Information Use in the Rwanda HMIS: an Information Infrastructure Analysis

A Case Study of Rwanda

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Abstract

Rwanda has made significant progress in digitizing and strengthening its health information system and uses DHIS2 as its Health Management Information System (HMIS). This HMIS through DHIS2, consists of several applications and technology that assist with information support for users in their decision-making process. How these users use various tools for information support is still an area that needs to be investigated.

To better understand how these tools are used this thesis applies Information Infrastructure as a theoretical lens to conceptualize the Rwanda Health Information System as a Health Information System to shed light on both social and technical contextual factors in play. In this thesis, we conduct a case study to explore the infrastructure and to understand better the hardships encountered by introducing new technology to the current system, which we call the installed base. With this perspective, this thesis will also look at the implication of this phenomenon.

Acknowledgements

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Lastly, I would like to thank Jørgen Paulsrud Andersen and Daniel Nguyen for joining me in this experience in Rwanda and for all the interesting conversations we had together.

Ozan Kara

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Abbreviations

DHIS2 District Health Information Software 2

WHO World Health Organization

UiO University of Oslo

HIS Health Information System

HMIS Health Management Information System

II Information Infrastructure

HII Health Information Infrastructure

R-HMIS Rwandan Health Management Information System

RHAP Rwanda Health Analytics Platform

RBC Rwanda Biomedical Center

HISP Health Information Systems Program

MoH Ministry of Health

LMIC Lower or Middle-Income Country

CHW Community Health Workers

Chapter 1

Introduction

1.1 Motivation

The importance of collecting, analyzing, and disseminating health data cannot be overstated, as it plays a crucial role in enhancing public health data outcomes and informing decision-making based on evidence for health workers [3]. In recent times, the use of digital tools has become increasingly vital in supporting as information support for health data analysis in Health Information Systems (HIS). However, developing countries face a significant challenge in this area as most of their HISs are fragmented and operate independently of one another [28][2]. As a result, researchers have identified fragmented and uncoordinated HIS as the primary obstacle to their effective use, which significantly hinders the efficient use of health information [2].

Rwanda is a country that has made significant progress in strengthening its health information system, including the development and implementation of a national health management information system using DHIS2 [18][26]. While there is some evidence of the impact of the HMIS on health outcomes in Rwanda, there needs to be more research on the use of digital tools for health data analysis and their impact on decision-making at different levels of the health system. There are constantly new applications being developed in DHIS2 to support health workers in their data analysis process, but little is known about to what extent these tools are being used

and by whom they are used.

In LMICs, health information systems often generate low-quality data that has limited use in informing decision-making. This is primarily due to the fragmentation and siloed nature of information management, which involves multiple partially overlapping vertical systems [24]. HISP with DHIS2 aims to address this by bundling resources in one platform with tools to build a national integrated HMIS [2].

The availability of standardized metadata packages in DHIS2 for use in different disease programs was a primary motivator for exploring the HIS in Rwanda. Our interest was to determine whether the WHO packages were being utilized and, if not, investigate the reasons behind the preference for the current HMIS tools used by the health workers, for example, data visualizations.

1.1.1 Proposed Theoretical Framework

In this research, we conceptualize Health Information Systems (HIS) as Health Information Infrastructures (HII) to better explain the complexity of the IS [13]. This way, we can use the characteristics of an II to explain further the struggles of building upon existing infrastructure and adapting to new HMIS tools in such a complex interconnected system. By adopting this approach, we hope to gain a deeper understanding of the factors that influence the adaptation of HIS tools and systems in these contexts. We will later compare the challenges that characterize HIIs with our research findings to address our research question better.

1.2 Research Question

The overall objective of this thesis is to contribute with better insight into what HMIS tools are being used by the different actors in the Rwandan HIS. New digital tools and applications are constantly being developed in DHIS2 without us knowing to what extent they are being used for information support by health workers in their decision-making tasks.

The research question is:

"How are various tools being used to support informed decision-making in the Rwandan HIS, and what are the implications?"

To be able to answer the research question we will adopt II theory [12] [13] as our theoretical lens to comprehend the reasons and ways in which the various technologies are utilized. The research is a case study that involved four-week-long fieldwork in Rwanda. The initial purpose of the fieldwork in Rwanda was to investigate the usage and implementation of WHO packages, but no meta-data packages were used during the study. Therefore, the research question above was first established after the fieldwork when we were back in Norway. However, we will still answer why they are not used, as it is relevant as a tool for the Rwandan HIS, which might explain why other tools are also not used or dropped.

1.3 Chapter Overview

Chapter 2, "Research context," provides an overview of Rwanda, and its health status, including information on their HMIS and administrative levels in the health sector. This chapter also gives a brief summary of the key stakeholders and their roles related to this topic, where HISP and DHIS2 are presented.

Chapter 3 "Related research," presents the literature and theories relevant to this research. Where II theory is adopted with a socio-technical viewpoint, this is to conceptualize the HIS as Health Information Infrastructure (HII), and HMIS as a sub-HII.

Chapter 4 "Research approach," the philosophical understanding and methodology used in this research are presented, along with a description of the methods used to conduct the study and analyze the results. The chapter includes reflections on the methods used.

Chapter 5 "Empirical findings," lays out the findings from the research conducted.

Chapter 6 "Discussion," connects the literature and theories presented in Chapter 4 with the empirical findings of Chapter 5 and explores how the

results relate to the research question using the II theoretical lens.

Chapter 7 "Conclusion," provides a summary of the answer to the research question, highlights the contribution of the research, and suggests possible future work.

Chapter 2

Research Context

This chapter provides necessary contextual information that pertains to the thesis. It commences with a brief introduction of Rwanda with general information, followed by a brief explanation of health information systems and the sub-HIS system, HMIS. Then DHIS2 is introduced, explaining the role of HISP in the relevant countries.

2.1 Rwanda

2.1.1 General Information

Rwanda is a relatively small, landlocked country located in East Africa, bordered by the Democratic Republic of Congo to the west, Burundi to the south, Uganda to the north, and Tanzania to the east. The surface area of Rwanda is around 26,338 square kilometers. The country is divided into five administrative regions, where the capital, Kigali, is one of them, which are further divided into 30 districts (see figure 2.1). An elected council and a mayor govern each district [27]. The official languages spoken in Rwanda are Kinyarwanda, French, Kiswahili, and English.

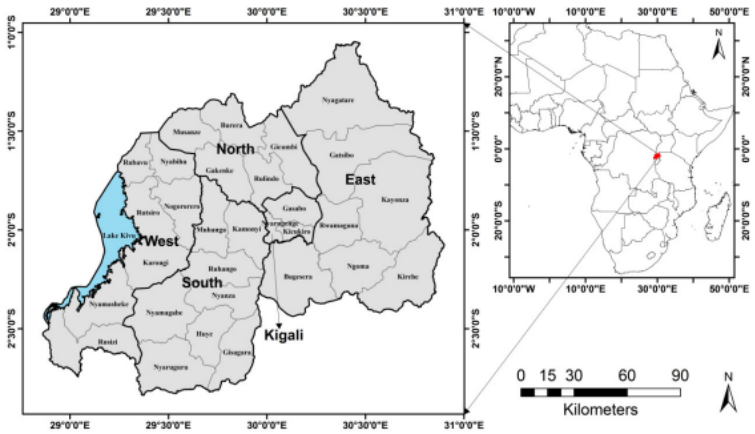


Figure 2.1: Map displaying the administrative provinces and where the country is situated in the African continent [21, p. 3]

The country has a population of approximately 13.3 million people (2022), according to the latest estimates [22]. Rwanda has a relatively young population, with over 60 % of the population under the age of 25. The population growth rate in Rwanda has been one of the highest in the world, with an average of 2.3 % per year over the last decade [22]. This demography has led to a rapid increase in the demand for education, healthcare, and other social services.

Rwanda has a tragic history, having been devastated by a genocide in 1994, in which a significant number of Tutsi people were killed by members of the Hutu ethnic group who were in the majority. Since then, the country has made significant progress in rebuilding and reconciling society, promoting peace, and strengthening its institutions.

The economy of Rwanda has been growing steadily in recent years, with a GDP growth rate of around 8 % per year, except for the year 2020, due to the COVID-19 pandemic. Agriculture is one of the primary sectors of the economy, accounting for around one-third of GDP and employing the majority of the population. Other key sectors include services, industry, and mining. The Service sector is the largest sector in Rwanda and contributes to around 47 % of the GDP. This sector includes services in the field of information and communication, but also human health activities, which have increased by over 20 % in 2022 [22].

2.1.2 Health in Rwanda

Since the start of the 21st century, Rwanda has made significant strides in public health and has achieved better outcomes on most indicators than neighboring countries in Sub-Saharan Africa. Child mortality rates for children under the age of five have seen a marked reduction from 185 per 1000 in the year 2000 to 39 per 1000 in 2021, according to the World Bank Group's under-five mortality data [10]. Similarly, maternal mortality rates per 100,000 live births have declined from 1160 in 2000 to 248 in 2017 [9].

The improvements in public health indicators in Rwanda over the past two decades are the result of several factors, including increased access to effective interventions and advances in socioeconomic conditions. The expansion of effective interventions, such as vaccinations and preventative care, has been key to improving health outcomes in Rwanda. Additionally, socio-economic improvements, including increased access to education and healthcare, have helped to raise overall life expectancy from 47 years in 2000 to 67 years in 2020, as reported by the World Bank Group [8]. These positive changes have resulted from sustained efforts and investments in public health by the government and its partners in Rwanda.

2.1.3 Administrative structure of the health system

The health delivery system in Rwanda is tailored to the hierarchical structure of the administrative levels in Rwanda (see figure 2.2). Every level has different actors and stakeholders who are involved in data collection and data analysis. The administrative levels and the corresponding health delivery systems (facilities) are [14]:

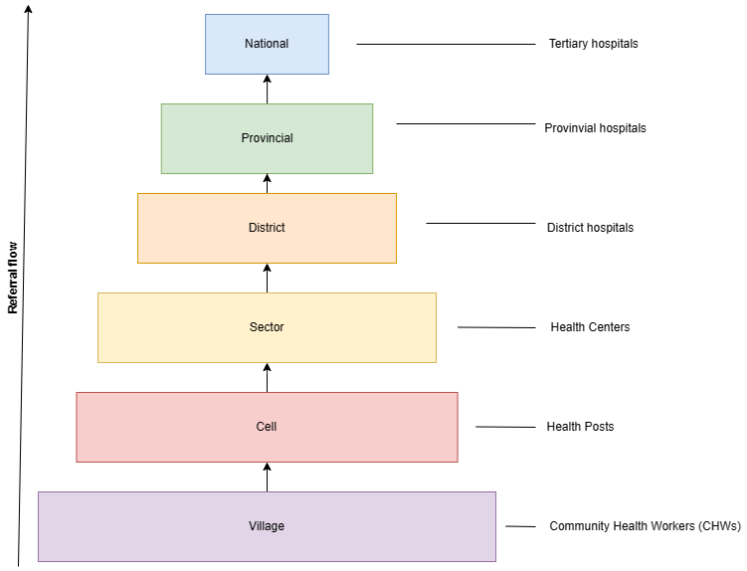


Figure 2.2: Administrative levels of the Rwandan health system and facilities

National level

At the highest level, there are tertiary hospitals or national referral hospitals that function as specialized medical centers with advanced equipment and expertise that lower-level facilities lack. These hospitals offer medical training and support to lower levels of healthcare. The Ministry of Health and the operational body RBC are also involved at this level. Where MoH coordinates and oversees the activities of the healthcare facilities, to implement new policies, guidelines, and regulations. RBC is monitoring disease programs that exist in the country.

Provincial level

At this level, there are provincial hospitals, also known as referral hospitals, which offer advanced clinical care. Patients are referred to these hospitals from district hospitals based on the type of medical care needed.

District level

At the district level, there are both district hospitals and private clinics. This level receives referrals from public health centers at the lower level. Some patients are referred directly to this level if needed.

Sector

At this level, we see the patient's first introduction to primary health care in the country. The primary healthcare facilities included in this level are health centers that are also often located in close proximity to the district hospitals. The management and coordination of health posts and CHWs in their area of responsibility are also overseen by health centers.

Cell

This level consists of health posts that function as a remote operating body of health centers, that provide similar services. Health centers will also consist of several health posts. Patients are then either referred to the responsible health center or directly to the district hospital.

Village

At the lowest level, we have community health workers (CHWs) that primarily focus on mother and child health, and give basic health education to the communities.

2.2 HISP and DHIS2

HISP is a global initiative that emerged in the 1990s when researchers from the University of Oslo were invited to participate in South Africa's Reconstruction and Development Programme (RDP) after the end of apartheid in 1994 [2]. The Health Information Systems Programme was born from this collaborative effort, which aimed to strengthen the country's health information systems and improve health service delivery. Since then, HISP has grown into a global movement that supports the development and implementation of HIS in many countries worldwide. HISP UiO, managed by the Department of Informatics at the University of Oslo, is a branch of HISP that is assisting me in this research. In HISP UiO strategy papers, the goal of HISP UiO is explained as follows:

"The overall goal of the Health Information Systems Programme (HISP) at the University of Oslo (UiO) is to enable and support countries

to strengthen their health systems together with regional HISP groups through increased capacity to govern their Health Information Systems in a sustainable way to improve the management and delivery of health services [17, p. 1]."

As part of this effort, they develop, maintain, and support the implementation of DHIS2, an open-source software platform that enables the collection, analysis, and dissemination of health data. By working closely with countries and organizations to implement DHIS2, HISP UiO is helping to build sustainable, adaptable, and cost-effective solutions to improve health service delivery. Their focus on data-driven decision-making and local ownership of health information systems underscores their commitment to empowering communities and improving health outcomes [17].

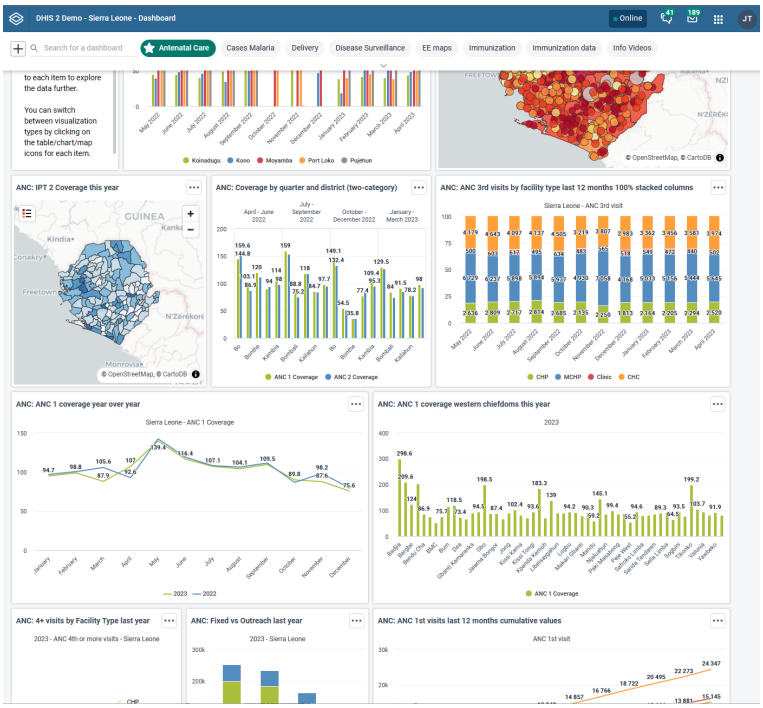


Figure 2.3: Example of a dashboard in DHIS2

The HISP team continues to refine the DHIS2 platform, to facilitate the collection of aggregate health data in accordance with the specific needs of individual countries. In addition, there are developer teams operating at the local level, like HISP Rwanda, who are focused on customizing

the software to meet the specific needs of individual countries [29] [2]. This localization effort is an important aspect of DHIS2's design, as it ensures that the system is tailored to meet the unique data collection and reporting requirements of each country[25]. By working closely with local developers and stakeholders, DHIS2 is able to support the development of sustainable, locally-owned health information systems. Currently, there are over 100 countries that use DHIS2 as their HMIS platform [29].

Chapter 3

Related Research

In this chapter, we will start with presenting IS and HIS. Then, we will present Information Infrastructure (II) as a theory to understand the complexity of heterogeneous socio-technical systems better. This will allow us to conceptualize the HIS in Rwanda as a Health Information Infrastructure (HII) that includes many sub-HIIs, like the HMIS. This will help us understand how the different tools are used and why they are used. The implication can also be drawn from the same II theory.

3.1 Information Systems (IS)

Given that this thesis delves into information systems within the health sector, it is crucial to initially explore the comprehension of IS as well as the distinct difficulties and developments pertinent to health information systems.

Richard T. Watson defines information systems as "Information system is a set of entities, shared patterns, and information processing capabilities that support goal attainment. [7, p. 520]". Winter (2011) describes it as an institution that takes care of the control and maintenance but also the storage of information. It further considers the socio-technical element of an IS. It describes the institution as a socio-technical subsystem [33], where both human actors and technical aspects are included in the system. That means the staff, as well as the information itself, along with the methods

that are used for management. The part of the information system that runs on a computer can be called a computer-based information system.

3.1.1 Socio-Technical Perspective

The "socio" aspect encompasses the people involved in the processing of information [33] and includes elements such as human behavior, routines, norms, culture, politics, and motivations. The "technical" aspect includes physical structures and tools used for information processing [33], such as hardware, software, and paper-based systems. Failure to consider the socio-aspect limits our comprehension of how the system operates and its impact on work processes, ultimately affecting the IS design. As part of this thesis, my focus is on information systems viewed through a socio-technical lens, where both elements are considered.

In the relatively early days of computing in organizations, in the seventies and the eighties, there were big assumptions going on by technologists that computer-based systems would increase productivity [2]. However, after the introduction of computer-based tools in organizations, the results showed several stories of failures. Research that started looking into this in the eighties showed that it was not only the technical aspect that was at fault when the system failed. "The research into failures rather revealed the reasons pertaining to the social, institutional, and political conditions, such as the absence of top management support, lack of user involvement, and the centralization of systems" [2, p. 12]. In other words, it was the context around the systems, like user involvement and management by the organization, that was the primary reason. Therefore, starting in the eighties we see a "social system" being implemented as a new perspective to view IS, and instead view the technical and social aspects together [2].

In addition, when designing and setting up information systems, it is insufficient to rely solely on technical aspects. Instead, it is essential to have insight into how individuals operate and their organizational practices. As a result, information systems must be regarded as intricate, interconnected socio-technical structures that consist of individuals in various roles and connections, hardware and software, as well as rules, standards, and regulations, among other things [19].

3.1.2 Health Information Systems (HIS)

The field of information systems includes many different types of systems. For the purposes of this thesis, the focus has been primarily on Health Information Systems (HIS), which is a collective term for information systems related to health. In Winter (2011), a hospital information system is defined as a " ... socio-technical subsystem of a hospital, which comprises all information processing as well as the associated human or technical actors in their respective information processing roles" [33, p. 33–34]. Therefore, from the definition of information systems, we are able to define health information systems, where it can be described as an IS in the healthcare sector.

In developing countries, Health Information Systems involve numerous health workers who are responsible for collecting, recording, organizing, and reporting data in various formats. The data and information gathered are then analyzed and utilized in diverse manners by different individuals to facilitate informed decision-making and enhance the delivery of health services [2]. Braa and Sahay (2012) argue, therefore that, the socio-technical perspective, is particularly vital in developing countries for understanding the HIS. Health Information Systems are not just systems that store and process data [2]. They also involve human and organizational stakeholders. A socio-technical approach can be beneficial in comprehending the obstacles associated with implementing new information systems or altering existing ones, as this will require not only technical but also organizational changes. These modifications can include adjusting work procedures and restructuring the organization [2].

Health information systems encompass a range of systems that integrate the collection, processing, reporting, and utilization of health information to enhance the effectiveness and efficiency of health services management at all administrative health levels [20]. Given the diverse information requirements across various healthcare domains, such as human resources, patients, diseases, and medications, HIS comprises multiple sub-systems tailored to meet these specific information needs. These sub-systems are designed to manage and analyze health data, generate reports, and provide decision support for stakeholders to improve health-

care outcomes. One such sub-system is a health management information system (HMIS).

3.1.3 Health Management Information System (HMIS)

One type of sub-system within HIS is the Health Management Information System (HMIS). HMIS is designed to collect, process, and report on aggregate health data to support evidence-based decision-making at various levels of the healthcare system [2].

HMIS is primarily concerned with collecting and analyzing health data at a population level rather than individual patient data. It provides information on health indicators such as disease prevalence, morbidity and mortality rates, and health service utilization. This data is then used to monitor health trends, identify disease outbreaks, and allocate resources appropriately [2].

3.2 Information Systems as Information Infrastructures

To comprehend the socio-technical aspect of information systems, the notion of information infrastructure proves valuable. Even though, having a social-technical perspective is valuable for comprehending the significance of the contextual factors surrounding information systems, incorporating the theory of information infrastructures (IIs) [13] can provide further insight into the intricacy of information systems and how they develop as a component of broader infrastructures. This approach can be particularly beneficial in effectively addressing and explaining the complexities of information systems.

Information Infrastructures (II) can be defined as "a shared, open (and unbounded), heterogeneous and evolving socio-technical system (which we call installed base) consisting of a set of IT capabilities and their user, operations and design communities" [13, p. 4]. This definition highlights the socio-technical nature of II, as it includes both the technical components (i.e., hardware and software) and the social aspects (i.e.,

shared goals, culture, and practices) of information systems. IIs are shared in the sense of being shared across various communities in countless and unforeseen ways, not only being used by a single user group. They possess an inherent unbounded openness and are ever-evolving, meaning that new components can be added and integrated with them unexpectedly and in diverse contexts [13] [12].

Components within an information infrastructure can include not only technical elements but also users, user communities, and organizations with varying and evolving requirements [13] [12]. All these factors lead to the characteristic of IIs being heterogeneous. Initially, IIs can be seen being "socio-technical networks" that include not only technological components but also humans, organizations, and institutions. Second, an II consists of ecologies of infrastructures, as described in Hanseth (2000) [12]. These ecologies are comprised of several sub-infrastructures that are interconnected, interrelated, and interdependent. This interconnectivity allows for the layering of sub-infrastructures upon each other, as well as the integration or replacement of existing infrastructures, which is known as the installed base [12] [13]. By considering an II as both a socio-technical network and an ecology of infrastructures, we can better understand how information systems operate as part of more extensive, interconnected system collectives rather than standalone ones [15].

Viewing IIs as emerging from their installed base implies that infrastructures are not created anew but instead rely on and expand upon what is already in place [12]. To foster growth in an II, it is necessary to adopt the approach of installed base cultivation [13] [32]. This involves recognizing the presence of an installed base and incrementally introducing changes to it in order to transform the II. This cultivation process comprises three main aspects to consider [32]. The first one is process orientation, which requires designers to modify existing technology and practices incrementally. The second aspect is user mobilization; this means that designers do not have complete control over the design environment and have no authority in prescribing what is going to be used and what is not. Instead of dictating what technology should be used, the designers should focus on creating motivation for the adoption of new technology. In Hanseth and Aanestad (2003), it is argued that the most motivated users of the

new technology need to be identified and selected before moving over to the less motivated users as the network grows [11]. Lastly, learning is an important aspect of the cultivation process, as designers need to identify what is working well and what is not [32].

3.2.1 Complexity of the Installed Base

In the context of an II, it is common practice to introduce new technical additions as either extensions or modifications of the existing ones within the installed base. In Braa and Sahay (2012), it is stated that "As the installed base grows, it becomes increasingly difficult to build systems from scratch and to implement substantial changes" [2, p. 14]. In other words, the larger it grows, the more complex the installed base becomes.

The significance of side effects in complexity theory lies in the fact that modifying one aspect of an II may cause unintended or intentional changes in other areas. This dependency on previous changes can affect the IIs development trajectory, as side-effects may initiate subsequent changes that lead to additional side-effects [16]. Complexity is defined by the "... dramatic increase in the number and heterogeneity of included components, relations, and their dynamic and unexpected interactions in IT solutions" [16, p. 2].

Chapter 4

Research approach

The following chapter provides an overview of the philosophical assumptions that underpin this study and the research methodology that was chosen to explore the research question. Additionally, I will outline the chosen approach to data collection and analysis procedures that were employed to generate insights into the research topic. By doing so, readers will gain a clear understanding of how the research was conducted and the underlying principles that guided the study.

4.1 Philosophical understanding

Every researcher brings their own set of underlying assumptions and beliefs to the research process, which shape their approach to investigating the research question. I adopt an interpretive philosophical assumption, which is grounded in the belief that "... assumption that access to reality (given or socially constructed) is only through social constructions such as language, consciousness and shared meanings" [5, p. 5], which guides my understanding of the nature of reality and the role of the researcher in generating knowledge. Interpretive researchers aim to understand phenomena through the meanings that people assign to them and to explore the subjective experiences and perspectives of research participants [5]. This approach is in opposition to the positivistic paradigm, which assumes that reality is objectively given and that the

goal of the research is to establish a "final truth" [5]. Instead, interpretive researchers aim to construct an inter-subjective understanding of the phenomenon in collaboration with research participants.

As an interpretive researcher, my focus in this study has been on understanding the phenomenon and its surrounding context through the perspectives and experiences of the research participants. Rather than seeking objective truth, I have sought to gather subjective meanings and interpretations from those in the field. As a researcher, I am aware that I have my own subjective assumptions about how the world is, shaped by my own knowledge and the input of others. These assumptions may influence how I approach the research, including the design of interview guides and other data collection instruments. For example, the questions in the interview guides were formulated based on my assumptions about what kinds of information might be most relevant or informative, given my prior knowledge of the context and the research questions at hand. It is important to acknowledge these underlying assumptions and their potential impact on the research process and outcomes.

Acquiring knowledge of the infrastructure, health system, and organizational structure in Rwanda is crucial in identifying the various stakeholders and their interests. Such information is necessary when examining an information system or any phenomenon related to the health sector. Additionally, understanding the perspectives of the users of these information systems is essential. By obtaining their subjective feedback, it is possible to gain insight into how they utilize the systems in their daily work, leading to a better understanding of their practices and challenges.

4.2 Case study

A case study approach has been selected as the most appropriate methodological framework for this research. Case studies are commonly used in social science research to provide an in-depth understanding of a particular phenomenon within its real-world context [34]. A case is typically distinctive, particular, and limited to the specific circumstances or context in which it occurs. The complex nature of the phenomena

makes this methodological framework a good candidate to research the phenomena within its own context to get insights into the situational factors at play [6] [1].

Case studies are useful in situations where a deep understanding of a phenomenon is necessary, and a strict focus is required. However, case studies have been criticized for their limited generalizability. Case studies are often viewed as being unrepresentative of the broader population, as they are based on a single or a small number of cases. This view suggests that case studies may not provide sufficient information to support generalizations about a given phenomenon [30]. However, it is argued that generalizability is not a requirement for good research, but rather, the key aim is to produce a rigorous analysis of the case at hand. It is worth highlighting that many tend to overestimate the significance of formal generalization, either based on extensive data or individual cases, as the predominant way to advance scientific progress [6].

4.2.1 Research Origin

When the field trip took place, there was not yet established a concrete research question for the study. There was a lack of knowledge about the usage of DHIS2 in Rwanda, more specifically, the use of the WHO packages provided by the platform to easily set up a dashboard for the different disease area programs. This initially sparked interest in performing a case study of Rwanda to understand which tools were used by the different stakeholders in Rwanda HIS. The research question was, therefore, established when the field trip was over to analyze the data in a more focused manner.

The field trip was performed through a joint effort with two other students who were working on understanding the same phenomena. All data collection and data analysis activities were conducted together throughout the research. On the first few days of the fieldwork, we were also joined by our supervisor, who accompanied the team and visited the sites. Together, we met the MoH representatives and HISP Rwanda. When the supervisor left, we maintained online communication to give an update on our early findings. A cooperative compilation of the collected data was made

throughout the fieldwork. Sharing of ideas and discussions together with the supervisors was necessary to narrow down our research focus.

After a few days in the field, it was established that the WHO packages were not used in the case of Rwanda, which shifted our focus over to rather understanding why they were not used, and what was used instead of the tools provided through DHIS2. Therefore, an effort was made to understand the HIS in Rwanda and HMIS as the sub-HIS system. A case study was a good framework to map out the different systems used by the different stakeholders in the HIS. A goal through the fieldwork was to understand the role of the systems at the different levels in Rwanda's health information system.

To obtain a comprehensive understanding of the use of information systems at different levels of the health system, we aimed to gather insights from various stakeholders. Instead of only focusing on existing solutions by the different actors, we also tried to identify their practices. Factors beyond just understanding the use of current systems were captured to understand the more comprehensive connection of the factors in the infrastructure.

4.3 Data collection

The upcoming section will outline the objectives for gathering data and selecting participants. It will also detail the diverse data collection techniques employed and the means of recording data.

4.3.1 Participants

The field trip was somewhat unplanned because of the exploratory and broad research area of the case. The participants and facilities we visited were chosen together with HISP Rwanda and MoH, who planned meetings with the different users of the HMIS. The intention was to cover all stakeholders and roles within the Rwanda HIS and cover all the levels in it. There were several limitations in the planning of picking candidates. Someone from HISP Rwanda was required to join us in many of the field visits because of the need for a translator. Therefore, both the interview

subject and the candidate from HISP Rwanda needed to be available at the same time for the field trip to take place. We were also very dependent on finding someone who could drive us to the participants.

During the four weeks in the field, we were able to only interview a limited amount of participants (see table 4.1). We were able to cover the national and district level but only managed to interview one data manager at both the district hospital and the referral hospital.

Name of the facility	Facility category	Subject
HISP Rwanda	HMIS office	DHIS2 implementor
RBC MCCH	MCCH division office	MCCH representative
RBC	RBC HQ	Data analyst
Kibagabaga District hospital	Hospital	Data manager
Muzanse Referral hospital	Hospital	Data manager
Muzanse Health Center	Health center	Head of health center
HMIS workshop at La Palisse Hotels Nyamata	Hotel	Data managers and data analysts

Table 4.1: Overview of interview subjects and their role

HISP Rwanda representatives had an important role in our field visits for us to better understand the context of our observations. Since HISP Rwanda worked together with the data managers and data analysts, they already had a relationship, which made it easier to communicate with them. However, this was also the reason most of the communication with the participants went through a third person, and they could sometimes speak on behalf of the interview subject.

4.3.2 Data Collection Methods

Before conducting the fieldwork, a preliminary investigation was carried out to examine the functionality of the applications in DHIS2 that is available to the data managers and data analysts. It was somewhat required by us to understand the use cases of the different functionalities of the data visualization application and other applications. This way, it could be easier for us to understand the context, and map out the similarities and differences between the systems in use later in the research. Additionally, approval for conducting the research was obtained by submitting an application to the Norwegian Centre for Research Data (NSD).

This study adopts a qualitative approach to data collection, utilizing interviews, observations, and document analysis. Visits were made to seven facilities at both the national and district levels, with multiple participants randomly selected for inclusion in the data collection process.

At the district level, the routine tasks of data managers at hospitals were examined, along with the systems and tools used to support their data management processes. A comprehensive mapping of the different systems and applications in use was carried out, along with an investigation into the reasons for their preference.

At the national level, the data analysis processes of data analysts at RBC were studied. This included an analysis of how they utilized the HMIS and the tools available to them to present their data. We looked at any difference in preference between data managers and data analysts.

4.3.3 Interviews

Semi-structured interviews were the primary method used for data collection in this study. Semi-structured interviews are a form of qualitative data collection that allows the interviewer to guide the conversation while also allowing the participant to provide their own perspectives and experiences. The semi-structured nature of these interviews provides flexibility in the questions asked, allowing the interviewer to follow up on responses or clarify any unclear statements.

Conducting interviews with this approach usually results in new topics and thoughts arising, that were not thought of prior to meeting the participants [4]. For example, our questions and understanding of the phenomena changed between the first data manager we interviewed versus the last one (figure 4.1).

Figure 4.1: Interview with a data manager demonstrating and explaining what tools he uses for data analysis

In this study, semi-structured interviews were conducted with healthcare professionals who have experience working with the Rwandan Health Management Information Systems (R-HMIS). The interviews were conducted in person, via phone or video call, and lasted between 30 minutes to an hour. The interviews were audio recorded with the participants' consent, and later transcribed for analysis.

The use of semi-structured interviews allowed for a deeper exploration of the participant's experiences and perspectives on HIS. The open-ended questions asked during the interviews allowed the participants to express their thoughts and opinions freely and provided rich data for analysis. Additionally, the flexibility of the semi-structured format allowed for follow-up questions to clarify or expand on the participant's responses.

In our first interviews, we rather used unstructured interviews, where there were no predefined questions at all. One reason for this was the

broad research area, where the research question was not really set yet. In unstructured interviews the conversation flows freely, uncontrolled [4]. The questions rather came naturally as a part of the topic participants wanted to talk about.

4.3.4 Observation

Observation is a method of data collection used in qualitative research that involves the systematic and careful observation of people, objects, or phenomena in their natural settings. In this study, observation was used as a supplementary method to semi-structured interviews, with the aim of gathering additional data to complement the interview findings.

Observations were conducted in healthcare facilities that were a part of the Health Information Systems (HIS). The researcher visited the facilities and observed the use of the HMIS and other tools by healthcare professionals, including how they accessed, inputted, and used aggregated data. The researcher also observed the physical environment of the facilities, including the layout and design of the HIS interfaces and the availability of necessary resources such as computers and internet connectivity.

Observations were recorded in field notes, which included detailed descriptions of the observed phenomena and any notable patterns or trends. These notes were later reviewed and analyzed to identify common themes and patterns related to the use of HIS in healthcare settings.

The use of observation as a data collection method provides a unique perspective on the use of HMIS in real-world settings. It allows for a deeper understanding of the practical challenges and opportunities associated with the implementation and use of HMIS. Additionally, observation can reveal aspects of behavior or practices that may not be evident through self-reported data or interviews.

There are also limitations to the use of observation. One major limitation is the potential for observer bias, where the researcher's interpretations of the observed behaviors may be influenced by their own preconceptions or biases. Additionally, observation can be time-consuming and may not be feasible for certain research settings or populations. However, the

observation performed was never really planned and naturally became a part of the environment where the interviews were conducted. It was helpful in the way of adding visual context to what is talked about by the participants, which also helps to remember the context around the data collected.

4.3.5 Document Analysis

To enhance the understanding of the research area, this study employed document analysis prior to, during, and after the field trips. Initially, the research team examined documents to obtain a comprehensive comprehension of the diverse systems and applications and their utilization.

After our field trips, we were provided with documents by both HISP Rwanda and the Ministry of Health to understand better the context of the data collected during the interviews and observations. These documents would, for example, give details on the utilization of paper-based registries and the duties and responsibilities of the interviewed participants. The documents from the government sites and RBC provided insights into how the HMIS was intended to be utilized in the country.

4.4 Data Analysis

To make sense of the empirical material gathered through fieldwork, I employed an interpretive approach that involved scrutinizing and critically examining the data [4]. This method enabled me to analyze the data in a more formal and structured manner. In Walsham (2006) it is stated that:

"... the researcher's best tool for analysis is his or her own mind, supplemented by the minds of others when work and ideas are exposed to them" [30, pp. 325]

In other words, even though this study was conducted together with two

other students. The process the data analysis happens primarily by one researcher in his own mind [31]. Both during and after data collection, and does not necessarily need to involve coding to identify themes in the findings. It, however, also mentions that discussions of the findings with other researchers also played its role as a secondary analysis.

Collaboratively, we produced transcriptions from each field visit soon after the field visit was over and later compiled them into more coherent documents and field reports. This way, it was easier to remember what was heard and seen while the memory of what we discovered still was fresh. To ensure reliable and relevant information, the transcriptions were generated through discussions and comparisons of all researcher's field notes and were written in cooperation with each other. This could include drawings that illustrate the patterns or the hierarchical structure of the facility we visited. We also labeled the most significant photos from each field trip to facilitate the analysis process.

The shared documents were then often presented to HISP Rwanda, who wanted updates or a short presentation to supply our analysis further. This cooperation also assisted us in how the next interview would be conducted to explore specific cases, going from unstructured to semi-structured interviews.

On an individual basis, I conducted data analysis by organizing, reading, and re-reading all written documents gathered during the fieldwork. At some point, I grouped the findings into distinct categories to better comprehend the research areas that we had investigated. This approach was particularly effective because our research explored a wide range of topics within the Rwandan HIS.

4.5 Reflections and Ethical Consideration

Before conducting research in Rwanda, it was necessary to determine whether my study was subject to notification to the Data Protection Official for Research (NSD) in Norway. If the project involves the collection and handling of personal data, it has to be notified to them, so they can ensure that the data handling is carried out in compliance with

the law. This research got the necessary licenses from NSD in Norway to conduct the research (see appendix A).

To ensure the protection of participant privacy, we took several precautions during data collection. Any data that could potentially identify participants or contain sensitive information was deleted after transcription (voice recordings). There was no consent form before the interviews, but because of practical reasons, HISP Rwanda assisted us verbally and told the participants about the research in Kinyarwanda because of language barriers. When photos were taken we made sure to ask for permission, and blurred out the faces in our notes, in case we wanted to use them in the thesis. We were not allowed to look at data in their systems that may contain sensitive data of patients, and therefore do not have pictures showing these as well.

There are several factors that could impact the data in our findings from the fieldwork. Our status as master students could influence the way research participants perceived our roles and the research. Health workers like the data managers from lower-level facilities could see us as people with the authority to bring changes to their R-HMIS, while participants at the national level could view us as master's students who just needed data to complete their master's thesis. This could also explain why we had a lot of research participants the first few days when the supervisor was present with us in the field. The "dead" time between finding participants for the research increased once the supervisor left.

There was also a problem of language barrier where we had no control over what languages were used, some participants would simply speak Kinyarwanda, and we were therefore very dependent on a translator. Certain nuances could be changed during the translation. Since we were dependent on HISP Rwanda to find relevant interviews we would join whatever they had in their plans, sometimes the meetings would be relevant for our research, but other times not, it could also be hard to establish the relevancy, when the meetings were only conducted in their locally spoken language, Kinyarwanda.

Chapter 5

Empirical Findings

5.1 The Rwanda Health Information Infrastructure

5.1.1 Organizational Structure of Rwanda Health System

Understanding the health information infrastructure in Rwanda is contingent upon comprehending the country's hierarchical structure and the functions of each level within the system.

Central level

The central level of the Rwanda health system is primarily responsible for overall strategic guidance, policy development, resource mobilization and allocation, and coordination of health services across the country [23]. The Ministry of Health is located at this level and provides support to the health system. The MoH sets national health policies and guidelines, supervises the implementation of health programs, regulates the health sector, sets standards for health service delivery, and evaluates the performance of the health system. Other key institutions at the central level include the Rwanda Biomedical Center which was established by the Ministry of Health to consolidate and streamline the implementation of various health programs and initiatives at the national level. Prior to the establishment of RBC, these programs were being implemented by

different departments and units within the Ministry of Health, leading to fragmentation and duplication of efforts. RBC was therefore established to provide a centralized and coordinated approach to the implementation of health programs, with the aim of improving efficiency, effectiveness, and accountability.

National referral hospitals

The national referral hospitals are located at the intermediate level of the Rwanda health system [23]. These hospitals provide specialized and tertiary care services to patients referred from health centers and district hospitals. Rwanda has four national referral hospitals: University Teaching Hospital of Kigali, Butare University Teaching Hospital, King Faisal Hospital, and Rwanda Military Hospital.

Intermediary Level

The intermediary level of the Rwanda health system includes district hospitals, health centers, and health posts [23]. These facilities provide primary and secondary care services to the population. District hospitals are located in each of the 30 districts of Rwanda and provide comprehensive health services. Health workers at these facilities are the first point of contact for patients seeking care.

Peripheral Levels

The peripheral level of the Rwanda health system includes community health workers [23]. They provide health education, immunizations, family planning services, and referrals to health facilities when necessary. Village health committees are community-based organizations responsible for mobilizing and coordinating community health activities.

5.1.2 The Actors in Rwanda HIS

HMIS administrators

HMIS personnel at the MoH are responsible for the management and maintenance of health information systems, including the DHIS2 platform. They ensure the timely and accurate collection, storage, processing,

analysis, and dissemination of health data at all levels of the health system. One specific task was setting the standard for reporting forms used by data managers.

Data managers in health centers, district hospitals, and referral hospitals

Data managers are responsible for managing and maintaining the health information systems at the facility level. They ensure that health data is collected, entered, and stored accurately and in a timely manner. They also conduct data quality checks and prepare regular reports on facility-level health indicators. Data managers also work with other health facility staff to ensure that health data is used to inform decision-making and improve the quality of care provided

Monitoring and Evaluation Officers

M&E Officers are responsible for ensuring the quality and effectiveness of health programs through the systematic collection, analysis, and use of data. Their tasks include monitoring program implementation, tracking progress toward program objectives, and evaluating the impact of interventions on health outcomes. They work closely with program managers, health providers, and other stakeholders to ensure that health programs are effective and efficient. M&E Officers also collaborate with data managers to ensure that data collection and management systems are functioning properly and that data is accurate and reliable. Their ultimate goal is to support evidence-based decision-making and continuous improvement in health programs.

Data analysts at RBC disease programs

Data analysts working with disease programs at RBC are responsible for analyzing and interpreting data related to specific diseases such as HIV, tuberculosis, malaria, and others. They work with program managers and other health professionals to develop strategies for disease prevention and control, including monitoring and evaluation of disease control programs. Data analysts also contribute to the development of evidence-based policies and guidelines for disease control programs, using data to

inform decision-making at all levels of the health system.

Head of health center

The head of the health center is responsible for the day-to-day management of the health center, including overseeing the provision of health services, managing staff, and maintaining essential medicines and supplies.

DHIS2 implementors at HISP Rwanda

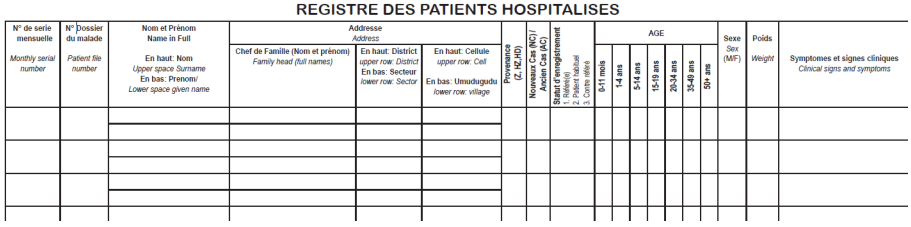
HISP Rwanda is a non-profit organization that works in partnership with the Ministry of Health and other stakeholders to develop and implement health information systems in Rwanda. They provide technical support and capacity building to strengthen the health information system, including the DHIS2 platform. HISP Rwanda also supports research and innovation in health information systems to improve the delivery of health services in Rwanda.

5.1.3 Applications in Use

DHIS2 (R-HMIS)

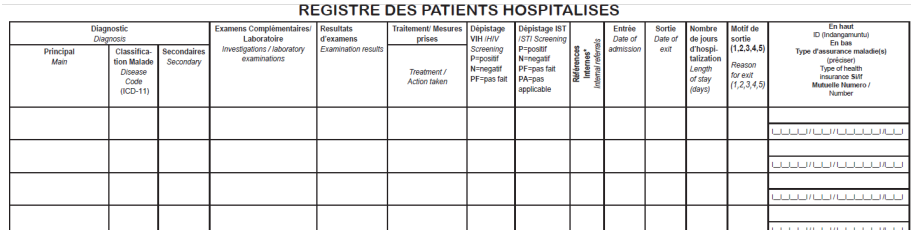
One of the key findings that emerged early on was that a significant number of actors involved in managing and analyzing data at RBC, who made use of the Rwandan Health Management Information System (HMIS), were not very familiar with the term “DHIS2”. It was rather commonly referred to as the “R-HMIS”. According to HISP Rwanda, only they and the DHIS2 implementors at the HMIS office were the only ones who had knowledge of the fact that the R-HMIS was powered by the DHIS2 platform. The reason behind this lack of awareness among the majority of DHIS2 users was that the Ministry of Health deliberately avoided using the term "DHIS2". This was done to prevent any further misunderstandings that the HMIS system was solely intended for districts. Instead, the system was referred to as the R-HMIS to avoid confusion. This way, it was made clear that the HMIS system was not just limited to districts but was a national system that could be used by all levels.

There was at least one data manager working in each of both lower-level and higher-level health facilities present in Rwanda. DHIS2 had a key role in the process of data collection, where it was the only tool utilized to digitize data entry. Data collection and entry into DHIS2 in Rwanda involves a hybrid system where both digital tools are used but also paper-based forms. After patient visits, health workers will register data onto paper-based registry forms (see figures 5.1-5.4). These registry forms are then used by data managers to compile the data into another paper-based form that is compatible with DHIS2 data entry requirements. Following the SOP guidelines provided by the central level, the data managers need to verify and make corrections to the data by comparing the received forms and registers, and finally enter the compiled data into DHIS2. This must be done before the 15th of every month, at midnight, which triggers an automatic data set locking where no more data entry is possible. The data managers mentioned that it was still possible to change the data sets after this date, but then the relevant program would have to fill out a request form for the HMIS unit at the central level to review the proposal. If the request is accepted, they will be able to unlock the dataset for the facility.


REGISTRE DES PATIENTS HOSPITALISES

N° de serie mensuelle *Monthly serial number*	N° Dossier du malade *Patient file number*	Nom et Prénom Name in Full En haut: Nom *Upper space Surname* En bas: Prénom/ *Lower space given name*	Addresse *Address* Chef de Famille (Nom et prénom) *Family head (full names)*	En haut: District *upper row: District* En bas: Secteur *lower row: Sector*	En haut: Cellule *upper row: Cell* En bas: Umuduguduu *lower row: village*	Provenance (C.S. (AD))	Nouveau Cas (NC)/ Ancien Cas (AC)	Statut d'enregistrement 1. Référé(e) 2. Patient référant 3. Interne	AGE 0-11 mois	1-4 ans	5-14 ans	15-19 ans	20-34 ans	35-49 ans	50+ ans	Sexe *Sex* (M/F)	Poids *Weight*	Symptomes et signes cliniques *Clinical signs and symptoms*

Figure 5.1: First page of patient registry for incoming patients


REGISTRE DES PATIENTS HOSPITALISES

Diagnostic *Diagnosis* Principal *Main*	Classification Maladie *Disease Code (ICD-11)*	Secondaires *Secondary*	Examens Complémentaires/ Laboratoire *Investigations / laboratory examinations*	Resultats d'examens *Examination results*	Traitement/ Mesures prises *Treatment / Action taken*	Dépistage VIH *HIV Screening* P=positif N=negatif PF=pas fait PA=pas applicable	Dépistage IST *ISTI Screening* P=positif N=negatif PF=pas fait PA=pas applicable	Référence Interne* *Internal referrals*	Entrée *Date of admission*	Sortie *Date of exit*	Nombre de jours d'Hospitalization *Length of stay (days)*	Motif de sortie (1,2,3,4,5) *Reason for exit (1,2,3,4,5)*	En haut ID (Indangamuntu) En bas Type d'assurance maladie(s) (préciser) Type of health insurance Sitf Mutuelle Numero / Number
													(_ _ _ _ _)/(_ _ _)/(_ _ _ _ _ _ _)/(_ _ _)
													(_ _ _ _ _)/(_ _ _)/(_ _ _ _ _ _ _)/(_ _ _)
													(_ _ _ _ _)/(_ _ _)/(_ _ _ _ _ _ _)/(_ _ _)

Figure 5.2: Second page of patient registry incoming patients

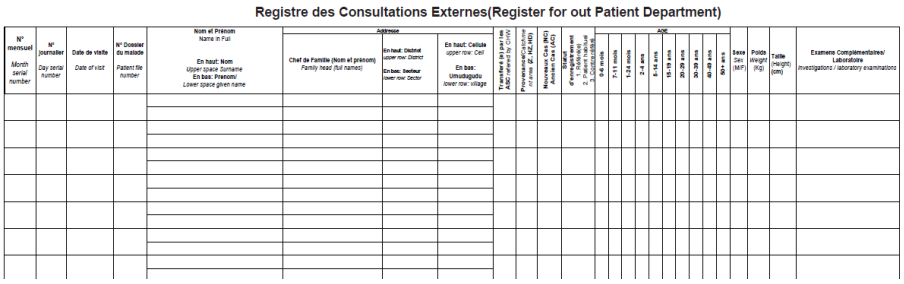


Figure 5.3: First page of patient registry

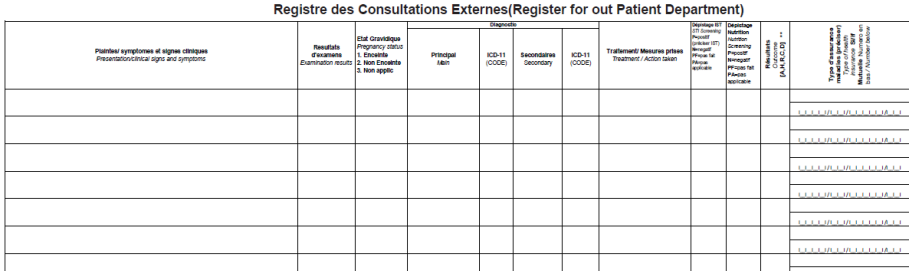


Figure 5.4: Second page of patient registry

DHIS2 does also have a role in the process of data analysis and presenting the data. Data managers at the facilities and data analysts at RBC have the routine task of providing reports when requested. Every month the data managers are tasked with attending a "coordination meeting" at the district level, together with E&M officers and other facility managers. During these coordination meetings, data managers typically present the latest data on the topic of interest, such as health outcomes or education indicators, using graphs, charts, and other visual aids. Participants then have the opportunity to discuss the data, share insights, and identify areas where further data collection or analysis is needed. The goal of the meeting is to improve coordination and collaboration among stakeholders, promote data-driven decision-making, and ultimately improve outcomes in the sector of interest.

Some data managers and data analysts presented good experience with using the DHIS2 data visualizer application. They were able to fetch the available data and create pivot tables, charts, and maps. Then an image capture tool like MS Windows snipping tool was used to make a

screenshot of the data visuals in the dashboard. They would also save the charts and tables they created for future use cases. Most dashboards they used were either made by the data managers or with the assistance of DHIS2 implementors. However, most use of DHIS2 would stop after fetching data into pivot tables. One of our early important findings was the limitation of DHIS2 use when analyzing data sets and creating visualizations.

The use of DHIS2 would mostly stop after fetching the data as tables, there were different reasons behind this:

1. DHIS2 training was halted due to covid. There has not been any well-organized refreshment training since 2019.

2. MoH decided to divide the M&E officers with IT expertise into new roles away from the district level. Therefore, the data managers no longer have the same level of experience with the R-HMIS tools.

3. Some data managers and data analysts are well-experienced with DHIS2, but other tools support their workflow better. Other tools are used to work around restrictions faced in DHIS2.

The figure below shows the workflow data managers go through to generate reports. They use a variety of different applications, yet the R-HMIS (DHIS2) is used in the process of data analysis in all cases to load the data (figure 5.5).

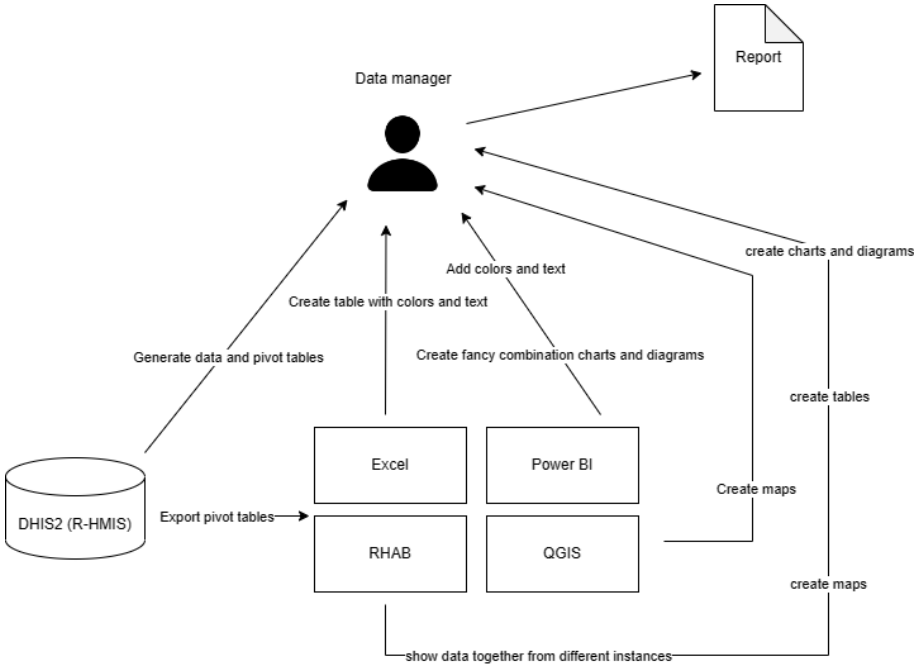


Figure 5.5: Applications used by data manager for data analysis and reporting

RHAP

RHAP is another dashboard application which is developed by Zenysis Technologies which specializes in data management and analysis solutions for government and international organizations. RHAP which stands for Rwanda Health Analytics Platform, is a platform specifically designed for the healthcare sector in Rwanda. RHAP is used as a comprehensive platform that consolidates and manages health data from different sources, providing data visualization, analytics, and reporting tools. This enables health workers at RBC and data managers to monitor and enhance health outcomes by streamlining analysis processes, identifying areas of improvement, and facilitating data-driven decision-making. Zenysis is an analytics and data interoperability platform that combines data from various systems, making them accessible within a single platform for analysis. It addresses the problem of siloed information systems that hinder analysts from comprehending the insights conveyed by data and performing comprehensive data analysis.

It was explained that RHAP was developed and adopted because of the

fragmentation of the DHIS2 system into three separate instances, which is:

1. The HMIS, which the data manager uses.

2. The HIV instance, in RBC.

3. SISCOM (System d'Information Sanitaire Communitaire), which contains data for community health services. The community data was previously collected through a RapidSMS system. A proof of concept was introduced in DHIS2 with identical data, which resulted in it being a separate instance.

Rather than migrating the entire dataset to a larger server, the standard practice was to create new servers for individual new DHIS2 instances when the existing server reached capacity. This was an easy approach since it did not affect the data reporting and quality. In order to address the issue of fragmentation caused by this, which used different standards and had limited analytical capabilities, RBC partnered with Zenysis. This collaboration enabled the integration of the three different instances into a single platform, RHAP. Data managers showcased examples of how data from the HMIS, SISCOM, and HIV could be presented side-by-side to support their data analysis needs for monthly coordination meetings, which was previously a cumbersome process that required querying each system separately.

One interesting finding was that RHAP and the functionalities for making dashboards looked very similar to DHIS2. The styles of charts, tables, and maps looked very similar to the functions that the DHIS2 data visualizer application provides. However, just like the use of DHIS2 it was also a varying use of RHAP by data managers, we did not observe any data analysts who used the platform. It was explained to us that Zenysis also arranges training for the platform.

Excel

Excel was the most used software tool for data visualization and analysis. Most data managers and data analysts preferred to fetch the relevant data

sets from DHIS2 and extract it to Excel to further manipulate the tables, add text, and customize styling. Then the relevant data visualization was extracted into some form of a report or presentation.

Data managers would often jump over to Excel when something did not work using the DHIS2 data visualizer. They would sometimes face restrictions with certain data elements, when they wanted to show totals of data elements with disaggregation, the totals would simply not show. There was also a lack of training for DHIS2 while most of the data managers and data analysts already had prior experience with Excel. We would often hear that the flexibility that Excel provides is just not matched in DHIS2. One data analyst or program specialist at RBC explained that statisticians and data analysts will always be interested in learning and discovering new tools for their data analysis, but most have their own workflow and expertise, their own "coding". The same data analysts would only create pivot tables in DHIS2 and use other tools for the rest of the analysis.

There was also this practice of saving data sets in Excel to avoid having to load the whole data set again, and the data was also made available by having it in Excel.

Power BI

Power BI was used by RBC data analysts as an alternative option to Excel. Data analysts would prefer to use Power BI for larger data sets, but also depending on the complexity of the data sets. Power BI was experienced as being faster than Excel.

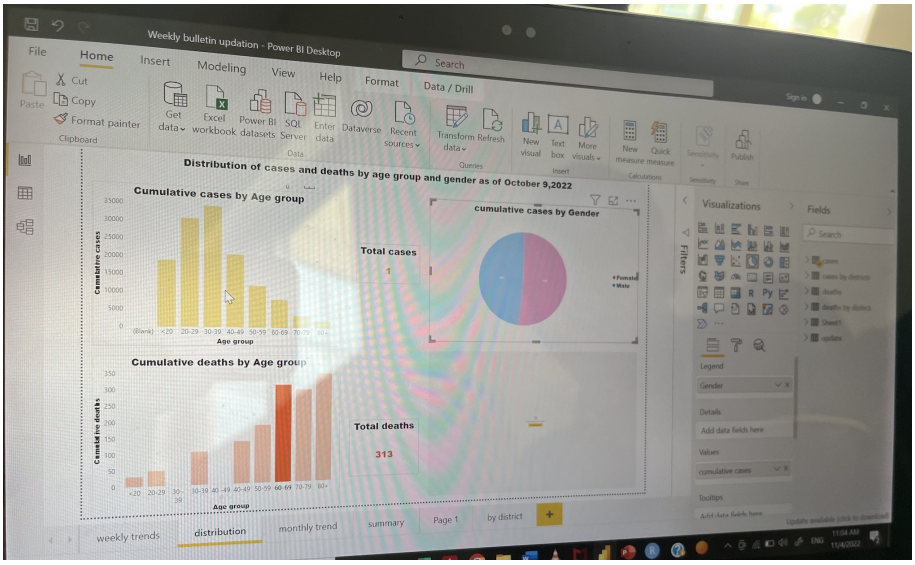


Figure 5.6: Power BI interface

The functionalities in Power BI are designed to create data visualizations that are more dynamic and interactive. Data analysts would click the diagrams and pie charts to show how the visualization would change (see figure 5.6). Power BI also allows users to share dashboards and individual data visualizations with others, rather than only being a personal productivity tool like Excel.

Data analysts at RBC would often use Power BI to create data visualization, and from there they could easily export it as pdf. Sometimes they would need to create good images or icons representing the data in the visualization, this was often done in Adobe InDesign. One illustration was shown where bar charts and line charts were shown together and created directly in Power BI, which was not possible in DHIS2.

QGIS

There were also cases in the RBC where it was mentioned that analysts sometimes use QGIS to create, for example, disease prevalence maps. The software was used when they needed to communicate the data through reports and presentations to the stakeholders.

5.2 WHO packages

The WHO packages for different disease areas were not used at all. The DHIS2 implementors at HISP Rwanda explained that installing these packages would only cause duplication since they already have disease programs and systems in place with their own set of standards. They viewed the metadata packages to be relevant for other developing countries where no such disease program exists, which is why they also would promote the use of these in other countries where they help with DHIS2 implementation. However, they did use the COVID package when the pandemic came.

Chapter 6

Discussion

The objective of this chapter is to discuss the empirical findings obtained during our four-week-long case study in relation to the relevant literature from Chapter 3. The aim is to answer our research question that was introduced earlier, "How are various tools being used to support informed decision-making in the Rwandan HIS, and what are the implications?"

6.1 Rwandan HMIS as sub-HII

In the "Relevant Literature" chapter, we presented HMIS as a sub-HIS that is designed to collect, process, and report on aggregate health data to support evidence-based decision-making at the different levels of the healthcare system [2]. In Rwanda, DHIS2 is implemented as their HMIS, referred to as R-HMIS, which includes tools for gathering, reporting, and analyzing data. Although the data managers use DHIS2 for collecting and reporting data, the system's usage drops significantly when it comes to data analysis, and alternative technologies and tools are frequently used instead. This trend is also observed among the data analysts at the national level as well.

Supplementary HMIS tools that are not directly linked to the R-HMIS are employed as support for data analysis and report generation. Excel, RHAP, and Power BI are among the software and systems that we discovered. These tools are rather interconnected with the R-HMIS, where

data utilized in these tools originates from the R-HMIS to support different tasks related to their routine data analysis process.

Different individuals and entities are involved in the utilization of HMIS tools, including data analysts at RBC, data managers at various facility levels, and MoH. As a result of their distinct interactions with R-HMIS and exposure to it, each of these actors has a unique perspective on the definition and application of HMIS. Additionally, diverse stakeholders back these tools.

The HMIS is supported by a various number of different actors, technologies, and tools (software). To comprehend the reasons behind the usage or lack of usage of these tools, we must examine the existing heterogeneity. Like most other HISs in developing countries, Rwandan HIS can also be best understood as socio-technical and heterogeneous. To comprehend these contextual factors that surround the HIS in Rwanda, we incorporate the II theory expounded in Chapter 3 [12].

The definition of II by Hanseth and Lyytinen (2010) stated that "a shared, open (and unbounded), heterogeneous and evolving socio-technical system (which we call installed base) consisting of a set of IT capabilities and their user, operations and design communities" [13, p. 4]. Having established that the HIS in Rwanda can be conceptualized as HII, we can now delve into the characteristics of HII (see table 6.1 for a summary of these characteristics).

II characteristics	Rwanda HMIS
Open	• The interoperability between the R-HMIS (DHIS2) and other tools • HMIS used by several different actors for the same or different purposes • New technology introduced and ongoing projects integrated into the system
Shared	• Shared by different user groups with different perspectives on the same HMIS • The R-HMIS use cases are presented or understood in different ways. Some make use of the dashboard functionalities in DHIS2, while others see it as a place only to report data
Evolving	• Constant new projects to add to the R-HMIS • RHAP solution added as a new system into the existing infrastructure. From data visualizer and Excel to data visualizer tools on RHAP
Installed base	• Existing procedures, knowledge, goals, routines, etc. • RHAP, Excel, Power BI, QGIS, etc.
Heterogeneous	• "socio-technical networks": • MoH • HISP • RBC • Facilities at different levels • Private facilities • R-HMIS • DHIS2 • Standards • Paper-based registry forms • etc.

Table 6.1: Rwandan HMIS as sub-HII and their characteristics

The HII in Rwanda exhibits heterogeneity in that it has a socio-technical installed base consisting of diverse technologies, procedures, actors, and stakeholders. These technologies are developed by various actors with their unique standards and objectives. For instance, DHIS2 is developed by HISP and locally maintained by HISP Rwanda through their DHIS2 implementors. On the other hand, RHAP is developed by Zenysis with its distinct goals. In essence, the utilization of different technologies and systems can be attributed to the demands set by organizations.

The HMIS, as a sub-HII, is best viewed as an integral part of a larger HII rather than a standalone system. It coexists with other technologies that cater to the actors and their interests. The R-HMIS, which is powered by DHIS2, is interlinked with RHAP and other tools in a way that enables the sharing of data among them for collaborative usage. Therefore, the sub-HII technologies employed in Rwanda, which are interdependent, interrelated, and interconnected, can be seen as ecologies of infrastructures, as Hanseth (2000) described [12]. This interconnectivity among sub-HIIs permits layering on top of existing sub-HIIs through integration or replacement, which is what we refer to as the installed base.

The impact of introducing a new technology to the HII in Rwanda depends on how well it fits with the existing installed base, which includes various actors such as MoH, WHO, health workers, HISP, NGOs, and Zenysis. Each of these actors has their own established practices for data collection, reporting, and analysis, as well as their own technology that they are familiar with and proficient in using. In this sense, the HII is not built from the ground up, but rather builds upon the already-existing infrastructure [12].

6.1.1 Introducing new tools to the sub-HII

To promote growth in an HII, it is necessary to adopt an approach known as installed base cultivation [7][13]. This involves acknowledging the existing installed base and implementing incremental changes in an effort to transform the HII.

It is difficult to determine whether installed base cultivation is actively tak-

ing place in Rwanda to enhance the existing HMIS system. Nevertheless, there are signs that it may be happening, whether deliberately or unintentionally. As we know, installed base cultivation has three elements [7], and the first one is a process-oriented strategy, which involves working with current technology and practices and progressively modifying them over time. For example, the case of integrating the three independent instances in DHIS2 (HMIS, HIV instance and SISCOM) into a unified platform to present the data together in RHAP.

User mobilization is another factor to consider, as the designer cannot impose what technology will be used in the infrastructure. Furthermore, motivation needs to be created for the adoption of the new tools. In Rwanda, the R-HMIS is used by every data analyst and data manager for loading the datasets, which is later used in the process of data analysis. However, when there are better or already established alternatives for the same data analysis tasks, the technology provided in the data visualization application in DHIS2 is dropped in favor of other tools. This is very evident from the feedback received from the data managers at the facilities and data analysts at RBC, who reported that DHIS2 was not flexible enough in their needs and preferred more advanced tools with greater functionality.

Lastly, the component "learning" is important, where the designer needs to establish if the new technology is working well with the installed base. DHIS2 already has a specific functioning role for the different actors and the other tools has their own set of functions in their data analysis tasks. New technology and tools are constantly introduced through DHIS2 for data analysis, such as the Data Visualizer App, WHO Data Quality Tool, and Scoreboard Dashboard Widget. We also see training done by MoH and HISP to promote and use these applications, yet we see that many of these projects fade away over time if there are similar technologies in place used by the data managers and data analysts.

In summary, the installed base is continually expanding with various initiatives introducing new technologies and organizational modifications. As the installed base grows, it becomes increasingly challenging to build upon it. Data managers have developed different preferences, with some

accustomed to using the national dashboards in RHAP, while others prefer Excel for all their data analysis tasks and some use the data visualization application in DHIS2 (R-HMIS). This situation could be interpreted as an instance where RHAP struggled to establish itself within the existing installed base since there are cases where it is not used at all. SISCOM users tend to utilize RHAP more frequently, whereas programs that have all the necessary information in one instance do not require the use of RHAP. This could explain the varying degrees of RHAP usage observed.

6.1.2 WHO Packages

The existing installed base can also be viewed as a reason why WHO packages never was adopted or considered to be adopted. It was explained in the findings that WHO packages were not really understood as a concept or it was not given that much thought by HISP Rwanda. The only packages that were installed were the COVID package, this is because no such system existed prior to the pandemic. The other disease-specific packages were not seen as relevant to Rwanda since they already had a system in place for these programs. Installing these packages would most likely just cause extra work and duplicate systems since it may fail to cultivate in the installed base.

HISP Rwanda viewed these metadata packages to be more relevant in other developing countries where no such program for disease areas exists, which would give a kickstart in the implementation of disease programs, where no prior standards are set. In other words, there is no strong installed base with many sub-HII present in countries where these packages might be more viable. This is why, HISP Rwanda usually promote the use of these packages in the other countries they assist, to help them with their HIS through DHIS2.

6.2 Concerns

Maintaining a HII that is heterogeneous in nature and with distributed control across multiple actors and with interconnected sub-HIIs is not a straightforward task. Connecting and integrating new technologies

and tools to the existing installed base requires careful planning and coordination. However, with limited communication between the actors involved, it can lead to parallel initiatives attempting to solve the same problems simultaneously. If we look at DHIS2 and RHAP we see two technologies that really have the same use cases, it is even presented in the findings that the dashboards and data visualizer tools in RHAP look very similar to the ones we find in DHIS2. RHAP wants to support health workers with information support for their decision-making just like DHIS2.

There are resources being put into the training of health workers to use these technologies, which really solve the same problems within the Rwandan HIS. It is hard to tell why RHAP is used more than DHIS2 for data visualization, but one indication comes from being told that the training of data managers and data analysts stopped in 2019 for DHIS2, due to covid. Zenysis on the other hand have been conducting training in collaboration with RBC, much more recently, and even a national dashboard is vizible.

There is a future concern worth addressing in relation to RHAP and DHIS2 being developed and updated in isolation. There is to date no communication between HISP and Zenysis, and from what we know there was no knowledge around the existence of this alternative platform. Future expansion and development around solving similar issues can create silo-like sub-HII, where the systems become less interconnected.

There are also concerns related to the side-effects that come from the natural complexity of an II, where one change or addition to the HII could cause unintended changes in another area of the infrastructure because of its interdependent nature of it [16]. Therefore, the side-effects could cause a butterfly effect of additional side-effects. For example, today, the data managers and data analysts are dependent on updates in both DHIS2 and RHAP for the dependencies to work without error. If the development of one project stops, we could see problems where today's solution is not working anymore.

6.3 Summary

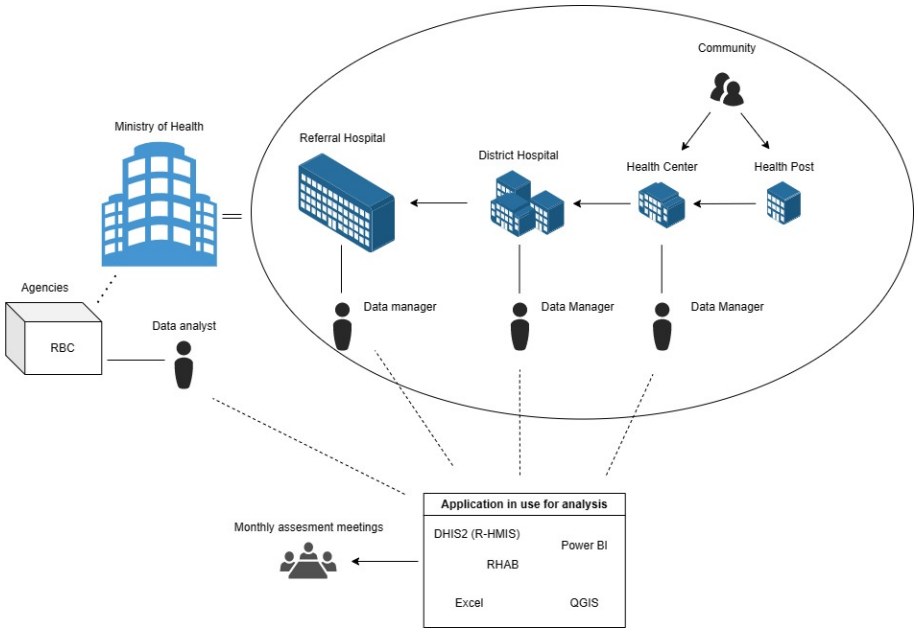


Figure 6.1: Simplified Rwanda HII

To summarize how various tools are being used to support informed decision-making in the Rwandan HIS. The administrative levels in the Rwandan health system consist of different actors with different areas of responsibility. The data analyst at RBC and the data managers located at the lower-level facilities use a wide range of different HMIS tools that seem to include many of the same functionalities (see figure 6.1). Rwanda has adopted DHIS2 to be used as its HMIS, yet the usage of the tools developed in DHIS2 are used at varying degrees by the same roles. DHIS2 is used in combination with paper-based registry forms for data collection and later entry into the national health database. For data analysis, the usage of the tools available in their R-HMIS (DHIS2) is used at a very low degree. Data managers and data analysts have to generate reports when requested. To do this, most of them load the tables with the relevant data sets in DHIS2 and export this to other data visualization tools that the individuals prefer.

To understand the implications of how these tools are used by the different actors we decided to look at the Rwanda HMIS as a sub-HII by conceptualizing Rwandan HIS as II. This is done to address the

heterogeneity and the socio-technical context of the sub-HII. The installed base in Rwanda makes it rather difficult to introduce new tools and sub-HIIs, where projects introduced through DHIS2 like the data visualization application does not get used at the level HISP intended it to be used. We have presented several concerns related to this. Both DHIS2 and RHAP are essential tools in the routine tasks of data managers and data analysts, both systems intend to solve the same issues and have their separate training and cultivation process in the installed base. The existing installed base makes it hard for the new technology or tools to find their spot in the infrastructure as sub-HII.

Chapter 7

Conclusion

This thesis aimed to answer the research question: How are various tools being used to support informed decision-making in the Rwandan HIS, and what are the implications?

The analysis is based on II as a theoretical lens, where the HII in Rwanda consists of several heterogeneous socio-technical complexities. The installed base consists of several interconnected systems and technologies that share data between them, and different stakeholders with varying perspectives on the sub-HII. Understanding the existence of the installed base and that it is not built from scratch allows us to understand why and how the different systems and tools are used.

RHAP, DHIS2, Excel, and Power BI are mostly used for the same data visualization use cases. Still, the usage by the different actors varies from one individual to the other, even though their routine tasks are similar. All data managers and data analysts use DHIS2 (R-HMIS) for data entry and later to extract datasets. What came as a surprise was that the information support from DHIS2 after this point mostly stopped, and other data visualization tools like RHAP, Excel, QGIS, and Power BI were used instead of the Data Visualization Application available in DHIS2.

To answer the part about implications in relation to this we saw early on that WHO packages were not used in Rwanda. A reason for this comes from the already existing installed base, where new technology introduced

to the infrastructure is met with resistance. They already had disease programs in place as sub-HIIs, to implement these packages would only cause a duplicate and the use was not seen as necessary. The actors in Rwanda HIS already have tools they are familiar with and are hesitant to change routines and processes. The technological "lock-in", where users are very reliant on existing tools, becomes hard to switch from, similar technology that intends to solve the same problems is therefore dropped.

There is also this problem of resource allocations being done for technologies like RHAP and DHIS2, simultaneously when Zenysis and HISP try to solve the same problems. They are also developed separately and could in the future cause fragmentation with less interconnectedness between the systems.

7.1 Future work

It was very interesting to take a look at how the health workers in the Rwandan HIS utilized HMIS tools and to see that the DHIS2 dashboard was so little used for data analysis. The generalization was done from just a few participants and it could be interesting to do the same generalization in other countries to see if the case is the same in these countries. For the WHO package, it could be possible to look at countries that do not have a "strong" installed base and see how the WHO packages are utilized in these countries. It could also be interesting to conduct action research and participate in a training session on DHIS2 applications, with the data managers and data analysts. It could be interesting to see how this is received and their impressions when we know the tool base they currently use.

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Appendix A

NSD Research Approval

Sikt

Vurdering av behandling av personopplysninger

Referansenummer	Vurderingstype	Dato
120740	Standard	23.09.2022

Prosjekttittel
Impact and use of DHIS2 metadata packages in Tanzania and Rwanda

Behandlingsansvarlig institusjon
Universitetet i Oslo / Det matematisk-naturvitenskapelige fakultet / Institutt for informatikk

Prosjektansvarlig
Johan Ivar Sæbø

Student
Ozan Kara

Prosjektperiode
09.10.2022 - 15.06.2023

Kategorier personopplysninger
Alminnelige

Lovlig grunnlag
Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)

Behandlingen av personopplysningene er lovlig så fremt den gjennomføres som oppgitt i meldeskjemaet. Det lovlige grunnlaget gjelder til 15.06.2023.

Meldeskjema

Kommentar
OM VURDERINGEN
Personverntjenester har en avtale med institusjonen du forsker eller studerer ved. Denne avtalen innebærer at vi skal gi deg råd slik at behandlingen av personopplysninger i prosjektet ditt er lovlig etter personvernregelverket.

Personverntjenester har nå vurdert den planlagte behandlingen av personopplysninger. Vår vurdering er at behandlingen er lovlig, hvis den gjennomføres slik den er beskrevet i meldeskjemaet med dialog og vedlegg.

VIKTIG INFORMASJON TIL DEG
Du må lagre, sende og sikre dataene i tråd med retningslinjene til din institusjon. Dette betyr at du må bruke leverandører for spørreskjema, skylagring, videosamtale o.l. som institusjonen din har avtale med. Vi gir generelle råd rundt dette, men det er institusjonens egne retningslinjer for informasjonssikkerhet som gjelder.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle alminnelige kategorier av personopplysninger frem til 15.06.2023.

LOVLIG GRUNNLAG
Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake. Lovlig grunnlag for behandlingen vil dermed være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

PERSONVERNPRINSIPPER
Personverntjenester vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

• lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
• formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke viderebehandles til nye uforenlige formål
• dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med

prosjektet
• lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER
Personverntjenester vurderer at informasjonen om behandlingen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18) og dataportabilitet (art. 20).

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
Personverntjenester legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og eventuelt rådføre dere med behandlingsansvarlig institusjon.

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til oss ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilke type endringer det er nødvendig å melde: https://www.nsd.no/personverntjenester/fylle-ut-meldeskjema-for-personopplysninger/melde-endringer-i-meldeskjema Du må vente på svar fra oss før endringen gjennomføres.

OPPFØLGING AV PROSJEKTET
Personverntjenester vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Kontaktperson hos oss: Henriette S. Munthe-Kaas
Lykke til med prosjektet!