes (Pappaioanou et al., 2003; White and Henderson, 1978), many public health decisions worldwide appear to be made intuitively or politically (Davis, 2002). Foreit, Moreland & LaFond (2006) stated that the interplay between improved information, demand for data, and continued data use could create a cycle that leads to improved health programs and policies. In Rwanda HMIS, routine data informs program development and improvement, policy development, strategic planning, and advocacy. A yearly planning meeting consists of representatives from all health factions discussing funding and resource allocation, using HMIS data for advocacy and policy-making. Program development and improvement are covered in data used for supervision, MoH field visits, and by health facility management basing decisions on HMIS data; monitoring trackers; verifying service performance; performing accounting; or getting daily, weekly, or monthly updates on facility activity. Strategic planning is covered through coordination and technical meetings at several health system levels.

These findings align with systematic literature review results exploring how administrators and health managers in LMICs used health data to make decisions (Wickremasinghe et al., 2016). Out of 14 papers included, Wickremasinghe et al. found 12 examples of tools to assist district-level decision-making, all of which consisted of two key stages: the identification of priorities; and the development of an action plan to address them. This matches the use practices of the DHIS2 Scorecards, where priorities of action are identified through the scorecards, and action is taken in areas of particular concern. Four tools with further steps included measures to review or monitor the agreed-upon action plan. This is covered in Rwanda through coordination meetings. In the review, HMIS data were used for prioritization in eight papers. Planning meetings and scorecard usage cover this in Rwanda.

Despite Rwanda going to great lengths in basing actions on routine data, there is always room for improvement. Constraining factors to informed action include insufficient time and resources for adequate facility supervision, where only certain facilities can be covered. While tools such as DHIS2 dashboards have enhanced efficiency, the adoption of these dashboards appears to have stagnated according to usage analytics. This contrasts with what has been documented in the literature, where tools to visually present health facility data gained popularity (Etamesor et al., 2018).

8.1.4 Adaption

Rwanda has examples of actions taken to improve the use and representation of data both within the HMIS and through alternative solutions. NGOs are creating separate information systems such as RHAP to meet unique requirements (Braa et al., 2007). Gasser (1986) argues there are three types of adaption work, fitting, augmenting, and working around, and the reliance on alternative platforms is an example of working around. However, several instances exist of governmental organizations expanding within the DHIS2 platform as well. HISP Rwanda and RBC have developed and implemented new features domestically, such as PBF and DHIS2 Scorecards, as well as adapting international WHO standards to domestic solutions. These are all examples of fitting actions (Gasser, 1986). Rwanda even received the best institutionalization award from the African Leaders Malaria Alliance (ALMA)[1] for the scorecards (malaria incidence and mortality were reduced by 85% in five years).

The healthcare system has also shown it can turn things around quickly, exemplified by the rapid adoption of standardized WHO metadata packages for COVID-19 service provision. In addition to supporting existing testing and

[1] https://www.moh.gov.rw/news-detail/rwanda-scoops-award-in-malaria-control-maternal-health-programs

reporting workflows, DHIS2 was used to track the quantity of incoming data samples and adjust staffing accordingly, ensuring appropriate testing capacity based on expected test volume. As DHIS2 was used for each step of the process, the overall time from sample collection to processing and results reporting was exceptionally efficient. The rapid development and deployment of COVID-19 health packages are an example of the successful dissemination of global standards (2020) and an example of augmenting work (Gasser, 1986).

The fragmentation aspect of adaption actions can be a barrier to effective use leading forward. The lack of standardization across different healthcare settings requires new staff to learn multiple solutions and can limit the ability to compare and analyze data across platforms. However, there are several ways in which this is about to be solved. As time progresses, competing platforms' functionality is adapted into the DHIS2 platform. Data triangulation offered by RHAP and Power BI is coming to DHIS2 (the arrival of DHIS2 version 2.39). HISP Rwanda is collaborating with the core DHIS2 developer team to incorporate elements from GRID3 into the Rwanda HMIS at a later stage. These are good examples of how HMIS strengthening is a continuously evolving process (Foreit et al., 2006). Several requests for the action research in Rwanda by Russpatrick et al. (2021) are already in place. Some users wanted the option to share dashboards with predefined groups of users, which is now possible. Others wanted the option to print dashboards to be used in reports, which is a feature now.

8.1.5 Learning

Rwanda faces several challenges regarding learning actions. Insufficient capacity building in fields such as training, skills, and coaching presents a significant barrier to learning (Lemma et al., 2020; Pappaioanou et al., 2003). The COVID-19 pandemic severely limited the amount of supervision and coaching, and DHIS2 academies held online had low attendance, limiting individual learning opportunities. Additionally, trained personnel leave for other jobs without transferring knowledge to their successors. Months or years can go by before the successor completes a training program. Studies confirm that to strengthen evidence-based public health, it is necessary to bring together essential principles and elements from all relevant disciplines in a problem-solving approach (Higginbotham et al., 2001; Pappaioanou et al., 2003; Rosenfield, 1992). Teaching decision-makers basic quantitative skills requires long-term and concerted efforts (Pappaioanou et al., 2003). Providing post-workshop assistance is crucial for participants to apply their skills and materials to on-the-job problem-solving. Participants may revert to previous work practices without supportive follow-up and supervised application of skills. This is apparent in Rwanda, and capacity-building efforts are heavily sought after.

8.2 Lessons learned from applying the Theory of Effective Use framework

This research supports the adaptability of the Theory of Effective Use framework and its constructs. Burton-Jones and Grange (2013) proposed a model they argued could apply to any information system in any task. To position and analyze the fieldwork findings, the generalized framework was adapted into the context of the enablers and barriers of the effective use of HMIS data in Rwanda, with altered context-specific definitions of its constructs. The analysis demonstrates that transparent interaction, representational fidelity, and informed action are all significant dimensions of effective use. In addition, adaption and learning actions act as precursors to effective use. Close to all data use practices and challenges discovered during the fieldwork could be positioned within the five constructs.

Although Burton-Jones and Grange argue their model could apply to any information system in any task, TEU has yet to see high uptake or be adapted to many different contexts. Other researchers that have attempted it have supported that the framework adapts well to new contexts (Bonaretti and Piccoli, 2019; Eden et al., 2020; Trieu, 2013). This thesis further supports the claim, finding the constructs appropriate for documenting data use practices and challenges in a national HMIS. Adapting the framework to (1) the context of a national HMIS, and (2) the findings from Rwanda, proved fruitful in investigating important aspects identified in the literature.

This paper provides a framework that aims to facilitate the organization of information in a manner that is easy to understand and apply for future research. The framework helps underscore the importance of users' and organizations' actions to improve effective use. Besides learning and adaptation actions having immediate benefits for effective use, they can also make users more knowledgeable and the system's context more or less complex. This adaption can be used as a template for future researchers and practitioners to assess the effective use of an HMIS.

The framework also helped answer calls for action from the literature. Firstly, Hoxha et al. (2020), in their systematic review of HMIS data use challenges in LMICs, concluded with the need for additional research to identify effective strategies for addressing the determinants of HMIS use. Secondly, the framework aligns with the HISP UiO Strategy Update (n.d.) to integrate review systems to identify gaps and address them, making continuous improvements in 'data out' processes. I argue that implementing TEU can be a fitting concurrent review system to identify the gaps in the use practices of an HMIS. By positioning the findings to the constructs of TEU, it paints a picture of what issues need to be

addressed. For example, if there are several challenges regarding learning actions within a district, the district management should strengthen its capacity-building efforts.

So why implement a new framework when others are already established? Both the PRISM framework (Hotchkiss et al., 2010; Hoxha et al., 2020) and the data use continuum from HISSM (Evaluation, 2019a) have been implemented to analyze HIS performance and data use practices. One reason to try something unproven was to explore the topic from a new perspective. Investigating the same issue using different models can lead to results complementing each other and bringing new insights. Another reason is that the PRISM and HISSM frameworks are large in scope. They can fit more immense scopes and projects where time and resources are less limiting. While the HISSM can be adapted to focus solely on its data use continuum, a continuum is not well-suited for a case study taking place just once. A continuum is a process that keeps going, changing slowly over time. Meanwhile, the HMN framework was found too generic for the purpose. It addresses data use with a broad perspective and considers data captured from various sources.

8.3 Implications for practice

The first section will discuss practical implications for Rwanda's HMIS. The results of this research may help Rwanda continue improving its HMIS use practices by providing a better understanding of the factors that drive and hinder the effective use of it.

The second section will cover implications for the HISP project and routine use of DHIS2 data. The thesis answers HISP UiO's call for research on data use and country health information system strengthening through the DHIS2 platform. The section includes input from researchers at HISP UiO and an external HISP employee. Fieldwork findings were shared with these people as they were researching information use.

8.3.1 Implications for Rwanda HMIS

PRIMASYS, a comprehensive case study of the Rwandan primary health care system by the WHO, pointed out "promote data use to inform policy and decision-making" as a consideration for the way forward (2017b, p. 27). The findings discussed in section 8.1 illustrates that this to a large extent has been achieved. Routine data supports everything from supervision visits, community management, and planning-, technical-, and coordination-mechanisms. This ensures that relevant data are available to meet the information needs of decision-makers from various sectors during key decision-making moments (Nutley and

Li, 2018). It contrasts the findings of Byrne and Sæbø's (2022) scoping review, where only two instances of routine data used for policy-making were found. The authors observed that the emphasis often lay on reporting data to higher levels rather than generating data for operational or facility use. Utilizing data for local purposes, as Rwanda does, promotes local development, moving away from its exclusive role as a reporting tool.

HISP Rwanda has been prominent in cross-country and within-country sharing of best practices, facilitating active sharing of resources, and local app development. Many local requirements cannot be accommodated by a generic core like the DHIS2 platform, and according to Russpatrick et al. (2021), that can be addressed by developing apps locally, regionally, or shared between countries. A platform is by default a half-product where the real value lies in the ability to accommodate tailored solutions on the more generic and stable core part of the system (Chrysantina and Sæbø, 2019; Dittrich, 2014). HISP Rwanda has proved the concept by developing and disseminating PBF, Scorecards, and more. Rwanda should keep up the good work with fitting and augmenting actions (Gasser, 1986), further expanding the scope of the HMIS. The same can be said about their adaption works on WHO metadata packages. Poppe, Sæbø, and Braa (2019) found that a pervasive challenge with the packages had been the limited penetration and use of these standards by countries. The lack of WHO metadata package implementation in Rwanda might not necessarily be alarming. The country already had a well-functioning domestic solution up and running when the packages were released. Their DHIS2 implementers have the knowledge and skills necessary to work with the WHO packages when required, e.g., supporting other countries in setting up their own HMIS. Poppe, Sæbø, and Braa (2019) found a lack of perceived use value concerning the cost of implementation in countries. In the case of Rwanda, there is no incentive to completely rework the current system.

There are a few concrete challenges that should be addressed. For the denominator data, the arrival of the new national population census should resolve the problem, at least on a national or regional level. Using geospatial methods could help generate predicted values that serve as a method to assess the plausibility and quality of statistics generated from health facility data, especially at the district level (Maïga et al., 2019). This method could also be useful for estimating numbers for health posts, which is completely lacking now (2021). This paper did not document the possibility of incorporating alternative denominator sources for indicator calculation and triangulation, e.g., GRID3's population estimates, or if the country completely lacked adequate denominator sources.

Regarding staff leaving their positions for other jobs, implementing more incentives may convince people to stay. Staff seemed motivated through financial

incentives such as PBF, so an idea would be to further work on that practice. In job positions that have required extensive capacity building, such as data managers, there need to be incentives to stay.

Some fragmentation issues identified during the fieldwork have already been addressed by the time this thesis is published, either by the core DHIS2 developer team or local stakeholders. It is appropriate to highlight the fact that preference for alternative platforms among users is not necessarily due to a lack of functionality in DHIS2, but rather stems from established habits and familiarity with other platforms over time. This could be exacerbated by the lack of training in DHIS2.

Capacity building is an overarching challenge that simple measures cannot address. Limited capacity to utilize data for decision-making can be improved by equipping stakeholders with the necessary knowledge and skills (Nutley and Reynolds, 2013), but conducting targeted follow-up can be a lengthy, costly, and labor-intensive endeavor (Nutley and Li, 2018). Literature on capacity-building interventions is rare, with only three of the 36 articles in Lemma's (2020) scoping review falling under this category. Those that cover capacity-building efforts focused on training individual health workers from various levels of health systems in data analysis tools and techniques for improving quality, analysis, interpretation, and use of HIS data (Nutley and Reynolds, 2013; Pappaioanou et al., 2003; Wilkins et al., 2008). Further, these studies emphasized the importance of organizational culture that incentivizes data use (2020).

The request to bring back physical DHIS2 academies should be followed up on, as digital solutions have not been sufficient. Introducing country-specific courses was an addition to the academies suggested by HISP Rwanda staff. Local HISP groups could collaborate with HISP UiO on courses that put additional focus on local needs and practices. That might sound like a lot of effort for low returns, but for a group like HISP Rwanda that supports nine additional countries, the benefits should outweigh the costs. These academies would benefit all these countries as their systems are closely related. As for the problem of trained personnel leaving for other positions, successors in roles such as data managers need more and earlier supportive follow-up and supervised application of skills.

An RBC representative said: "Usage of the platform and its different functionalities seems to vary greatly depending on how much pressure comes from a central level." A push for learning action from a national level will strengthen DHIS2 compared to the other platforms. As capacity-building efforts in the last few years have been widespread for platforms like RHAP or Power BI, it is no wonder DHIS2 sees less use. How this data visualization training is delivered and how competent the graduates are, is yet to be understood.

8.3.2 Implications for the HISP project

The HISP UiO Strategy Update for 2019-22 (n.d.) put focus on data use and strengthening of countries' HISs: from managing processes that enable 'data in' (to DHIS2) to focus on 'data out' concerning data quality analysis and use for strengthening health services delivery and improving health outcomes. Despite the significant global deployment of DHIS2, there has not been a corresponding enhancement of data use to support national HIS improvements in LMICs.

This paper identified several ways DHIS2 has improved data-informed decision-making for enhanced program planning and management, supervision, and program improvement in Rwanda. Stakeholders are using decades of experience to develop new solutions rapidly. Routine data reports are weekly, monthly, quarterly, bi-annually, or annually. Routine data is used in workshops, coordination meetings, technical meetings, reviews, governmental advocacy and policy-making, and more. The data is used at all levels of the health hierarchy. MoH respondents noted how routine data informed their supervision visits, identifying and addressing recurring data problems with health facility staff before the visits. Facility management points to decisions based on HMIS data: monitoring trackers, verifying service performance, performing accounting, or getting daily, weekly, or monthly updates on facility activity. Even CHWs interact through community-based surveillance.

Byrne and Sæbø's (2022) scoping review concluded with three suggestions for the way forward: (1) to document in more detail and share how data are being used; (2) to investigate how data were created and who uses such data; and (3) to design systems based on work practices and, in tandem, develop and promote forums in which 'conversations' around data can take place. This thesis directly answers all three suggestions. Firstly, data use practices and the subsequent data-driven decision-making is documented in detail. Secondly, all health system levels were studied, uncovering how each uses the data. Thirdly, work practices where conversations around data took place were documented.

By sharing the interviewee's technical feedback with the core developer team, and the fieldwork findings with researchers at HISP UiO and an external HISP employee working in Spain, I got valuable feedback from trustworthy sources working in the field. The implementation of community-based surveillance, fragmentation issues, and metadata packages was of particular interest to HISP.

The fact CHWs are empowered to send alerts to the system for early warning of potential disease outbreaks is very similar to Uganda's approach to community signals management for Ebola outbreaks and something HISP wants to look at more closely. The distinction between the SISCOM, HMIS, and HIV instances in

Rwanda provides valuable insights for HISP to comprehend intentional DHIS2 architectures implemented by countries, as opposed to those that may arise due to governance gaps or performance issues. HISP has lacked information about user preferences regarding data analysis tools, such as user perspectives and why they choose other software. In addition, the fact tables alone account for 80% of the data visualizations were hard to take in. Tables are often used for reporting and verification but are far less suited for analyzing and interpreting trends. A HISP employee wondered if other countries would find similar trends in usage analytics.

Standardized packages are an excellent tool for countries that do not already have metadata systems in place, but are a harder sell for an already established country like Rwanda. The WHO packages might not fulfill their intended role as a standard solution implemented worldwide (Poppe et al., 2018), but rather as an example of a best practice solution used as inspiration. The fact that new package releases lacked detailed documentation of added or modified content is something HISP is working to improve with changelogs and release notes. A lack of clearly defined procedures to facilitate the implementation of standards has already been noted in the literature (Poppe et al., 2019) but is still an issue. The feedback from HISP Rwanda representatives that the metadata packages would be "more useful at facility level if indicators on accessibility, availability of commodities, training, staffing, and quality of service" were also of great interest. A module for facility-attribute data (availability of services, commodities, staff, etc.) is in the works, and the fact there is some field demand for it was good to confirm.

8.4 Chapter summary

The chapter discusses the practices of data use in Rwanda's HMIS and compares them to relevant literature on HIS strengthening and data-driven decision-making in LMICs, to what degree the application of the TEU framework was a good fit for the research, and the research's implications for practice, both regarding Rwanda HMIS and the HISP project.

Rwanda HMIS supports data-driven decision-making. Stakeholders have high access to relevant health data and the system collects comprehensive and local data that accurately represent health status and services. Decision-making heavily relies on HMIS information, facilitating program development, policy-making, and coordination. Best practices are actively shared, and significant resource adaptation is taking place. However, challenges include data fragmentation across platforms and outdated population denominators, impacting accuracy. Insufficient capacity building and limited supervision hinder the effective

use of data.

The TEU framework helped organize the findings and identify factors that influence the effectiveness of data use in an HMIS. This paper supports the framework founders' argument that it could apply to any information system in any task, and encourages other researchers to adapt and implement it in further contexts. TEU can be a fitting concurrent review system to identify gaps in the use practices of an HMIS. Using TEU over other established frameworks like PRISM and HISSM for case studies with limited time and resources can be advantageous.

The study found that Rwanda's HMIS is well-established and drives decision-making processes, but there is still room for improvement. It offers insights to create an environment that facilitates and motivates HMIS users to use HMIS more effectively to achieve better decision-making performance. It highlights the importance of local adaption of the platform, developing apps locally, regionally, or shared between countries, and cross-country and within-country sharing of best practices. The chapter also discusses the challenges of limited capacity building and the need to equip stakeholders with the necessary knowledge and skills. Additionally, the study has implications for the HISP project and routine use of DHIS2 data. It highlights feedback from HISP representatives on community-based surveillance, fragmentation issues, and metadata packages. The findings provide valuable insights for HISP's future work in LMICs.

Chapter 9

Conclusion

The study set out to answer the following research question:

> *What are the practices of, enablers, and barriers to data use in Rwanda HMIS?*

This qualitative case study examined data use practices across all health system levels and documented the challenges faced. The analysis positioned the findings from the fieldwork as enablers and barriers to the constructs of an adapted Theory of Effective Use framework.

The Rwanda HMIS has several practices that support transparent interaction, representational fidelity, and informed action. There is a high level of user access to health data, with stakeholders such as policymakers, healthcare providers, and international organizations engaged to ensure that data is relevant to their needs and interests. Additionally, the data collected represent the health status and services the healthcare system provides well, with high data reporting from all health system levels. The system involves the community in decision-making and identifies local health priorities. Furthermore, the granularity of the data is kept intact, ensuring that local users have the detail required for public health interventions planning, execution, and monitoring. Finally, decisions are primarily based on the information obtained from the HMIS, with several practices in place, including program development and improvement, policy-making, coordination and technical meetings, and advocacy. HISP Rwanda has been prominent in cross-country and within-country sharing of best practices, facilitating active sharing of resources, local app development, and adaptation works on WHO metadata packages.

While there are several enablers of data use, Rwanda also faces some challenges. Data fragmentation across different platforms, such as DHIS2, RHAP, Microsoft Power BI, and several alternatives to DHIS2 maps, are significant barriers. Addi-

tionally, outdated population denominators have led to the gradually worsening accuracy of representations, especially noticeable at the lower reporting levels. The main barrier to effective use is the lack of capacity building across the health system. Supervision and coaching efforts took a hit when the COVID-19 pandemic hit. Online DHIS2 academies have not been a success. Staff in positions that have required extensive capacity building, such as data managers, leave for other jobs without transferring knowledge to their successors. Months or years can go by before the successor completes a training program. A push for learning action from a national level will strengthen DHIS2 compared to the other platforms, as capacity-building efforts in the last few years have been widespread for platforms like RHAP or Power BI.

9.1 Contributions

The thesis offers contributions in four areas: (1) the literature on HIS strengthening and data-driven decision-making in LMICs, (2) the literature on TEU, (3) practical implications for Rwanda's HMIS, and (4) practical implications for the HISP project.

The thesis contributes to the literature on HIS strengthening and data-driven decision-making in LMICs. Overall, the findings support the literature, but some areas also reveal discrepancies. The involvement of various stakeholders, such as policymakers, healthcare providers, and international organizations, is consistent with the literature's recommendation for engagement to ensure data relevance and meet their needs. The extensive data reporting across different healthcare system levels in Rwanda reflects the literature's recommendation for comprehensive data collection. The development of DHIS2 apps to address new features improves data representation, but several users still prefer alternative software, especially for data triangulation, visualizations, and presentations. The use of routine data in Rwanda HMIS for program development, policymaking, and strategic planning corresponds to the literature's recommendation of informed action. The findings also align with the literature's recognition of the importance of district-level decision-making and prioritization based on health data.

The adoption of DHIS2 and alternative solutions reflect the literature's recommendation of adapting technology to enhance data use. Finally, the findings indicate insufficient capacity building and limited learning opportunities, such as low attendance at online academies and a lack of training for newly employed. The literature emphasizes the importance of training and skills development, highlighting the need for sustained efforts in capacity building and ongoing support.

This paper adds to the scarce literature on the TEU, a framework that has yet to see high uptake or to be converted to many different contexts. The thesis adds to this understudied field by adapting and applying the framework to new settings. Adapting the framework to (1) the context of a national HMIS, and (2) the findings from Rwanda, proved fruitful in investigating important aspects identified in the literature. This research helps advance the TEU and can be used as a template for future researchers and practitioners to assess the effective use of an HMIS.

Practical implications for Rwanda's HMIS. The thesis helps Rwanda improve its already well-established HMIS practices by identifying the factors driving effective data use, and those that hinder it. The findings can help Rwanda improve its HMIS by reinforcing the use of data in decision-making, tailoring solutions to local needs, addressing fragmentation challenges, investing in capacity building, and promoting national-level support and coordination. These actions can contribute to a more robust and effective HMIS in Rwanda, supporting improved healthcare planning, delivery, and outcomes.

Lastly, there are practical implications for the HISP project. The thesis answers the HISP project call for action to document the routine use of DHIS2 data. It provides HISP and its DHIS2 platform with real-world examples of data use practices and the challenges faced, direct feedback from interviewees, and a framework (TEU) that can be utilized as a review system in future research projects, identifying gaps to be addressed. The findings help HISP understand the impact of their work, address areas for improvement, identify new opportunities, and prioritize their efforts to enhance health information system strengthening and data use.

9.2 Further research

The findings and contributions of this thesis provide a basis for several relevant avenues for further research: into this research specifically, in Rwanda, in other countries, regarding WHO packages, or the TEU framework.

If someone were to pick up the baton and cover the gaps and limitations of this research, a few aspects would be of particular note. This thesis set out to document as many health system levels and stakeholders as possible in the limited time span of only a month. It did not get to interact with CHWs or health posts directly, and the fieldwork was limited to three of Rwanda's 30 districts. Thus, the results may not be generalizable to all districts or stakeholders of the country. Covering all health system levels and districts would ensure that results represent the situation of the entire country.

Regarding further research in Rwanda, following up on the evolution of data use practices over time would be useful to monitor progress and impact. Moreover, as the constructs outlined in this thesis capture broad aspects, each construct may be suited for separate research topics. Examining capacity building, in particular, warrants close scrutiny.

It would be beneficial to initiate similar research projects in multiple countries to gain deeper insights into factors influencing the effective use of HMISs. This would allow for comparative analysis of results and the identification of patterns and outliers over time. Such analysis would help identify areas for continuous improvement for the countries involved and the HISP project.

The initial research to be addressed in this thesis was about (1) how standardized WHO metadata packages for DHIS2 had contributed to more and better information use in Rwanda, and (2) how they shape and are shaped by the context in which they are deployed. As for the first point, the packages largely remained inspirational sources for domestically developed solutions in Rwanda. The second point remains unanswered and warrants closer inspection in other countries. As the WHO packages were used when developing systems for other nations, investigating those solutions would be of great interest. Poppe et al. (2021) call for further research to assess to what extent standardization of health packages has led to improved data use practices still stands.

As for the TEU framework, I encourage others to keep adapting it to new contexts, expanding on the literature. It was well suited to document use practices in an HMIS and I suggest others to utilize it in further countries. It would also be useful to revisit the same context and investigate data use practices like Burton-Jones and Volkoff did (2017), analyzing data-related issues of accuracy (how well information in or derived from the data holding reflects the reality it was designed to measure) and consistency (variation among how users in a given role and across roles used DHIS2. Alternatively, if time and resources are sufficient, combine the five constructs used in this thesis with accuracy and consistency.

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