# Designing mobile instant messaging for collaborative health data management in Rwanda

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# Abstract

Fast and efficient communication is crucial for workers that are required to collaborate. Instant messaging has been found to be more efficient than email and other asynchronous messaging systems when used for asking quick questions. Group chats have also been shown to stimulate collaboration between multiple users.

In this thesis, we explore how mobile instant messaging can facilitate and stimulate collaboration between health data managers working in different facilities in Rwanda. An instant messaging application for Android has been developed and tested during this project. The application connects to the health management information system in Rwanda that is used by the data managers to collect and aggregate health data. The application also supports collaborative and social data analysis, by providing the users with a platform to share and discuss health data visualizations in groups. We have applied Social Presence Theory, Media Richness Theory and Social Data Analysis for the development of the Android application, as well as to analyze empirical data concerning the design and implementation of an instant messaging application for health data managers.

The research method used in this project is called Action Design Research (ADR). Three cycles of testing have been conducted, both at the University of Oslo and in Rwanda. The empirical data collected during a month-long field test in Rwanda and subsequent data analysis has resulted in nine design principles for how to design an instant messaging application. To facilitate collaboration, we found low data consumption, loose coupling of the system and self-explanatory graphical user interface (GUI) to be important design principles. As well as having predefined HMIS users and private and self-monitored servers to run the systems on. Presence awareness, statistical integrations, flexible group compositions and attachment integration is found as the design principles that stimulate collaboration.

# Acknowledgments

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# Glossary

**Android** "is a mobile operating system developed by Google, based on the Linux kernel and designed primarily for touchscreen mobile devices such as smartphones and tablets. Android's user interface is mainly based on direct manipulation, using touch gestures that loosely correspond to real-world actions, such as swiping, tapping and pinching, to manipulate on-screen objects, along with a virtual keyboard for text input" (Wikipedia 2017a).

**DHIS 2 messaging system** is the messaging functionality provided by the DHIS 2 web platform. This feature provides the users with an email like interface, and is not set up to use notifications.

**DHIS 2 messages** are the messages that can be sent from the DHIS 2 messaging system in the DHIS 2 web portal.

**DHIS 2 interpretation** allow users to share data visualizations with other DHIS 2 users with the purpose of discussing collaborative- and social data analysis. This interpretation includes a text describing the data, as well as the possibility of commenting on the visualized data.

**DHIS 2 Messenger** is an instant messaging application and system that Niclas Hammer Halvorsen made for his 2015 master project. His project, study and the development of the application is described in his master thesis called: "Effektene av mobil- og data-mediert kommunikasjon i et helseinformasjonsystem" (Halvorsen 2015).

**DHIS Chat** is an HMIS (DHIS 2) integrated instant messaging application for Android. The application was made for this master thesis, and was tested in the health sector in Rwanda in February of 2017. It connects to DHIS 2 and a user can log in directly to the application with his or hers DHIS 2 user credentials, without any setup.

**iOS** "(formerly iPhone OS) is a mobile operating system created and developed by Apple Inc. exclusively for its hardware. It is the operating system that presently powers many of the company's mobile devices, including the iPhone, iPad, and iPod Touch. It is the second most popular mobile operating system globally after Android" (Wikipedia 2017c).

**JavaScript** "is a high-level, dynamic, untyped, and interpreted programming language. It has been standardized in the ECMAScript language specification. Alongside HTML and CSS, JavaScript is one of the three core technologies of World Wide Web content production; the majority of websites employ it, and all modern Web browsers support it without the need for plug-ins" (Wikipedia 2017d).

**Openfire** is an open source XMPP chat server.

**React Native JS** is a cross platform framework for building native applications for mobile using React. React is based on JavaScript.

**WhatsApp** Messenger is a freeware, cross-platform and end-to-end encrypted instant messaging application for smartphones.

**Windows Phone** "(WP) is a family of mobile operating systems developed by Microsoft for smartphones as the replacement successor to Windows Mobile" (Wikipedia 2017e).

# Acronyms

**ADR**  Action Design Research.

**API**  Application Programming Interface.

**AR**  Action Research.

**BIE**  Building, Intervention, and Evaluation.

**DHIS 2**  District Health Information Software.

**DR**  Design Research.

**GCM**  Google Cloud Messaging.

**GUI**  Graphical User Interface.

**HIS**  Health Information System.

**HISP**  The Health Information Systems Programme.

**HMIS**  Health Management Information System.

**ICT**  Information and Communications Technology.

**IM**  Instant Messaging.

**IoT**  Internet of Things.

**kB**  kilobyte.

**MIM**  Mobile Instant Messaging.

**MoH**  Ministry of Health.

**MQTT**  Message Queue Telemetry Transport.

**MUC**  Multi User Chat.

**RURA**  Rwanda Utilities Regulatory Authority.

**UI**  User Interface.

**WHO**  World Health Organization.

**XML**  eXtensible Markup Language.

**XMPP**  Extensible Messaging and Presence Protocol.

# Chapter 1

# Introduction

> "Because you will ask a question to whoever and get a response immediately and you will be able to be sure who is online."
>
> (Data Manager, Rwanda, 2017)

Use of Instant Messaging (IM) has grown immensely since the end of the last century. It began as desktop applications, then grew to become part of social media platforms. IM has now, since the smartphone was introduced, become an integral part of our phones and daily lives. Soon after IM took off, researchers began to study what the implications of introducing this technology into the workplace would be.

Studies showed that IM was an efficient, informal and flexible way of getting feedback (Hudson et al. 2002). It was less intrusive than face-to-face conversations and even phone calls, and IM groups were found to strengthen the interconnectivity and collaboration amongst the workers (Ou and Davison 2011).

The Ministry of Health (MoH) in Rwanda collaborates with The Health Information Systems Programme (HISP) from the University of Oslo to improve health data and the use of these data. HISP is a global network that develops and promotes an Health Management Information System (HMIS) called District Health Information Software (DHIS 2). DHIS 2 is used in nearly 50 countries worldwide, and Rwanda is one of the leading countries in the adoption of this software.

A Health Information System (HIS) (also referred to as HMIS) is a management information system, whose goal it is to improve the health status of individuals in a population, by providing accurate information to support the decision-making process at each level of the health organization. A HIS can be described as an integrated effort to collect, process and use health information and knowledge to influence policy-making, program action, and research. (Lippeveld 2001)

Decision making is a key word when talking about HISs, and especially informed decision-making. That is because decisions that are unsupported

by data can pose great problems for a country's health management. HISs try to solve this by making the information available for those responsible for making decisions. As described by Lippeveld "The HIS structure should permit generation of necessary information for rational decision making at each level of the health system, from local all the way up to national." (Lippeveld 2001, p.3)

In the project described in this thesis, we developed and tested an IM chat application that connects to Rwanda's HMIS called DHIS 2. The goal of the application is to enhance communication for health workers across health facilities and to provide a platform for collaborative and social data analysis.

## 1.1 Motivation

Rwanda is an ideal country to test an HMIS integrated IM application. In Rwanda, the telecommunication infrastructure has grown rapidly over the last two decades. The country has achieved the highest growth rate of Information and Communications Technology (ICT) in Africa (ITU 2017) and has a mobile phone penetration of 79% nationwide (Rwanda Utilities Regulatory Authority 2016). The large coverage of mobile phone use and social media is an asset to the ministry of health in Rwanda.

The HMIS team Lead at MoH in Rwanda described their motivation for an IM application like this:

> "I think the motivation behind it is that we looked at the approach of social media and you know when you go around the road, and even in the town, you will see everyone busy on the social media. Everyone are on WhatsApp, Viber or other social media. So we thought we could take the same idea and use it in the health sector."

They want to improve communication by using tools that the workers are already familiar with and at the same time connect that tool to the HMIS. By connecting the IM application to the HMIS, it is also possible to integrate data visualization and data use. The Lead of HMIS continues:

> "It can contribute to the information use, so that is why we thought of this idea of messaging. Like having messaging to be used in technical support, but also we just add in the idea of information use like visualizing charts and interpretations. So it means we wanted to take advantage of the technology and have people already busy with social media and look at the area where people are really attracted and just put in information use."

The request from MoH in Rwanda constituted an IM application that connects to the national HMIS that also provides a collaborative data

visualization platform.

The HMIS system in Rwanda, DHIS 2, has a web-based Graphical User Interface (GUI), which can be accessed via a portal. In this portal, the users have access to data visualization tools, statistics, and a messaging feature. This messaging feature is similar to an email client, but it is, however, only possible to send messages to other registered users on that particular DHIS 2 server. It does not support sending file attachments nor does it support presence awareness, which means that it is asynchronous.

Users of DHIS 2 complain that the messaging feature is inefficient to the point where it can take hours or days to get a response. In the search for a more efficient and reliable messaging system, MoH in Rwanda decided to try an IM application. Their choice fell on WhatsApp, which is a free to use cross platform IM application that is owned by Facebook. This application has made communication more efficient, but there are some concerns regarding the safety and security of the work related messages sent with it. It also does not support data visualization. This is what triggered the request of an IM application from the MoH.

In 2015, Niclas Hammer Halvorsen delivered his master thesis, called "Effektene av mobil- og data-mediert kommunikasjon i et helseinformasjonsystem" (Halvorsen 2015). The thesis described the development and testing of a first generation HMIS integrated IM Android application. As with our application, Halvorsen's application was tested in Rwanda by data managers from one health district. The application he developed, called DHIS 2 Messenger, had some problems in regards to the cost of using it and lacking functionality. To solve these problems, and to go even further than Halvorsen did, we developed a second generation HMIS integrated IM Android application, called DHIS Chat.

DHIS Chat, the second generation HMIS integrated IM application, is tested in Rwanda. We follow most of the design principles laid out by Halvorsen in his thesis in regards to what his findings were. The application is open source, and thus follows an important principle by HISP, to create systems that are free to use and open for everyone to customize as he or she see fit. To make the code open source is important because use cases can change over time and adjustments might have to be performed. Instead of waiting for and paying others to make those adjustments, open source code facilitates fast and agile customization by giving everyone access to the code.

## 1.2   Research question

The main motivations behind this project was the master thesis from 2015 and a request from the MoH in Rwanda wanting to utilize Social Media and increase information use among end-users of DHIS 2. With information use in mind as well as further Halvorsen's study we want to research the effect

Mobile Instant Messaging (MIM) can have on collaboration between the data managers in Rwanda.

The research question for this thesis is as follows:

> "How can Mobile Instant Messaging facilitate and stimulate collaboration between health data managers in a low-resource context?"

We limit our study to focus on one specific case: Rwanda is the low-resource context, where the data managers use DHIS 2 as their HMIS.

In our study, we have used three main concepts from literature. These are social presence theory, media richness theory and social data analysis. To conduct our study, we have used the Action Design Research (ADR) method as proposed by Sein et al. With ADR, a scientific contribution is committed via design principles which are generalized through formalizing the findings of our study. These design principles will be discussed more in-depth in chapter 8.

## 1.3 Chapter overview

This master thesis is divided into eight chapters. In the following section, an overview of these chapters is given.

**Chapter 2 - Theoretical perspective** includes relevant theoretical concepts namely social presence theory, media richness theory, and social data analysis.

**Chapter 3 - Project background** contains information about Rwanda, its infrastructure and health sector.

**Chapter 4 - Method** is comprised of a description of the project, the ADR method with its stages, and a problem formulation.

**Chapter 5 - Development of the IT artifact** includes a description of the problem areas of the first generation IM application, choices we made during the development and a technical description of the DHIS Chat system.

**Chapter 6 - Instant messaging as a HMIS collaborative tool in Rwanda** describes our execution of the empirical study of IM implementation for data managers in Rwanda.

**Chapter 7 - Findings from beta testing of DHIS Chat** contains a thorough description of the findings from the test in Rwanda.

**Chapter 8 - Discussion and analysis** consist of a discussion of the findings from the empirical work in Rwanda, relevant literature and design principles.

**Chapter 9 - Conclusion** describes the practical and theoretical implications of the study, as well as suggestions for further development.

# Chapter 2

# Theoretical perspective

In this chapter we discuss the theoretical perspective of the project. An overview of social media will be provided to define the theme of the chapter. IM will be discussed, together with social presence theory, media richness, instant messaging at work and MIM. In the next section, we discuss social data analysis to provide a framework for how a data analysis platform should be designed, as it is of interest to support data management analysis work in Rwanda directly through IM. The last section contains a description of how the theoretical perspectives of this chapter is used in the remainder of this thesis.

## 2.1 Social Media

Social media is all around us and is used to keep in contact with friends and family, share thoughts and images, and like or comment on each other's posts. It has some different definitions, each of which touches upon the same topics. Two of them are:

> "Social Media is a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of User Generated Content." (Kaplan and Haenlein 2010, p. 61)

and

> "Social media employ mobile and web-based technologies to create highly interactive platforms via which individuals and communities share, co-create, discuss, and modify user-generated content." (Kietzmann et al. 2011, p. 241)

Kaplan et al. describe that there are six types of social media, which are as follows: collaborative projects, content communities, social networking sites, blogs, virtual game worlds and virtual social worlds (Kaplan and Haenlein 2010). Social networking sites are the most common and most

widely used platforms, like Facebook, Twitter, and LinkedIn. Kietzmann et al. groups these sites into: sites for the general masses (Facebook and Twitter) and sites that are more focused on professional networks, like LinkedIn (Kietzmann et al. 2011).

## 2.2   Instant messaging

IM is widely popular socially and is used increasingly more in the workplace. It is characterized by its immediate reception of messages, facilitating efficient and effective communication between people (Ou and Davison 2011).

Instant messaging is internet-based and quasi-synchronous text chat in real-time (Grinter and Palen 2002; Herring 2002). Synchronous, meaning that one expects to get an answer immediately, because of notifications and an online status representing the recipient's availability. In contrast to asynchronous communication like email where sender and receiver do not have to be online simultaneously. However, IM can also be asynchronous as the receiver might log off and not respond in a while.

IM messages are usually short, simple, informal and interactive with Internet slang and abbreviations of common words. Common use cases are quick questions, scheduling, and coordination. It is also used for clarifications and organization of impromptu social gatherings as well as keeping in touch with family and friends (Nardi, Whittaker, and Bradner 2000). In a synchronous messaging system the conversational topics can change in an instant unlike email. And unlike face-to-face conversations the people that are not present can catch up any time with groups (Mark Handel and Herbsleb 2002).

In addition to one-to-one messages, most IM tools also support groups. Groups are multi-user (many-to-many) conversations, which can be closed or public. The user will either get invited to join a conversation with specific members or access a public chat room with little or no control over other group participants.

Herbsleb's study showed that more than synchronous messaging, it was presence awareness that brought people to use IM tools (Herbsleb et al. 2002). Presence awareness and "buddy"-lists are two of the main features that differentiate IM from other messaging tools like email and these will be described in the next subsection. Media richness, and instant messaging's position in the workplace and its transition onto the mobile phone will also be presented.

### 2.2.1 Social presence theory

Unlike email, which allows sending a message to any email domain, most IM systems only support chat with other users with an account in the same IM system. However, in a global IM system (like Facebook Messenger or WhatsApp to name a few), many people you do not know are present. As a solution IM includes "buddy lists". Each user creates his or her own list of users one potentially wants to interact with and be aware of (Herbsleb et al. 2002; Nardi, Whittaker, and Bradner 2000). Some also allow for favorites to gain easier access to users which one have more interactions with than the others. These buddy lists also show each user's status and can be a way of creating and maintaining a connection to other users by monitoring their presence.

An important feature of instant messaging is presence awareness. Social presence theory state that the critical factor in a communication medium is "social presence" and is defined by the "degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships"(Short, Williams, and Christie 1976), meaning to which degree a person is perceived as a real person in the chat room (Short, Williams, and Christie 1976; Gunawardena and Zittle 1997). The activity status of a user is often a badge of different colors or a text status representing online, idle or offline. Some also support creating a specified status like "on the phone," "on vacation" or "available for questions" (Boyer, Cortes, and M Handel 1998). It can also report time of last log in and whether the user has received and even read a specific message.

IM help people negotiate availability (i.e. stating that both parties are available for conversation) by consulting the buddy-list and look at their online presence. More importantly, when it is time to initiate a conversation and expect a reply (Nardi, Whittaker, and Bradner 2000). In many work-related cases, people wait until a person is online to begin a conversation or choose another online co-worker to talk to instead.

Lombard and Dutton states that "An enhanced sense of presence is central to the use, and therefore the usefulness and profitability, of new technologies" (Lombard and Ditton 1997, p. 1). This suggest that greater perception of presence give a feeling of non-mediation, hence better quality of interaction (Churchill and Bly 1999). Which in turn might also lead to impromptu collaboration and opportunistic interactions.

### 2.2.2 Media richness theory

"For communication to be successful, the receiver must understand the message the sender intended to send and both the receiver and the sender must agree that the receiver understood the message." (Dennis and Valacich 1999, p. 11). Sometimes a problem is the lack of clarity and understanding of the task and context when interacting through a

communication medium, this usually has something to do with media richness. Daft and Lengel first introduced Media richness theory as a framework for determining the "ability of information to change understanding within a time interval" (Daft and Lengel 1986, p. 560) or the medium's ability to convey the information sent over it (ibid.). Many argue that a face-to-face conversation or video conference is the richest mediums as the social context, gestures, and immediate feedback is present, while pure text like email scores low on media richness. IM is suggested as a combination of spoken and written language (Segerstad and Ljungstrand 2002) and would fall somewhere between the two (face-to-face and email) on the media richness scale (Cameron and Webster 2005).

Building on the social presence theory of media which is a complex interaction of technical capabilities, contextual characteristics and personal perceptions (Short, Williams, and Christie 1976), Daft and Lengel introduce three main factors associated with rich communication media. The factors are immediate feedback, cue variety, and message personalization (Zmud, Lind, and Young 1990; Short, Williams, and Christie 1976; Daft and Lengel 1986). It is also those that allow verbal and nonverbal cues, use natural language, and can convey emotion (Cameron and Webster 2005).

Rich media are thought to be best when communicating vague ideas or concepts (ibid.), and although IM is a text-based medium the fast feedback gives a good flow of the conversation and the nonverbal symbols like emojis, presence awareness, and multimedia can include information beyond the words themselves when the message is transmitted (Dennis and Valacich 1999).

### 2.2.3   Instant messaging at work

There are many studies on instant messaging at work (Churchill and Bly 1999; Cameron and Webster 2005; Herbsleb et al. 2002; Mark Handel and Herbsleb 2002; Nardi, Whittaker, and Bradner 2000; Ou and Davison 2011; Isaacs et al. 2002). Instant messaging was slowly introduced into the work environment in the late 90's and has since then become popular in collaborations and coordination tasks.

In business environments, email has been the most common communication medium. However, it is now apparent that it is inadequate for efficient interaction in real-time (Luo, Gurung, and Shim 2010). Most of the studies conducted on messaging at work found that people saw instant messaging as a flexible and informal way of getting efficient feedback, and could even be more productive than to set up an appointment (Hudson et al. 2002). People also saw IM as less intrusive than face-to-face conversations and phone calls, especially regarding groups (Nardi, Whittaker, and Bradner 2000; Mark Handel and Herbsleb 2002). Groups play a role in teamwork as it can strengthen the interconnectivity and interconnection, which is a variable for the development of mutual trust and communication quality

(Ou and Davison 2011).

The studies performed by Handel and Hersleb, and Isaacs et al. showed that leadership was concerned with personal conversations or losing employee productivity. However, the results showed an abundance of work related topics (Mark Handel and Herbsleb 2002; Isaacs et al. 2002). Most studies concluded that the conversations were mostly about coordination, scheduling, and clarifications. Some also found that it can be effective for discussing complex work topics just by using text and instant messaging (Isaacs et al. 2002). The conversational contexts are maintained by the persistence of textual conversations which lead to a more robust conversational zone (Nardi, Whittaker, and Bradner 2000). Multitasking is also possible with IM, and some people used IM to substantiate phone calls with additional information or talk to coworkers while in a video conference (Cameron and Webster 2005; Isaacs et al. 2002). In many cross-site work environments IM is also the replacement of "hallway"-talk, giving room for opportunistic conversations.

With event notifications and people using IM frequently, interruptions might become an issue in the workplace. People might set their IM settings on silent and ignore relevant information. The studies, on the other hand, showed that people expect interruptions during work hours and even though one get interrupted it is worth it because one gets updated on critical information as well as the possibility to handle situations before they turn into a "crisis." (Hudson et al. 2002). "While it [IM] facilitates online connectedness it also contributes to work interruptions. However, by helping to shape a social network, enabling quality communication and trust, the negative effects are negligible — and no more serious than those that occur as a result of other interruptions such as phone calls and impromptu conversations." (Ou and Davison 2011, p. 68).

Even though most instant messaging at work relates to IM on computers, mobile phones are used more increasingly with IM. The mobility and constant availability and attentiveness to our phones is a factor we can take advantage of in work situations.

### 2.2.4   Mobile instant messaging

IM has been popular for some years, but since the introduction of smartphones, "... mobile instant messaging (MIM) have gained considerable momentum. Applications like WhatsApp, Viber, and Line allow mobile users to send real-time text messages to individuals or groups of friends at no cost." (Church and Oliveira 2013, p. 352). Most of the MIM applications also replicate other IM functions like sending attachments, voice call, and even video calls.

Researchers points to constraints of mobile phones like "smaller screens, less convenient input facilities, and lower multimedia processing capabilities than desktop computers" (Lee and Benbasat 2004, p. 82), that can dete-

riorate the user experience of such applications. However, the popularity of such applications (for example WhatsApp) has skyrocketed in the later years, according to statista.com (Statista 2017) (see figure 2.1).
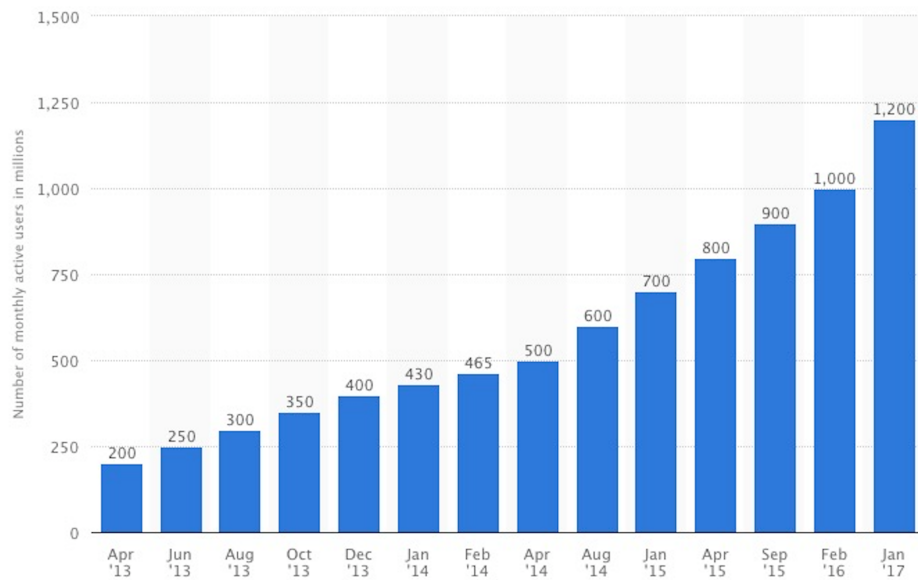


Figure 2.1: Number of monthly active WhatsApp users worldwide from April 2013 to January 2017 (in millions)

In this section, IM, IM at work and MIM has been discussed. We now shift the focus to a rather new social phenomenon called social media analysis.

## 2.3 Social data analysis

A crucial aspect of a HMIS is analysis of health data. To provide the users of our application with a tool to further data use and help them to discuss health statistics, we need to understand how to design such a platform. For this, we have chosen to draw on literature from social data analysis to inform our IM design.

The term social data analysis represents a way of manually mining data in collaboration with others. The idea behind social data analysis is that a group of people can make better sense of the data together, than on their own. Martin Wattenberg coined the term in 2005 when he, by chance, discovered that his "historical name" applet was the source of extensive discussion around the Internet, on blogs and forums (Wattenberg and Kriss 2006). These discussions resulted in articles about how to design social data analysis tools (ibid. and Heer, Viégas, and Wattenberg 2007).

Wattenberg presents three hypotheses for why his applet became such a well used social data analysis tool in his article: 1. Common ground,

but unique perspective 2. Expressive spectator interface and 3. Discovery transfer (Wattenberg and Kriss 2006). These hypotheses were further tested by Heer et al. when they made an asynchronous collaborative information visualization tool (Heer, Viégas, and Wattenberg 2007).

The first hypothesis that Wattenberg proposes "... is that a combination of common ground with unique individual perspectives will encourage social data analysis." (Wattenberg and Kriss 2006, p. 553). Common ground is the factor that makes the conversations and the discussion about the data possible and exciting. He also argues that it is beneficial for the development of the conversation/analysis that each person has a unique perspective on the data that is analyzed. Wattenberg goes on to say that: "... because each person is approaching the data in a different way, a group may collectively explore more pieces of the data." (ibid., p. 553).

In his second hypothesis, Wattenberg suggests that "... a social data analysis tool should support spectators as well as active participants." (ibid., p. 553) It is argued that for information visualization, the "expressive" quadrant of the spectator interface taxonomy (introduced by Reeves et al. 2005) should be used to design the interface. The "expressive" quadrant describes an interface where both input and output are amplified. The reason for why the interface design should be like this is because clarity and understanding of the data are critical (Wattenberg and Kriss 2006).

The third and last hypothesis regards discovery transfer, which is the ability for users to transfer their discoveries to other users when discussing the data. Without the ability for users to share their finding, there is nothing to discuss. "Thus, a natural design principle might be that information visualization software ought to provide "application-state pointers" if it is intended to support collaborative analysis." (ibid., p. 554).

## 2.4 Use of theoretical perspectives

In this thesis, we have based our work on mainly three theoretical perspectives, namely social presence theory, media richness theory and social data analysis. In this section, we will discuss how these perspectives have been used throughout our project.

An important principle of the ADR method is that the artifact (in this case, DHIS Chat), should be "theory-ingrained", meaning that it should be developed in such a way that it is "informed by theory" (Sein et al. 2011, p. 40). We have used the three aforementioned theoretical perspectives to design the DHIS Chat application and the underlying IM system.

The application has a contact list or "buddy list" with a presence indicator and is developed to use notifications to accommodate for social presence theory and fast response. It also features file attachments (currently only images) because e.g., technical problems can be solved quickly by sending a

descriptive picture of the problem. This accommodates for media richness, as it can describe much more than written text alone. IM at work, together with one of Halvorsen's design principles was two important factors for the development of the group chat feature in DHIS Chat, as the literature on IM at work constitutes groups as a good tool for collaboration and interconnection (Ou and Davison 2011). The concept of social data analysis and its proposed hypotheses have been used to develop and design a collaborative visualization tool, that uses regular IM groups together with a visualization preview inside the group to give the users an intuitive platform to discuss health data. Social media was also a influence for the collaborative visualization tool.

The three theoretical perspectives have been used in the analysis and coding of the raw data from the testing in Rwanda. This has resulted in nine design principles. But, not all of the principles are derived from the theory, as some of them are also backed up by the empirical findings and observations.

# Chapter 3

# Project background

This master thesis builds on another master thesis from 2015 by Niclas Halvorsen, called "Effektene av mobil- og data-mediert kommunikasjon i et helseinformasjonssytem" (Halvorsen 2015). Halvorsen's thesis attempted to introduce an HMIS integrated IM application to a health environment in a developing country.

The IM application developed in conjunction with the master thesis from 2015 was reported to have some technical issues, to the extent that it was not usable. Two of the biggest problem areas reported were data consumption (airtime) and usability. Even so, the consensus of the test was positive, and a need for this kind of application became apparent.

Our project aims to bring Halvorsen's research further. It also looks at the possibilities to take the IM application even further to facilitate and stimulate collaboration in a health environment in developing countries. Halvorsen had Rwanda as his primary focus in his project. As a continuation of his work and collaboration with local stakeholders, we also chose Rwanda as the context and location of our test. Some of the reasons why exactly Rwanda was selected were active use of DHIS 2 and a well-established telecommunications infrastructure.

This chapter will give an introduction of Rwanda, its ICT and health system, as well as information about the current communication tools used amongst the health workers today.

## 3.1   Rwanda

Rwanda is one of the smallest countries in the African mainland (Place 1999) and located some degrees south of the equator. Even though it is small, Rwanda has one of the highest population density in Africa with around 12 million inhabitants. Five provinces divide Rwanda: Northern, Southern, Eastern, Western and Kigali – where one can also find the capital, Kigali City. Although Rwanda is on the list of the world's least developed

countries, they have developed the country greatly since the 1994 genocide, with transportation infrastructure, water supply, and electricity in the major cities. The government is also investing a lot in telecommunications to become a vibrant knowledge economy and the IT hub of Africa (Freedom House 2016; Kamwangamalu 2016).

Rwanda is a trilingual country with the local language Kinyarwanda as the population's mother tongue. Most of the inhabitants also speak French; this has been taught in schools as the country's official language since the 1920s. A handful of the population – young or well-educated people – also speaks English as it replaced French as an official language in 2008, for Rwanda to become a destination for tourism and businesses (Kamwangamalu 2016).

### 3.1.1 Telecommunications

"Rwanda has achieved the highest ICT growth rate in Africa, as well as building Africa's first country-wide wireless broadband network." (ITU 2017). The government of Rwanda has and is still investing a substantial amount of money to improve their ICT and infrastructure to expand Internet access and affordability. In 2016 and 2015, Rwanda ranked as the country with the most affordable Internet of the least developed countries in the world (Alliance for affordable internet 2016). Nevertheless, a report from Rwanda Utilities Regulatory Authority (RURA) shows that the Internet penetration is only around 35% nationwide (Rwanda Utilities Regulatory Authority 2016).

Mobile phone penetration, however, is significantly higher with 79% across the country. Even in the rural areas, the use of mobile phones is high. This is made possible by a mobile network that covers over 99% of the total land mass. There are three mobile operators in Rwanda. The largest mobile operator is MTN Rwanda Ltd, which provide phone services to 46% of the population. The two others are Tigo Rwanda Ltd and Airtel Rwanda Ltd with a market share of 36% and 18% respectively (ibid.).

3G has been deployed geographically in 75% of the country by MTN and accessible to 92% of the population (ibid.). 3G gives most of the country – at least the big cities – good coverage and fast Internet, which we noticed during our stay in Rwanda. Vendors in the street selling cash cards for data bundles and airtime from the different operators are everywhere and often side-by-side sharing a parasol. These cash cards range from 100 RWF to 5000 RWF. For 5000 RWF, which is around 6 USD, one can buy 3GB for a month. 4G is also emerging in Rwanda with a geographical coverage of 32% and accessed by 47% of the population (ibid.).

It is hard to find data on how many people own a smartphone and especially how many health workers own one. However, Halvorsen conducted a survey on phones amongst data managers in Rwanda in 2015. Here he found that 51% of all data managers owned a smartphone

Figure 3.1: MTN and Tigo stands are sharing a parasol

(Halvorsen 2015). This gives us a base of users and a good starting point for the project.

## 3.2 HISP

This project was conducted under the supervision of HISP researchers, located at the University of Oslo. HISP is a global network with a goal of enabling and supporting countries to strengthen their HMIS in a sustainable way to improve their management of health services (HISP 2011). HISP has different units in many different countries, including Rwanda. As a means to assist in health management improvements, they have developed an open source HMIS tool. This system is called DHIS 2, and is more often than not used in developing countries with a lack of resources like ICT, electricity, and stable funding.

## 3.3 DHIS 2

DHIS 2 is a HMIS developed at the University of Oslo and is promoted by HISP. The development of DHIS started in 1997, and it became the de facto standard HIS in South Africa at the time (Braa and Sahay 2012). Development of the second version of DHIS started in 2004. The system is built using only open source frameworks and is, therefore, free to download and use. Braa et al. (2012) defines DHIS as "a tool for collection, validation, analysis and presentation of aggregated statistical data, tailored to supporting integrated health information management activities" (ibid., p. 236).

Rather than being a preconfigured database application, DHIS is designed to be a generic tool. According to Braa et al. it has an "open metadata model and flexible user interface that allows the user to design the contents of a specific information system without the need for programming." (ibid.,

p. 236). Figure 3.2 show an overview of the DHIS 2 user interface and dashboard.

The system is today deployed and in use in nearly 50 countries worldwide. Most of the countries using DHIS 2 are developing countries in Africa and Asia, in addition to 23 organizations across four continents (DHIS 2015).
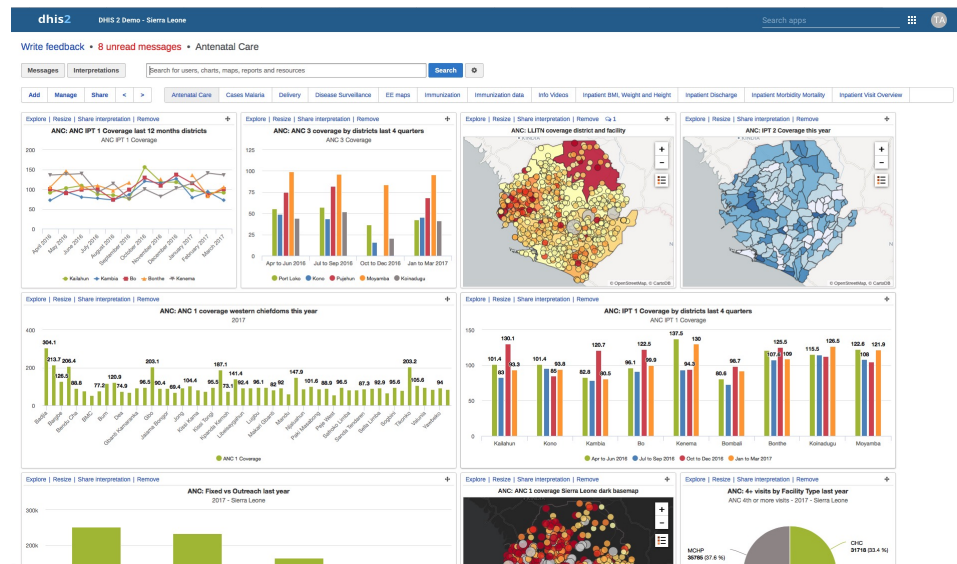


Figure 3.2: Overview of the DHIS 2 dashboard

### 3.3.1 DHIS 2 Interpretations

DHIS 2 lets you create advanced data visualizations. These visualizations are called interpretations and will be referred to as DHIS 2 interpretations in this thesis. DHIS 2 interpretations include charts, reports, pivot tables and geographic information system (GIS). When a data visualizations have been created in the DHIS 2 portal, DHIS 2 interpretations of these can be made. DHIS 2 interpretations allow users to share the visualization with other DHIS 2 users with the purpose of discussing collaborative- and social data analysis. This interpretation includes a text describing the data, as well as the possibility of commenting on the visualized data. An example of a DHIS 2 interpretation can be seen in figure 3.3 on the next page.

### 3.3.2 DHIS 2 in Rwanda

Rwanda currently uses DHIS 2 as the country's HMIS. It is used for monitoring health issues and surveillance of disease, and also to store facility registries (ibid.). Rwanda started using DHIS 2 as their national HMIS in 2012. DHIS 2 is used on all levels of the health hierarchy from the ministry on top, down to the health care centers. They currently have
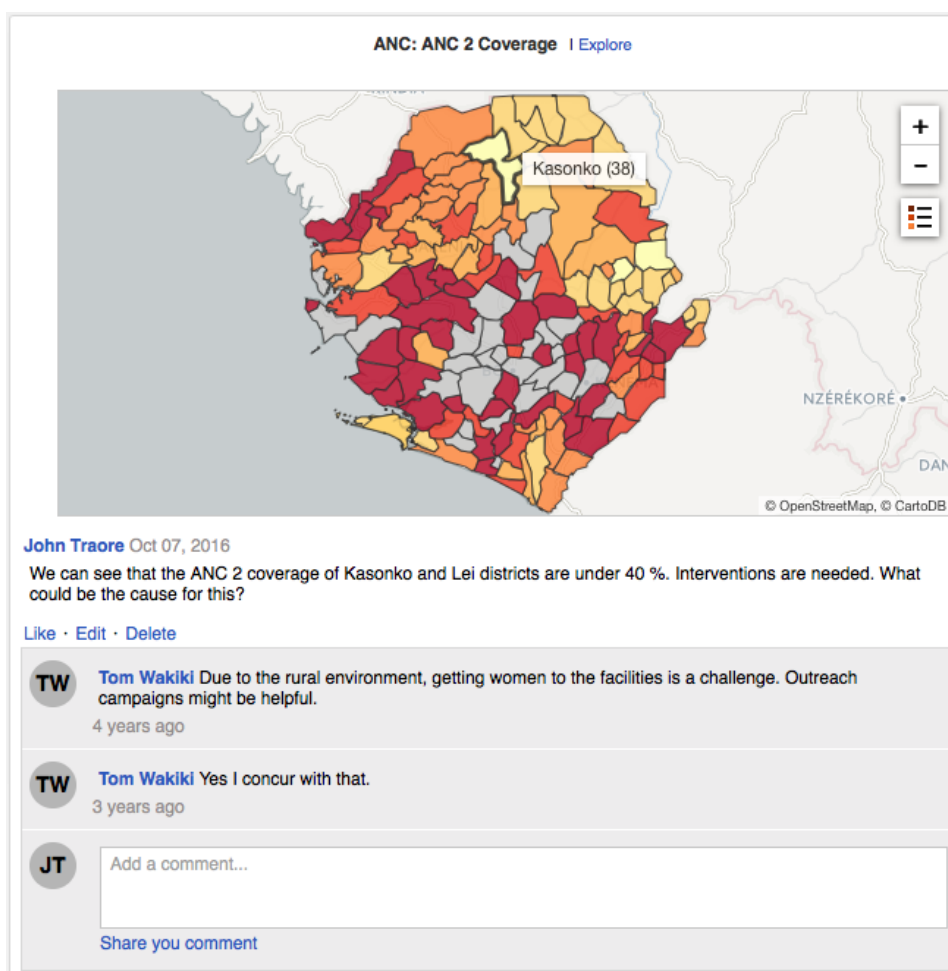
Figure 3.3: Example of a DHIS 2 GIS interpretation

seven different instances, where one of them is the main instance without extensions, while the others are versions of DHIS 2 specifically for financial- and performance-based use and disease surveillances (Ministry of health, Rwanda 2016).

## 3.4 Health hierarchy and the Ministry of Health

This project was performed in close collaboration with the MoH in Rwanda. The ministry is the supreme body of Rwanda's health organi- zation. Included in the ministry is an HMIS team, responsible for the DHIS 2 system. They customize DHIS 2 for Rwanda's needs and make sure the system is running at all times. They also provide end-users with technical support.

The HMIS team Lead played an active role in the past master thesis and the testing of the previous application. For our project, he made specific requests in regards to features of the chat application and has been involved

from the start. During our stay in Rwanda, we shared offices with the HMIS team at the ministry and got to observe how they work in regards to DHIS 2.

The MoH in Rwanda had two main requests for new application features. These are described below:

**DHIS 2 interpretations**

DHIS 2 interpretations are a crucial part of the DHIS 2 system, because analysis of health data is such an important task of a health information system. Because of this, MoH wanted to include DHIS 2 interpretations in the IM application to facilitate for more discussions and information use (i.e. data analysis and reflection) among the health workers in Rwanda. In addition to have a display of the DHIS 2 interpretations, they also wanted a more social way of discussing and analysing these visualizations to help data managers to share experiences and learn from each other.

**Attachments**

With technical support in mind, attachments were requested as an added functionality. Mainly images to describe a problem or a solution, but also other documents like PDF or other files to share amongst the users. There was also a wish for video/voice calls like Skype, or Facebook Messenger has integrated.

Many units make up the health sector in Rwanda. Our focus is the ones who regularly uses DHIS 2. Below MoH and the HMIS team at the national level, there are M&E's (monitoring and evaluation) officers stationed at the district hospitals. In Rwanda, there are 30 districts with at least one district hospital in each of them. These M&E's are the supervisors of the 800 data managers situated at the health facilities in the districts. Data managers are the lowest level DHIS 2 users, and they are responsible for data collection and entry in DHIS 2. The data flow follows this hierarchy from the bottom to the top. The ministry at the highest level uses this data for decision-making, and also all lower levels *should* use the data for local decision making.

## 3.5   Communication in the health sector

Communication in the health sector in Rwanda is a rather complex topic with a lot of different channels. In this section, we will present data from a survey regarding communication at work, as well as the two most used communication channels. We will also talk about some of the other communication channels that were reported to be used.
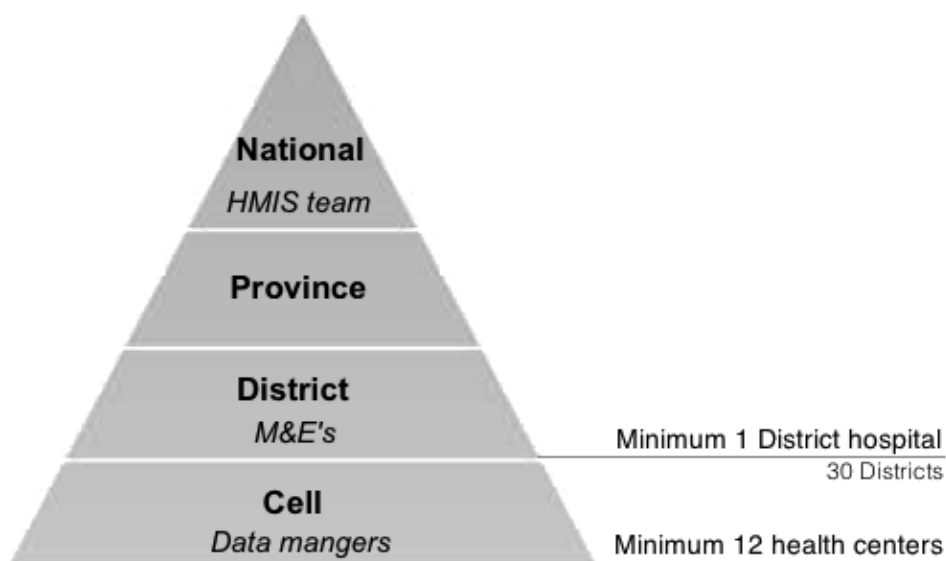
Figure 3.4: Hierarchy in the Rwandan health sector

### 3.5.1 Communication channels

In 2015, Halvorsen sent out a questionnaire to 800 data managers in Rwanda. 377 of them answered (Halvorsen 2015). This questionnaire informed him on the communication situation in Rwanda. One of the questions in the questionnaire was: "What communication channel do you use the most at work?". The data Halvorsen got from this question is presented in figure 3.5 on the following page. The results show a wide spread in the preferred communication channel, where 45% communicate through a phone (SMS or phone call) and 50% communicate with email or similar methods (like DHIS 2 messages).

### 3.5.2 Messaging in DHIS 2

DHIS 2 has a messaging system inside its portal (henceforth called the DHIS 2 messaging system). It is set up similar to an email client, where one can add recipients, subject, and the message itself. The system supports one-to-one and one-to-many communication. Where the system differs from regular email is the fact that it is not possible to send messages to other servers. Users in the database of the DHIS 2 instance can only receive and send messages from and to users on the same instance. The system lacks features like attachments, availability (e.g "buddy lists"), and notifications.

Some countries restrict the use of the messaging system and give the lower level DHIS 2 users access to a feedback system instead. This feature limits the use of messages so that the person using the feedback system is only able to send messages to pre-set recipients (often a support team). The
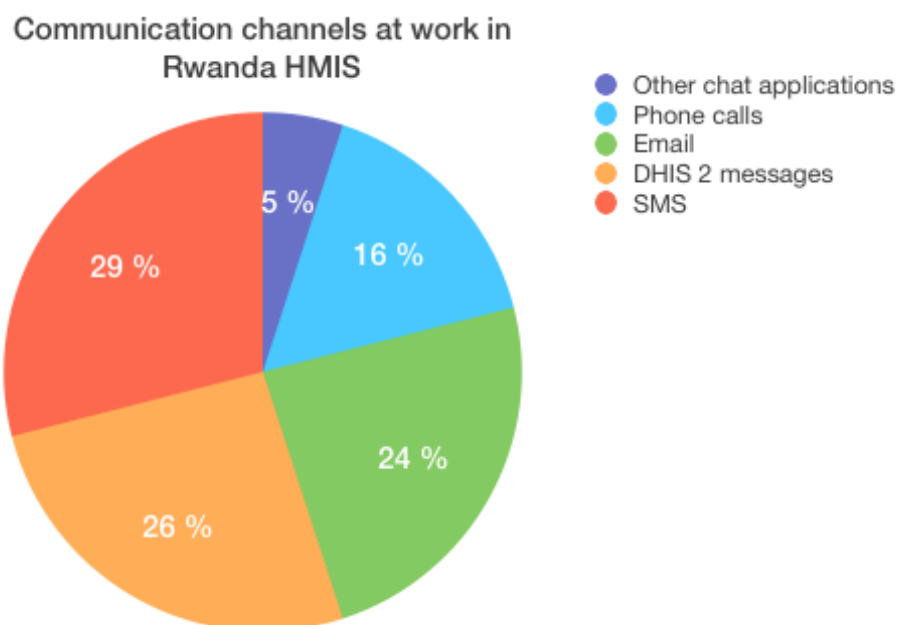
Figure 3.5: Result of the questionnaire in 2015 on preferred communication channels at work. Obtained from Halvorsen (2015)(Halvorsen 2015, p. 33)

user that writes the message can therefore not contact a specific person, but rather ask a group of people a question.

Both our test group and Halvorsen's test group reported that there are problems in regards to using the messaging system provided in DHIS 2. The most common feedback on the system was that it takes too long for anyone to answer. Most of the people we interviewed told us that they had used the system before, but they do not use it regularly.

### 3.5.3 WhatsApp

WhatsApp is a freeware, cross-platform messaging application that supports end-to-end encryption. It is available on Android, iOS and Windows Phone, and reports of having over 1 billion users in more than 180 countries (WhatsApp 2017). The MoH in Rwanda and their health facilities use WhatsApp as a communication channel. Both the head of HMIS and the data managers informed us that the whole health sector hierarchy is organized in WhatsApp groups.

Johnston et al. (2015) report that "WhatsApp represents a safe, efficient communication technology." (Johnston et al. 2015, p. 45) for surgeons and other health professionals. Although WhatsApp has end-to-end encryption, it was acquired by Facebook in 2014 (WhatsApp 2017), which makes its money by selling information about their users. As to whether it is safe or not, Watson et al. (2016) argue that "... in its current form, WhatsApp is unsafe to handle patient data and is inappropriate

for use in a clinical environment." (Watson et al. 2016, p. 302) The head of HMIS at MoH told us in an interview that WhatsApp is only used for quick communication, not for collecting data or sharing any confidential information, which is also the general consensus from the data managers.

All the data managers in our test group reported that they used WhatsApp. How frequently they sent messages regarding work related issues fluctuated between 6 and 20 messages a day.

### 3.5.4 Phone calls and SMS

Most of the data managers reported that fast response time is important to them. As mentioned earlier, this is one of the reasons why they do not use the messaging functionality in DHIS 2. Some of the data managers also reported that they use phone calls and SMS as a way to communicate at work. In a group discussion we had at the district hospital, the consensus of the data managers was that they used WhatsApp for coordination, while they used phone calls for more in-depth information. They emphasized that both phone calls and WhatsApp facilitated quick response.

## 3.6 Second generation messaging application

One of the goals of this project has been to create a second generation mobile messaging application for the health sector in Rwanda. The first application, called DHIS 2 Messenger, was created by Niclas Halvorsen in 2014/2015, which he describes in his master thesis (Halvorsen 2015). DHIS 2 Messenger was well received, and a new iteration was necessary to further study the use and effect it can have in an organizational context. His application had some problems that we have aimed to solve, while also adding some new functionality requested by the MoH. Since this is a continuation of Halvorsen's project from two years ago, his thesis and observations have served as a source of inspiration and discussion throughout our project.

In short, both of the applications connect to Rwanda's HMIS, called DHIS 2. To log in to the application, one must provide valid DHIS 2 credentials. Halvorsen's application, DHIS 2 Messenger, is the first of its kind that connects to DHIS 2. The application had functionality like DHIS 2 messages, one-to-one chat, one-to-many and many-to-many chat (Multi User Chat (MUC)/groups), availability, notifications, and DHIS 2 interpretations. Some of the problems with the application were its substantial data consumption and confusion about what the difference between DHIS 2 messages and one-to-one chat was.

Our application, called DHIS Chat, aims to overcome some of the problems in Halvorsen's application, which he describes in his thesis (ibid.). We have

also added functionality requested by the MoH in Rwanda, like attachment and a way to analyze health data in collaboration with others (named interpretation MUC). In Table 3.1 we can see a comparison of the new application (DHIS Chat) and Halvorsen's DHIS 2 Messenger as well as the messaging functionality in DHIS 2 and WhatsApp. Our application is built from the ground up, using *new* technology like React Native JS and native modules. The back end chat server is mostly the same as Halvorsen used. The chat functionality of our application is designed to mimic the behavior of WhatsApp, as it is the messaging application that most people in Rwanda with a smartphone are accustomed to.

| Comparison of functionality in communication channels | | | | |
|---|---|---|---|---|
| Communication channel | DHIS 2 | DHIS 2 Messenger | DHIS Chat | WhatsApp |
| 1-to-1 chat | ✓ | ✓ | ✓ | ✓ |
| 1-to-n chat | ✓ | ✓ | ✓ | ✓ |
| n-to-n chat | ✕ | ✓ | ✓ | ✓ |
| Synchronized chat | ✕ | ✓ | ✓ | ✓ |
| Availability | ✕ | ✓ | ✓ | ✓ |
| Notifications | ✕ | ✓ | ✓ | ✓ |
| Attachments | ✕ | ✕ | ✓ (Images) | ✓ |
| Call | ✕ | ✕ | ✕ | ✓ |
| Interpretations | ✓ | ✓ | ✓ | ✕ |
| Interpretation chat | ✕ | ✕ | ✓ | ✕ |

Table 3.1: Comparison of the functionality of the most used communication channels in Rwanda's health sector

# Chapter 4

# Method

This Chapter focus on the method chosen as a framework and guide to conduct our research. The project timeline is presented with a project summary before we give an introduction to ADR. The main part of this chapter will describe our use of ADR and the steps taken in our project. The chapter concludes with study limitations and constraints.

## 4.1 Project summary

This thesis deals with the development and testing, as well as the technical and social characteristics of the second generation HMIS integrated IM application, called DHIS Chat. Some components of the system, like the backend of the IM server, is an evolution of the system used in 2015, while others like the Android application were redeveloped from scratch. More information on the development of the IT-artifact can be found in Chapter 5.

The project commenced in the winter of 2015. The planning phase started in November with a meeting were Niclas Halvorsen, developers from HISP, supervisors and ourselves discussed the previous IM system and ideas for the new project. During this phase, we also had two skype meetings with the leader of HMIS at MoH in Rwanda to discuss his requests for the new application. We also spent some time setting up the old system and learning about the technologies used.

From September 2016 to February 2017 we focused on the development of the new IM application, all the while planning the execution of the testing in Rwanda. The field trip lasted from the 1st of February until the 1st of March. During this time, we collected empirical data for our research and tested the application.

We conducted the testing from the HMIS office at MoH in Rwanda's capital Kigali. During the test period, a total of 20 people tested the system for a

variable amount of time. 14 of the 20 testers, used the application for well over three weeks.

Figure 4.1 presents the timeline of the project.
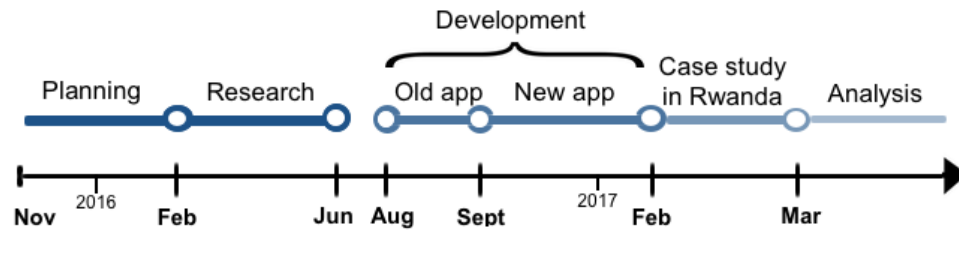


Figure 4.1: Project Timeline

## 4.2   Action Design Research

To investigate and understand the effects of introducing an application into a health organization, the focus of the research should be directed towards organizational use and change. Action Research (AR) is a research method, introduced by Kurt Lewin in 1946 (Lewin 1946) that can be used to obtain knowledge about this. "AR addresses social system change through action that is at once a means of effecting change and generating knowledge about the change." (Cole et al. 2005, p. 326). The AR method focuses on practical problems with theoretical relevance. The researchers conducting an AR study will often intervene in an organization to introduce the change. Many HISP projects use this research method because of its unique ability to inform theory while addressing relevant problems.

In addition to understand the organizational use and change, we also want to understand the process behind the development of a communication system, like the one we have created, in a health information system. In this setting, a method like Design Research (DR) (sometimes also referred to as design science) can be used. DR "... focuses on creating and evaluating innovative IT artifacts that enable organizations to address important information-related tasks." (Hevner, March, and Ram 2004, p. 98). DR should also "... incorporate theory in the development of the artifact as well as make a theory-building contribution." (Cole et al. 2005, p. 326).

We want to understand both the organizational use and change, as well as evaluate the IT artifact. To fulfill both these needs, we have used a research method called Action Design Research (ADR), which combines AR and DR. Sein et al. introduced ADR in 2011 and is, therefore, a relatively new research method.

ADR is an approach to produce knowledge by intervening in an organization through developing an innovative IT artifact. This method consists

of four stages, namely 1. Problem Formulation, 2. Building, Intervention, and Evaluation (BIE), 3. Reflection and Learning and 4. Formalization of Learning. Each stage contains at least one principle, with seven in total as displayed in figure 4.2.
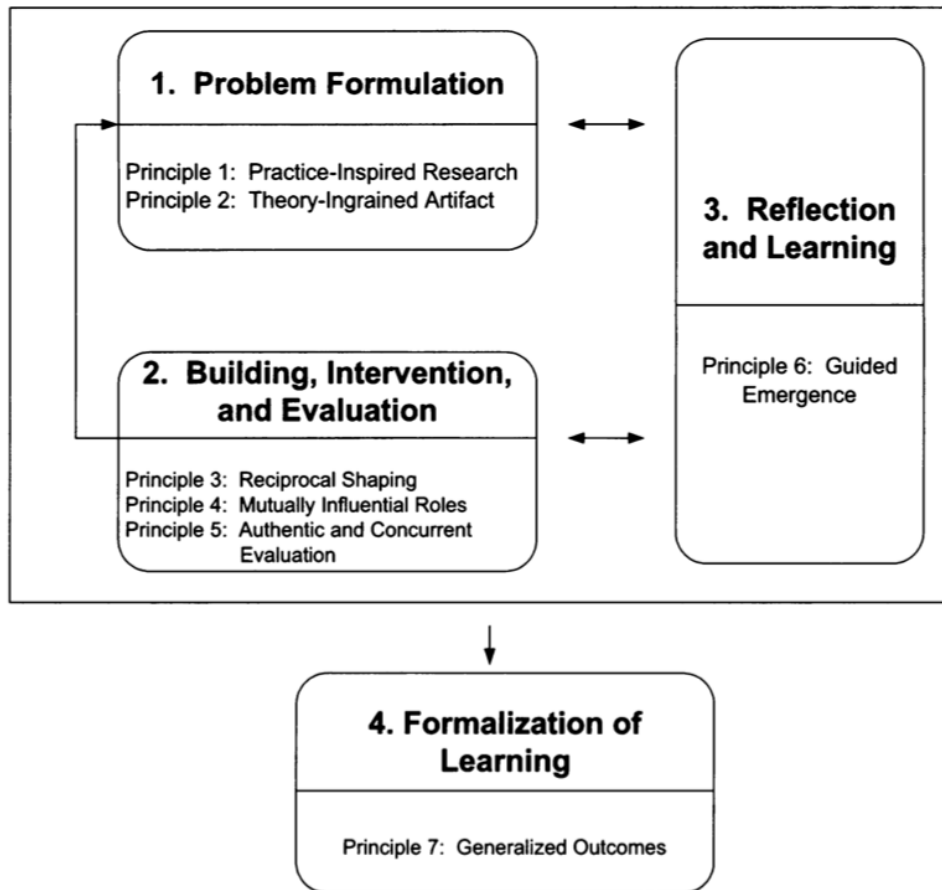


Figure 4.2: The four stages and seven principles of ADR. Obtained from (Sein et al. 2011, p. 41)

The article "Action Design Research" by Sein et al. (Sein et al. 2011) describes the ADR stages and their principles as follows:

**Stage 1: Problem Formulation**
Here, the researcher should identify, articulate and scope the problem. The principles following this stage are *practice-inspired research*, where one should emphasize "viewing field problems (as opposed to theoretical puzzles) as knowledge-creation opportunities" (ibid., p. 40) and *theory-ingrained artifact* which "emphasizes that the ensemble artifacts created and evaluated via ADR are informed by theory." (ibid., p. 40). This means finding a real-world problem and create an IT artifact based on theory that aims to solve it.

**Stage 2: Building, Intervention, and Evaluation (BIE)**
The second stage is called "Building, Intervention and Evaluation"

and here one should use "the problem framing and theoretical premises adopted in stage one." (Sein et al. 2011, p. 41). The thinking behind this is that it gives a "platform for generating the initial design of the IT artifact." (ibid., p. 41). In this stage, the building of the artifact, the intervention in the organization and the evaluation is important. These three keys give what is called BIE. "The outcome of the BIE stage is the realized design of the artifact." (ibid., p. 42). BIE is an iterative process made up of cycles, and it can either be IT-dominant or organization-dominant. The three principles this stage draws upon, are *reciprocal shaping*, *mutually influential roles* and *authentic and concurrent evaluation*.

**Stage 3: Reflection and Learning**

This stage "moves conceptually from building a solution for a particular instance to applying that learning to a broader class of problems." (ibid., p. 44). This stage draws upon a principle called *guided emergence*, which captures a vital trait of ADR: "the interplay between the two seemingly conflicting perspectives" of AR and DR (ibid., p. 44).

**Stage 4: Formalization of Learning**

The objective of this stage is that "the situated learning from an ADR project should be further developed into general solution concepts from a class of field problems." (ibid., p. 44). *Generalized outcomes* are the seventh principle that this stage draws upon.

In the following sections, we will describe the use of the ADR stages and the cycles of this project.

## 4.3   Problem Formulation

Our project is driven by the need for an efficient and flexible communication tool with the possibility for information use and collaboration for end users of DHIS 2 in Rwanda. This need makes the foundation for principle one in ADR; practice inspired research.

To identify, articulate and scope the problem area we had to understand the current communication behavior and standards within Rwanda's health sector. This meant that we had to familiarize ourselves with Halvorsen's research, findings, and his IT artifact. We were especially interested in identifying unresolved issues and problem areas. During the planning phase, we had a meeting where the application was discussed as mentioned in section 4.1, we read his thesis and explored the technology, concepts, and theory used in the former project.

At the same time, we were introduced to the leader of HMIS at MoH as our contact person in Rwanda and stakeholder. We had two Skype meetings with him where we discussed his thoughts on the results of the last project and his hopes for what a new iteration of this project could accomplish. The

high data consumption was one of the things from the previous application we discussed in length. We also talked about the features he wanted to add. These features were group chats with DHIS 2 interpretations as topic, attachments and voice/video calls. The key quote of our meetings and the impression we were left with was that he wanted the end users to have:

> "Information at the fingertips."

We decided, together with the leader of HMIS, to focus on improving data consumption and the interpretation feature from the previous application, which already had one-to-one chats, MUC, and interpretation display. We also wanted to focus on attachments, however, the voice and video calls were not considered important enough and also too time-consuming to add to the application.

To further understand what makes a good IM application and design, a review of literature on chat in the workplace, media richness, social presence theory, and social data analysis was conducted, giving us the foundation for ADR's principle two: Theory-ingrained artifact.

## 4.4 Building, Intervention and Evaluation

Based on the findings in the problem formulation stage, we decided that it would be necessary to explore the possibility of integrating a data analysis tool with the application, as well as reducing the data consumption. This was the two main concerns that became our platform when the initial design of the application was generated.

The BIE stage contains three principles, all of which describes how the stage should be conducted. The first principle in this stage is called reciprocal shaping, and its focus is that the artifact should be continually worked on (shaped) throughout this stage, to accommodate both the artefact and the organizational context. Some small changes were suggested by the HMIS team at MoH when we first demonstrated the application, to better fit the organizational context. We also had to modify a part of the architecture of the system before they let us connect to their servers, because it originally stored the users password.

The second principle of BIE is called mutual influential roles and regards the importance of mutual learning among the project participants. After each cycle, which is described in detail in the following sections, we gathered feedback from the project participants and implemented most of the suggestions into the application. During our main field test, we also added requested functionality while the test was ongoing. The project participants will be presented in section 4.4.1 on the next page.

The last principle in this stage is called authentic and concurrent evaluation. This is the principle that makes ADR unique because it does not

separate evaluation and building. Rather, evaluation is part of the designing and shaping of the artifact. During our work in Rwanda, we used the evaluation to better understand how the artifact was used and what it was used for.

In the next sections, the different stages of our BIE stage will be discussed. In figure 4.3, an overview of the cycles is presented.

### 4.4.1 Project participants

During the BIE cycles, multiple participants were a part of the testing phases. In this section the particitpants will be presented as well as their role in the health sector in Rwanda.

**Data managers**

Our primary test group was the data managers. They use the DHIS 2 system in their daily work and are therefore the end-users of the system. At each health facility in the country, there is one data manager. They are responsible for data collection and the entry of data into the DHIS 2 system. In total, 11 data managers tested our application.

The data managers that took part in our test were all from the same district. As a consequence of this, they all knew each other and communicated frequently. All the data managers had access to a WhatsApp group where some of this communication took place. Two of the data managers that tested our application also tested DHIS 2 Messenger in 2015. This meant that we could discuss the differences between our and Halvorsen's application, thus giving us a good base for comparison between the two.

**HISP Rwanda**

HISP Rwanda is a non-governmental organization (NGO), whoes goal it it so strengthen the HMIS of Rwanda, and to promote DHIS 2. To ensure sustainability and a continuation of the project, Two training session with a representative from HISP Rwanda were conducted. In these sessions, we helped the HISP representative to set up his development environment, as well as conduct a code review and a walk through of the system. We also made sure the representative was participating in the training of the data managers. In return, he was our interpreter, guide and a part of the test to assist the data managers. The goal is that HISP Rwanda will use the existing code to develop the chat application further, in alignment with local requirements and needs.

**Ministry of Health**

The MoH was one of the primary motivators for this project and an important participant in our study in Rwanda. Our contact person was the lead at the HMIS office at MoH. This office became the base for our operations while we conducted the tests in Rwanda. The HMIS team is a technical team with responsibility for the servers and HMIS at MoH. They also do technical support, as well as customization of DHIS 2 to fit the need of the data managers around the country.

### 4.4.2 IT-dominant BIE

In their paper, Sein et al. 2011 suggest that the BIE stage "... clarifies the focus of innovation, which may come from the artifact design or the organizational intervention." (ibid., p. 42). The difference between these two and the choice the researchers take will help decide if the research should follow an IT-dominant BIE or an organization-dominant BIE. In this project, the IT-artifact (the collection of all the systems like the Android application, DHIS 2 and Openfire) is the focus of innovation. Sein et al. assert that an IT-dominant BIE ".. suits ADR efforts that emphasize creating an innovative technological design at the outset." (ibid., p. 42). Because of this, we classify the BIE stage as IT-dominant.

During the BIE stage, we conducted three cycles where all of them contained development, testing, and evaluation. The first cycle was an prototype test with our supervisors in Oslo, the second was an alpha test with the HMIS team at MoH, and the third and final cycle was a beta test with 11 data managers from a district in Rwanda. These cycles will be discussed in more detail in the following sections.

### 4.4.3 Cycle 1: Development and prototype testing

This cycle was used for the main development of the application. We used an iterative process where prototypes were produced and tested by us, the ADR team, every day. This made the uncovering of bugs much easier, and in the end, the application more robust.

Before the field trip to Rwanda, the application was prototype tested by both our supervisors. The supervisors downloaded the application via Dropbox and installed it on their phones. This test gave us some insights into how first-time users react to the design of the application, what functionality was obvious and what functionality needed explanations and consequently redesign. We also discovered some new bugs during the test. These bugs were dealt with the following days.

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### 4.4.4 Cycle 2: Alpha test at MoH

When we first arrived in Rwanda, we held an introduction and a demonstration of the application for the HMIS team at MoH. We also conducted an interview with the head of the HMIS team about the motivation behind this application and why MoH felt it was necessary to have a messaging application that is connected to DHIS 2. We were also introduced to HISP Rwanda and its leader, which gave us a brief introduction to their work and what the hierarchy of the health sector in Rwanda looks like.

Cycle 2 started by resolving the problems found in the test in cycle one. The first field test was conducted at MoH, together with the HMIS team. This test session took place about one week after we arrived in Rwanda and included six people, four of which was from the MoH HMIS team and two from HISP Rwanda. The focus of this test was to introduce the technical team to the alpha version of our application, as well as gather information about what functionality might be missing. The consensus of the test was very positive, even though some bugs were discovered.

One of the issues of the test was the standard and older age of the phones used by the team. This was something we had anticipated, but we did not know exactly what to expect. Fortunately, we did get to test the application for a week on our own on the phones that were bought for the test that Halvorsen conducted in 2015. The issues the application had with these old phones were sorted in the third cycle.

Even though the test session at MoH only lasted an hour or so, the HMIS team and one of the developers from HISP Rwanda continued to use the application throughout our stay in Rwanda.

### 4.4.5 Cycle 3: Beta test

The main testing started two weeks after we arrived in Rwanda, as a group session with eleven data managers. The session began with an introduction of us and the project. The data managers then got an agreement that they read through and signed. The agreement contained information on the project, what their responsibility was during the test and what they could expect from us. The agreement can be found in Appendix D. When the contracts were signed, we created user profiles for the data managers on the test server. While the user profiles were created by one of us and a representative from HISP Rwanda, the other held a demo of the beta version of our application for the data managers.

When the user profiles had been created, and the demo of the application was done, airtime (data packets) were bought for the data managers, as stated in the contract. Those data managers who did not own an Android phone received a test phone, and everyone downloaded the application from Google Play. In total, 7 test phones were given to the group. When

everyone had installed the application, the data managers were handed a questionnaire. This questionnaire contained questions about their use of other messaging and social media platforms, as well as their use of DHIS 2 in general, and DHIS 2 interpretations specifically. This helped us map what to be expected by a general end user of DHIS 2 regarding further testing. The questionnaire can be found in Appendix B.

During the beta test with the data managers, more bugs were reported and solved and changes were requested. The reporting of bugs and other communication was all done via the application. The system itself gathered data about the usage of the application like messages sent in one-to-one chat, messages sent in group chat, how many users were logged in during a day, how many groups were created, and so on.

While the testing continued, our main concern was to connect the system to a production instance of DHIS 2. Since launch, the system had been running on a server provided by the HISP team at UiO and was connected to a dummy instance of DHIS 2. Therefore, it did not provide data visualizations (DHIS 2 interpretations) with actual and relevant data to the data managers. The delay of the connection to the production server was caused by security concerns.

In a meeting with the HMIS team Lead, we gave an in-depth description of the code and showed that no passwords were saved. We also explained that the system only used the Application Programming Interface (API) of DHIS 2 to log in. After this meeting, we were given the permission to connect to the production server. This took place on the evening of the penultimate day. During the test period, we also did a walk through of the code and the setup of the development environment for a representative developer from HISP Rwanda as mentioned in section 4.4.1.

Before the end of our time in Rwanda, we had another group session with the data managers at the district hospital. This session was conducted to get a sense of what the test subjects felt about the application as a group. After the group session, we had an interview with three of the data managers, including the head data manager from the district hospital.

On the last day of our study, all the remaining data managers were called into MoH for a one-to-one interview about their experience with the application. When these interviews were conducted the application had been updated to accommodate the DHIS 2 production server, so we helped the data managers to update the application. We also gave them the remaining airtime, so that the test could go on for two more weeks after we left Rwanda. We finished the interview with a thorough explanation of the DHIS 2 interpretations functionality of the application, and how that related to the interpretations inside the DHIS 2 portal.

The BIE cycles can be repeated multiple times, but due to time restrictions, we only had time for three. An illustration of our BIE cycles is displyed in figure 4.3 on the following page. After its completion, we went home to Norway and processed our findings.
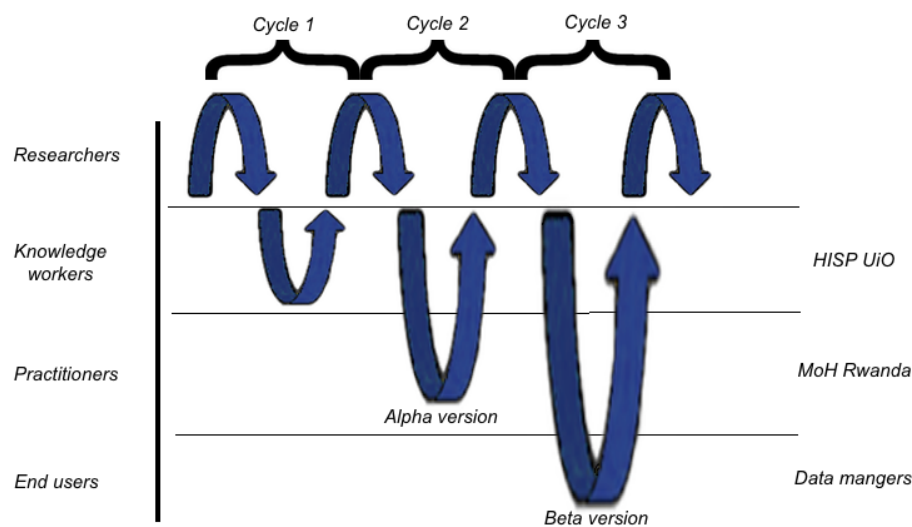
Figure 4.3: Overview of BIE cycles

## 4.5 Reflection and Learning

To go from a specific instance, reach guided emergence into a broader class of problems and apply the knowledge into theory, we had to get a clear overview of the data and results from the BIE stage. The data came from multiple sources and in different shapes. Statistics were put into tables and compared with relevant data. Interviews, which had been taped, were transcribed, coded, and discussed, and casual conversations and observations had either been written down or been photographed. The different data sources are described in the next section.

### 4.5.1 Data collection

To capture a holistic, complete and contextual portrait of the setting and use of the messaging application we collected a mix of qualitative and quantitative data (Jick 1979). Our qualitative data sources were mainly observation and participant observation, interviews, survey, and questionnaires, but also documents and texts. The test participant's impressions and reactions also gave us important information (Myers 1997). Our quantitative source was messaging statistics saved on our server to validate the qualitative findings.

Our main data collection tools have been:

- Questionnaire

- Group discussions

- In-depth interviews

- Statistics from server logs and chat application

- Observations

- Casual naturally occurring conversations

Additionally, we asked participants to sign an agreement between us, MoH and them where we also asked for information like name, role, whether they had a smartphone, contact information and more.

All of these methods has been useful in different ways, giving us either key information or information to substantiate our key findings. As a secondary source of information, we also used Halvorsen's master thesis to get an overview of previous work and compare findings.

**Questionnaire**

At the beginning of the beta test, a questionnaire was handed out to the 11 data managers. This was done to get background information on their use of DHIS 2, other IM applications, DHIS 2 interpretation knowledge and use, as well as their preferred method of communication. This gave us answers to many misconceptions in regards to the use of DHIS 2 interpretations and assumptions we had made before the study. Although the answers were short, they gave us insight on how communication was conducted amongst the data managers in our test district.

**Group discussions**

In the second week of cycle 3, we found out that all of the data managers using our application were having a coordination meeting at the district hospital. We used this as an opportunity to see one of their health facilities and arrange a group discussion. In the group discussion, the goal was to get a variety of viewpoints on the chat application (Brinkmann and Kvale 2015). The discussion lasted for forty minutes, and except two data managers, all of them were present, including a representative from the HMIS team.

As discussion moderators, we introduced topics like old features, new features, data consumption and so on for them to discuss. We got relevant feedback and found that they had many thoughts on the chat application. We asked the data managers what they thought was the biggest difference between DHIS Chat and WhatsApp, and one of them answered the following:

> "WhatsApp is connecting with telephone numbers, but DHIS Chat is only for DHIS2 users. Related to DHIS this app is very usefull, now a days us data managers always using DHIS application in our daily work. This app can be used to connect with all data managers, and mass messages can be sent out if something is wrong etc. It will be easy to give contribution."

When we asked the data managers if they had used WhatsApp less, since the test of DHIS Chat started, one of them said:

> "I think that from the day we started testing this application, we have used WhatsApp less. This application is very useful for us data managers. Yesterday I talked to another data manager in another district. I said to him: "Do you know DHIS2 Chat"? He said: "What is this?" And I told him that we were testing the app and he was very jealous!"

These statements show excitement among the data managers for an MIM integrated with DHIS 2 for the purpose of easing the data managers daily work communication.

**In-depth interviews**

In-depth interviews were a priority from the start. In the beginning, we conducted a thirty minutes interview with the HMIS team lead who was an initial motivator of this project. It was important to get his views on the project, the motivation and why a messaging application was needed for the health workers in Rwanda. As the lead of the HMIS team, he gave descriptive and extensive answers, supplying us with important insight on the present situation. When asked about the current situation in regards to data use and DHIS 2 interpretations, he answered:

> "So, currently they have monthly meetings where they discuss epistemological data, but you know in DHIS2 there is what we call favorites. You just create your chart and save it. But till now they have not been using interpretations more, but what they do is saving the charts, saving the reports and then they use it in the epistemological meetings."

We also interviewed the data managers testing the application at the end of the beta test. These interviews were conducted in the third week of testing, and the main topics were what functionality they used the most in the chat application, what they liked, disliked and the reasons why. We also asked about ideas for new features. This gave us information on use patterns and what features they want in a messaging application to fulfill their communication and collaborative needs. These interviews are our main source of data and what we are basing our analysis on in the later chapters.

Out of the 11 data managers, nine showed up for an interview. To prepare for these interviews, we made flexible interview guides. Decisions about which questions each data manager was asked were made depending on their answers and their use of the application during the test phase. The interviews were conducted at the HMIS office. Not all data managers were fluent in English so when they had trouble understanding the questions, someone from the HMIS team translated.

**Statistics from server logs and chat application**

As all one-to-one chats, group chats and interpretation chats sent with our application were private; we should not and were not able to access these messages. Most of the messages were also written in Kinyarwanda, the local language, so understanding the messages would not have been feasible. What we did to monitor the use of the application was to save statistics on all messages sent, both in groups and one-to-one chat on the server. The chat server also created statistics on how many people were logged in at the same time, active conversation and other useful statistics that could substantiate the findings in the interviews.

**Observations**

Key observations were done on two levels during the alpha and beta tests; the use of the messaging application and the dynamic between the data managers.

Some of the data managers started one-to-one chats with us. We were also a part of two groups. These could give us some data on use patterns, although they were not conversations one would normally have because they mostly concerned the testing of the application.

During the group session, we got to observe where some of the data managers worked and their dynamic. They seemed to know each other well, but some were more outspoken than others. This also showed in the statistics – who sent many messages and who did not.

Throughout our stay in Rwanda, we shared an office with the HMIS team. This gave us the insight to see how they do technical support and how often. We noticed that they often spoke on their phones and always worked inside the DHIS 2 system. Some were also using WhatsApp a lot. We also observed meetings and how they work on a more organizational level.

**Casual naturally occurring conversations**

Another positive thing about sharing the office with the HMIS team was lunch breaks and time between tasks. This gave opportunities for casual conversations on how they work and how the current situation is in Rwanda in regards to communication in the health sector. We also talked about culture, and why Rwanda is the country it is today, which gave us a better understanding of the context for the project. During the application demonstration with the MoH in cycle 2, we also got feedback to consider before the field test of the beta version.

The visit to the district hospital gave opportunities for casual conversations about the HMIS teams daily work. On the drive from the MoH office

to the district hospital, we were accompanied by one of the HMIS team members. He told us about how they conduct their technical support and their interaction with the data managers. On the way back, one of the data managers caught a lift with us, giving us more casual feedback on the application and information on his daily work routines.

| Method | Description | BIE Cycle |
|---|---|---|
| Questionnaire | The 11 data managers got a questionnaire about current use of communication tools and DHIS 2 interpretations | BIE Cycle 3 |
| Group discussion with MoH | An impromptu discussion between us and 4 people from the HMIS team was conducted after the first demonstration of the application about their needs in a chat application | BIE Cycle 2 |
| Group discussion with the data managers | A group discussion with 9 of the 11 data mangers were performed at the district hospital to get a general view of usage and opinions about the need of a messaging application from the data mangers | BIE Cycle 3 |
| In-depth interview of data mangers | 9 of the data mangers were interviewed on their experiences about the application as well as messaging use and ideas for future application features | BIE Cycle 3 |
| In-depth interview of HMIS Lead | The team lead was interviewed about the motivation for the project and his thoughts on the usefulness of the application | BIE Cycle 2 |
| Observation | Observation of use and organizational structure was done of both data managers and HMIS team | BIE Cycle 2 / 3 |
| Casual naturally occurring conversations | When an opportunity was given we asked the HMIS team as well as data mangers about their work and other questions we might had forgotten during interviews | BIE Cycle 2 / 3 |

Table 4.1: Data collection summary

Table 4.1 gives an overview of all the data collection methods used,

a description of each of them and in what BIE cycle the method was used.

### 4.5.2 Data analysis

As has already been described, we used interviews, groups discussions, questionnaires and casual conversations to gather data. Most of these sessions was audio recorded and later transcribed. During our stay in Rwanda, we wrote field notes and summaries of meetings to aid memory.

All the data gathered during BIE stage 2 and 3 was transcribed in full. Quotes from data managers and other test participants in this thesis are excerpts from those transcriptions. Because of the local English accent, some parts of the audio recordings were incomprehensible to us which means that some of the transcripts might not always be of the best quality.

These transcripts and some of the field notes were coded by hand. This made it easier to categorize and connect the results. As we did not have too much data, no aid of code-and-retrieve programs was used. Instead, we tried to see connections with the codes we had, combined codes or made new ones. An illustration of the coding is presented in figure 4.4. Coding is a good approach if you are not testing existing theory, but develop theory from empirical data as we are trying to accomplish (Brinkmann and Kvale 2015). It is also a helpful tool for moving the analysis from a descriptive level to a more theoretical level and give new insights and interpretations.
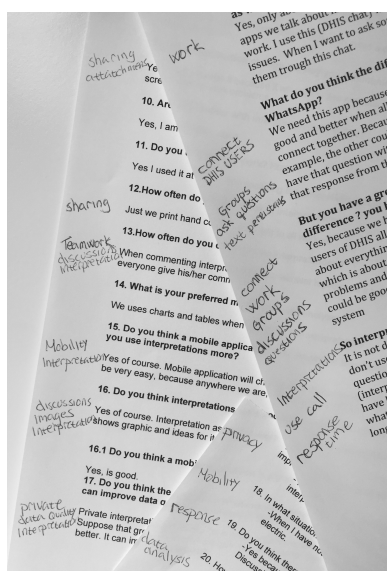


Figure 4.4: Example of coding the interviews and questionnaires

The codes were later analyzed, some were removed while others were

combined. An example of codes that were combined is "fast response" and "availability" These codes were combined because of the lack of data on "fast response", so we combined them together as just "availability". "Availability" was later added to other codes. An illustration of the process of combining codes can be seen in figure 4.5. The most frequent codes resulted in headings in section 7.2 *Feedback on the chat application* and section 7.3 *Conversational topics in DHIS Chat during beta test*. The codes found less frequently are also placed under these headings where it could substantiate and add to the findings. Some of the codes from the questionnaires is described in section 7.1 *Data manager's current use of communication tools in Rwanda* as the questions mostly related to the use of communication tools before the test of DHIS Chat. The codes helped us into the final stage of our project: Formalization of Learning.
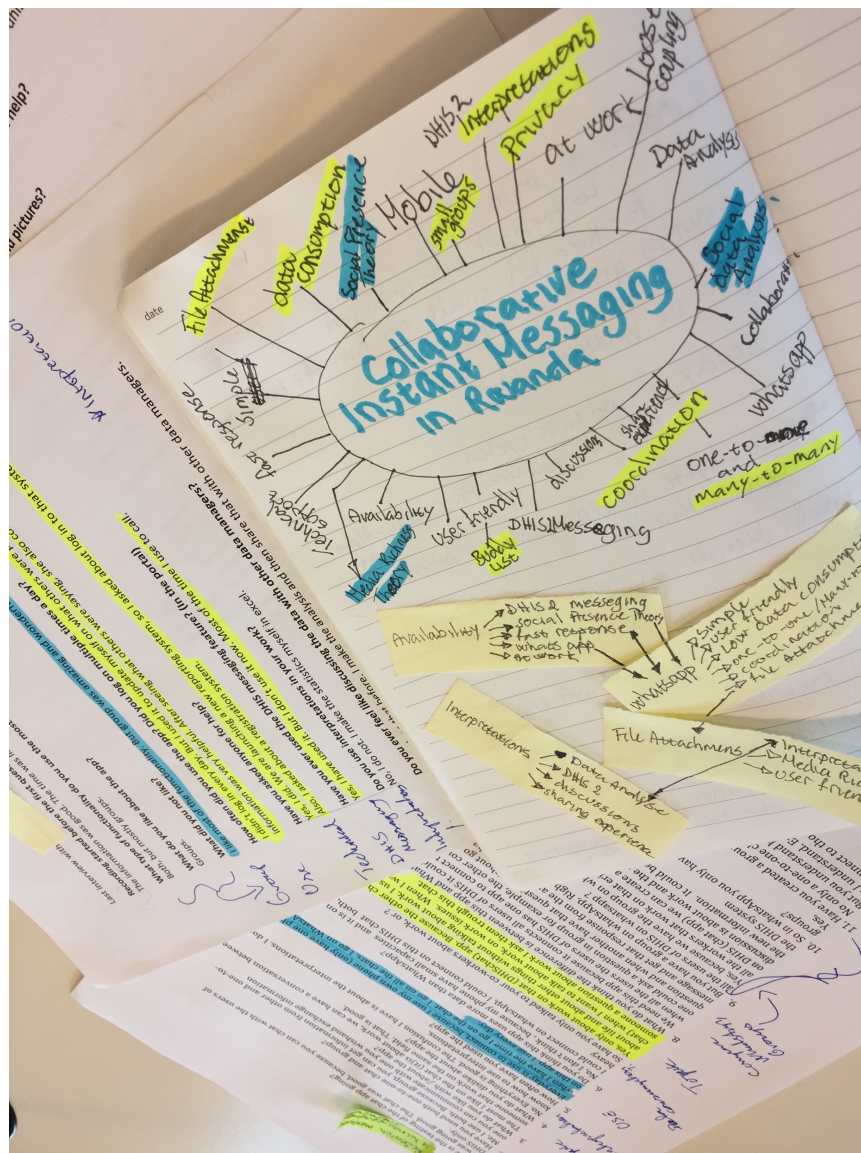
Figure 4.5: Example of the process behind combining and analyzing codes

## 4.6   Formalization of Learning

In the final stage, we have outlined the accomplishments made by the DHIS Chat application and discussed the organizational change. With these outcomes, we have created nine design principles. To conclude with these design principles, we have taken all codes, frequent or not, combined them and analyzed these with theory. Some of the design principles is also a direct product of the statistics and use of DHIS Chat. An example of how the process from codes to design principle is illustrated in figure 4.6.

DHIS 2 Interpretations
Interpretations MUC
Collaboration                   Analyzed with theory
Sharing experience    ──────────────────────▶        Social Data Analysis
Mobility


Groups
Privacy
Coordination                    Analyzed with theory
Support               ──────────────────────▶         Flexible groups
Teamwork
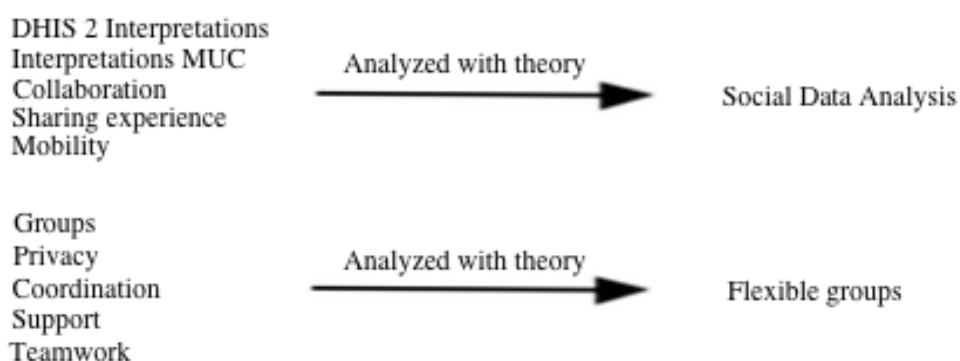
Figure 4.6: Example of code to design principle

We have also discussed how these fit into theory and related them to the class of problem: Collaboration between health data managers in low-resource countries. The artifact itself is the solution that solves the problem. Both the design principles and the artifact can be generalized. The final design principles can be found in section 8.7.


## 4.7   Study limitations and reflections on constraints

In this section, we present limitations of the study and constraints we experienced in our testing and in the analysis of our findings.


### 4.7.1   Instant messaging during beta test

During our tests, we had a focus on not leading people to a conclusion or "force" them to use the application. Therefore, we have deliberately chosen not to initiate any conversations through the application. This was done to prevent our results from being too subjective or bias. We believe that this approach has given us results that are more objective, compared to what we would have seen if we actively initiated conversations. On the other hand, we have answered questions and other messages that were sent to us through the application, so the testers knew they could reach us there.

| Stages and Principles | | Artifact |
|---|---|---|
| **Stage 1: Problem Formulation** | | |
| Principle 1: Practice-inspired research | The research is driven by the need for a new and improved communication tool for end-users of DHIS 2 | Recognition: Shortcomings in the existing communication tool, drove users to multiple other tools. |
| Principle 2: Theory-ingrained artifact | The theory used was media richness, social presence theory, former project etc. | |
| **Stage 2: BIE** | | |
| Principle 3: Reciprocal shaping | Problems encountered were iteratively fixed. And also feedback was discussed as findings. | Alpha version: Was based on requests from MoH and theory that indicated what a "good" IM tool was. |
| Principle 4: Mutually influential roles | The ADR team included researchers with an IT development background to include theoretical and technical perspectives. MoH and HISP worked with the ADR team in close collaboration to get practical perspectives. | Beta version: Added features the MoH saw as important to meet the needs of a data managers and made to fit older OS. |
| Principle 5: Authentic and concurrent evaluation | DHIS chat was first tested with the HISP team, then MoH and then in a wider setting with the data mangers and MoH | |
| **Stage 3: Reflection and learning** | | |
| Principle 6: Guided emergence | Features and use of the application were recognized as communicational patterns and assumptions to work related practices. A specific technical use was brought to an organizational communication pattern | New requirements for the application was noticed as possible design principles |
| **Stage 4: Formalization of learning** | | |
| Principle 7: Generalized outcomes | Design principles for a mobile communication tool in the health sector was formed | A complete version of the artifact including our design principle should have been made. However, there was not time for another iteration |

Table 4.2: ADR method summary

### 4.7.2 Payment

During the test period, we paid the data managers 5000 RwF (Rwandan franc) in air time. This translates to around 6 USD and three gigabytes of data for one month. We did this to facilitate the use of the application

because some of the data managers never paid for mobile data on their own. The idea of DHIS Chat is that the users are available at all times, and seeing as some of the data managers do not have access to wireless internet at their workplace, giving them access to the Internet through the phones was the best option.

The decision of paying the data managers in airtime was discussed and approved by our supervisors and the HMIS Lead at MoH. We bought the air time with our own money and was later refunded by the university. We believe that the reimbursement of the data consumption costs is a fair compensation that did not alter the premise of our study.

### 4.7.3   Ethical constraints

We decided early on that we would only read or translate messages that were available to us through the application. This means that we have only been able to see what the testers wrote in messages sent directly to us or sent to groups that we were part of. This was done to prevent leaking of any sensitive information. During our interviews with the data managers, we asked them what the topic of the conversations was, but we never asked directly what was said, who said it or who was part of the conversation.

In this thesis, we have anonymised all the test persons, except the HMIS Lead at MoH who has agreed to be named. We have also decided not to expose the district where all the data managers work. All of these measures have been put in place to keep the data managers anonymous so that they can be shielded from scrutiny in any way.

### 4.7.4   Time constraints

Testing of the application was done over a period of a month, from the 15th of February to the 15th of March, though the frequency of usage dropped significantly after we left Rwanda on the 1st of March. This means that the data managers tested the application actively for around two weeks. Hersleb at al. (2002) tells us that "Low-fidelity prototypes can be useful for evaluating interfaces, but understanding how the technology impacts social, political, privacy, and other concerns will require actual use over some period of time." (Herbsleb et al. 2002).

When we first arrived in Rwanda, we hoped that the test would start more or less at once. Unfortunately, the HMIS team was busy catering to World Health Organization (WHO) representatives as well as us, so we were not able to start the test before the middle of February. This means that the test was active for only two weeks, which is not enough to understand the "social, political, privacy and other concerns." (ibid., p. 177) Because of this, we asked the HMIS Lead at MoH if we could extend the test to the

15th of March. He agreed, but the data managers were unfortunately not using the application as much after we left.

### 4.7.5 Few testers

In total, including the HMIS team and a tester from HISP, the DHIS Chat application was beta tested by 15 people. When testing an instant messaging application, it is important that many people are involved, because it is an interactive technology. If no one is online, there is also no one to interact with. This does therefore somewhat defeat the purpose of the test, and it is hard to get a good picture of the impact of the technology. With that said, some of the 15 testers were online most of the day, which is a good indicator that the application was used actively.

### 4.7.6 Linguistic constraints

As discussed earlier, the official languages of Rwanda are Kinyarwanda, English, and French. While most of the population speak both Kinyarwanda and French, English has just recently been added as an official language and has not been taught in many schools before now. Therefore, some of the data managers did not speak English and many spoke English poorly.

When we first met the data managers, we asked them to answer a questionnaire that was written in English. Some of the answers we got back from the data managers did not answer the questions or were not completely understandable or irrelevant. To combat this in the interviews, we asked that a representative from MoH would be present to help with translations if we were not able to understand each other. Because the HMIS team had so much to do while we were there, they were not able to translate all the interviews, but they did help when it was needed.

During our group discussion at the district hospital, it became obvious that the people who were most competent in speaking English also were the ones who spoke the most. The data managers that were not comfortable with speaking English in a group did not participate actively in the discussion. This means that the findings of the group discussion might not represent the thoughts of the whole group, and possibly also skews the representation of the group discussion data towards participants of younger age and/or with more education.

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## 4.8 Ministerial ban on mobile phones

After we came back from the field trip in Rwanda, one of the data managers sent us a message on the DHIS Chat to tell us about a ministerial ban on the use of phones at all health facilities. The ban took effect on the 1st of March 2017 (The New Times 2017). The HMIS Lead at MoH later confirmed that the ban was real. Whether or not this ban also includes data managers and other workers at health facilities that are not medics and nurses is still unclear. The HMIS Lead did not know the extent of the ban, and reports from the data managers themselves are conflicting. The ban on mobile phones in health facilities is discussed in more detail in chapter 8.

# Chapter 5

# Development of the IT artifact

This chapter describes the functional problem areas and choices taken in the preface of the system development. A thorough description of the IT artefacts components and architecture is further presented before finishing off with how the application and its code is distributed.

## 5.1 Problem areas

During the testing of DHIS 2 Messenger application, some issues were discovered which meant that the user experience was lessened. The primary problems that occurred during testing was larger data consumption than desired and a confusing GUI.

Halvorsen's test showed that the users could only send 2-5 messages on 100 RwF (~0.12 USD) of airtime with his application (DHIS 2 Messenger), while on WhatsApp they could chat in 30-45 minutes on the same amount (Halvorsen 2015). After investigating the reason for this, Halvorsen concludes that the large data consumption of the application was due to the large eXtensible Markup Language (XML) documents that Openfire use (ibid.). These XML documents can be compressed, but Halvorsen did not do this.

However, we identified another, possibly more prominent problem. That is that the users mostly sent DHIS 2 messages. DHIS 2 messages can only be sent and received via the DHIS 2 API, which is not built for mobile applications. Depending on the request to the API, the response can be massive and does, therefore, need to be used carefully. In total, the users sent 227 DHIS 2 messages and only 78 chat (one-to-one) messages (ibid.). This statistic strengthens our argument. It is also apparent from the code written by Halvorsen that DHIS 2 messages never get saved on the phone.

This means that for every time the user clicks on a DHIS 2 conversation, the application must download the messages from the API.

The test users also reported that they did not understand the difference between one-to-one chat and Multi User Chat (MUC), henceforth also called groups, in DHIS 2 Messenger. The problem was that the interface of both one-to-one chat and MUC looked the same and that they did not understand how to see the members of the group (Halvorsen 2015). The groups in DHIS 2 Messenger were all public, which meant that everyone was part of every group. Because of this, there was no way to make a group with self-selected people (ibid.) All of this, together with the confusion of the GUI, means that this was probably the reason no one sent any MUC messages throughout his test.

One missing feature that the data managers in Halvorsen's test wanted was the ability to send attachments, like documents, images, and videos. They emphasized that images would be particularly useful in support situations where problems are difficult to explain in words (ibid.).

## 5.2   Choices

Regarding the previous application, DHIS 2 Messenger, some choices of what to keep and what to remake had to be done. The choices and the repercussions of the decisions are presented in this section.

### 5.2.1   A new application

When we started this project in 2016, we had a meeting with Halvorsen. We talked through his decisions, his research results – positive and negative – and architecture in regards to his system infrastructure. Halvorsen had three components to make the messenger system function with DHIS 2: Android application, chat server, and Google Cloud Messaging (GCM) module for DHIS 2.

The spring of 2016 was spent looking at and trying to understand the code in these components and the flow of the system. To get the Android application to work, we had to set up the chat server. The chat server Halvorsen used was an Openfire instance (See section 5.3.3 on page 60) with a plugin he developed for authorization against a specified DHIS 2 instance. With no knowledge of Openfire and no documentation on this plugin, it was challenging to understand how to integrate it with our Openfire instance correctly.

While learning about Openfire, we were also looking at the Android application. We were not comfortable with native Android development, so we started with tutorials and looking at Halvorsen's code and data flow.

We got the DHIS 2 Messenger application running, but as we had no chat server running, we could not log in or send messages.

By August, Halvorsen's setup was running on a server, but as we tested the application, we quickly discovered that it did not work. Some functionality like multi-user chat (many – to – many conversations) made the application crash and requested data did not show. The technology moves fast and libraries and API's get changed or deprecated. We then had two possibilities: update the DHIS 2 Messenger application or make a new one. To save time and hopefully extend the functionality of the application, we first decided to upgrade the DHIS 2 Messenger application. After trying to update and replace code where the application crashed it became apparent that it would not be an efficient use of time and too much had to be changed both in terms of the code, but also the user interface and data consumption.

In September we started to shift our focus from the old application (DHIS 2 Messenger) to a new application that we named DHIS Chat. We looked at ways to reduce data consumption and in general how to develop an efficient chat application.

### 5.2.2 React Native

With the choice of creating a new chat application, also came the possibility of changing the framework. DHIS 2 Messenger was developed in native Android, but as mentioned we had no experience with Android before this project. Halvorsen had also looked at Apache Cordova, a cross-platform framework, as an option. This framework is based on JavaScript, a programming language we both know well. Halvorsen's reason for not choosing Cordova was that it tends to drains a lot of power from the phone's battery. Over a year had gone by since his research on cross-platform frameworks, so we decided to revise this option.

As we were researching cross-platform technology, we found React Native JS to be the best choice for our messaging application. With React Native JS developers can write JavaScript, which is then transformed into native code for a particular mobile platform like Android or iOS. Companies like Instagram. Airbnb, and Facebook, which is the creator, have all used React Native JS in their cross-platform applications (Martinez and Lecomte 2017).

What makes React Native JS stand out is the fact that while most cross-platform frameworks like Cordova target the browser and is rendered in a WebView, React Native JS use its host platform's standard rendering API. The way that React Native JS is rendered means that it can access native User Interface (UI) components, whereas other frameworks often use HTML components. Because of this, the user gets more of a "native feel" to the application (Eisenman 2015). Additionally, React Native JS utilize multiple threads and renders UI elements in their own thread, while

logic is performed in others. This gives a better performance and a more responsive application compared to other cross-platform frameworks. It also allows for a good workflow and rapid testing with hot reload and a debugger console you don't get with native Android development. This became helpful throughout the BIE stage of our ADR project, with rapid changes based on testing. Our research did not provide any indication that React Native JS as a framework had any effects on the phone's battery, so Halvorsen's reason for not developing cross-platform did not affect our choice.

Many of the new DHIS 2 platform modules are developed using React.js, a framework for creating web applications, and as the name suggests, React Native JS uses this as its base. Before the development of our application began, we had worked with the DHIS 2 system as interns, and by doing so learned React.js. Because of this, it was easy for us to get started with this cross-platform framework, which claims that you can "Learn once, write anywhere." With React Native JS you also get a sound project structure, and the code can be reused efficiently. This was important to us from a sustainability point of view, as we intend to hand over the code to local developers at HISP Rwanda.

Pros of choosing React Native JS:

- Multi-thread gives good performance
- Native UI - components
- Builds on React.js
- Cross-platform
- Don't need to load your application on the device for every update – saves time
- Can reuse a lot of the code

Cons of choosing React Native JS:

- Not real native
- New framework
- Prioritize iOS first, then Android.

Developing cross-platform instead of native development can prevent a lock-in situation. Although most data managers in Rwanda use an Android operating system (OS) on their phones, some also use Windows Phone or iOS. By developing native, you will either have to additionally develop one or two similar applications in different native languages or exclude all of the users not having and Android OS. With a cross-platform framework, you can reuse all of the UI elements and most of the logic – This will both save time and money. In a broader perspective, the statistics on most popular operating systems might differ in other countries also using DHIS 2.

### 5.2.3 Chat server

Although we decided to make a new Android application, we chose to keep most of Halvorsen's backend of the system. Halvorsen used a chat server called Openfire that implements a protocol called Extensible Messaging and Presence Protocol (XMPP). The choice we made to keep Openfire was not an easy one, as it has some shortcomings. The process of choosing what chat server and protocol to use will be discussed further.

Message Queue Telemetry Transport (MQTT) was one of the protocols that Halvorsen looked at when he decided what technologies to use. MQTT is often referred to as THE Internet of Things (IoT) protocol, mostly because it uses very low bandwidth. Halvorsen's conclusion, when looking into this protocol, was that it had too little documentation and too few supported libraries, which would have made the development much harder (Halvorsen 2015). Unfortunately, the same is true today. The protocol is mostly used for IoT and does not natively support group chat, so we decided not to go any further with MQTT.

We also looked at other solutions, like connecting to an already existing API. The two we found most interesting were the Facebook Messenger API and the Slack API. The reason for why this would be interesting is that we would not have to worry about the backend of the system, as that would have already been taken care of by the API. The problem with these APIs is that they do not support the use of other applications than their own, which poses a problem because we needed to implement DHIS 2 interpretations into the application. Further, these APIs makes the company behind them the owner of the sent messages. That these companies might be able to see these messages is not acceptable, as one of the points of the application is that the health workers should be able to discuss health data and other sensitive information concerning the inner workings of MoH in Rwanda.

Since Halvorsen had already made one application work with Openfire and the fact that we wanted not to replicate his study, but to go deeper and further investigate the phenomenon of instant messaging and social media at work, we decided to settle on using the Openfire server in this project as well. XMPP and Openfire combined are the most well documented and used IM protocol and server in the open source communities.

### 5.2.4 Modelling

Our findings revealed that the reason for a significant amount of the data consumed by DHIS 2 Messenger was twofold. The first, and most likely the primary source of the large data consumption was the fact that the application was designed to send and receive both one-to-one and MUC messages, as well as DHIS 2 messages. The DHIS 2 messages API is used inside the DHIS 2 portal and was never intended for mobile applications.

It would probably not have been a problem if the test users mostly used the chat feature, but as Halvorsen's thesis states they did not – probably due to confusions of who could see the content of the chat conversations. The second source of the significant data consumption was the fact that the communication with the chat server, Openfire, was not compressed.

When we started to build our system, a lot of thought went into how we should model the different components. We discussed the possibility of having a middle layer between the application on one side and DHIS 2 and Openfire on the other. The theory behind this was that all the communication to and from the application would be standardized, and the middle layer could be used to remove any unnecessary data coming from DHIS 2 and Openfire. As we would have needed to implement methods for all possible requests and their corresponding responses, this would have caused a lot of additional development. We also discussed the possibility of developing our own protocol to use with the middle layer, so that we could customize all the communication to our need. In the end, we realized that this solution would be too complex. We solved the problem by adding a plug-in to Openfire. This plugin will be discussed in more detail in sections 5.2.5 and 5.3 on the next page.

### 5.2.5 Application data flow

Because we wanted to reduce the data consumption as much as possible, we decided to remove DHIS 2 messages from our application. This decision is based not only on reduction of the data consumption but also the fact that the test users in Halvorsen's study found it difficult to understand the difference between DHIS 2 messages and the other type of messages available in the application. Because of the significant section of data managers that answered that they usually used DHIS 2 messages for communication at work in Halvorsen's study, we still wanted a connection between the chat system and DHIS 2. Our solution became to send a chat log to the inbox in the DHIS 2 messaging system.

In figure 5.1 on the facing page, we can see how we solved the problems with DHIS 2 messages. In our application, chat messages always go to the Openfire server from the phone. The phone does not send messages directly to the DHIS 2 API. Instead, the Openfire server communicates with the DHIS 2 API. With this method, the phone will only send XMPP messages which are much more friendly on data consumption.

### 5.2.6 Security

"Within the healthcare sector, information security aspects are of vital importance, and may be of serious hindrance for the adoption of IM-based services" (Bønes et al. 2007, p. 678). When discussing sensitive health data and information in a national software system, security is crucial.
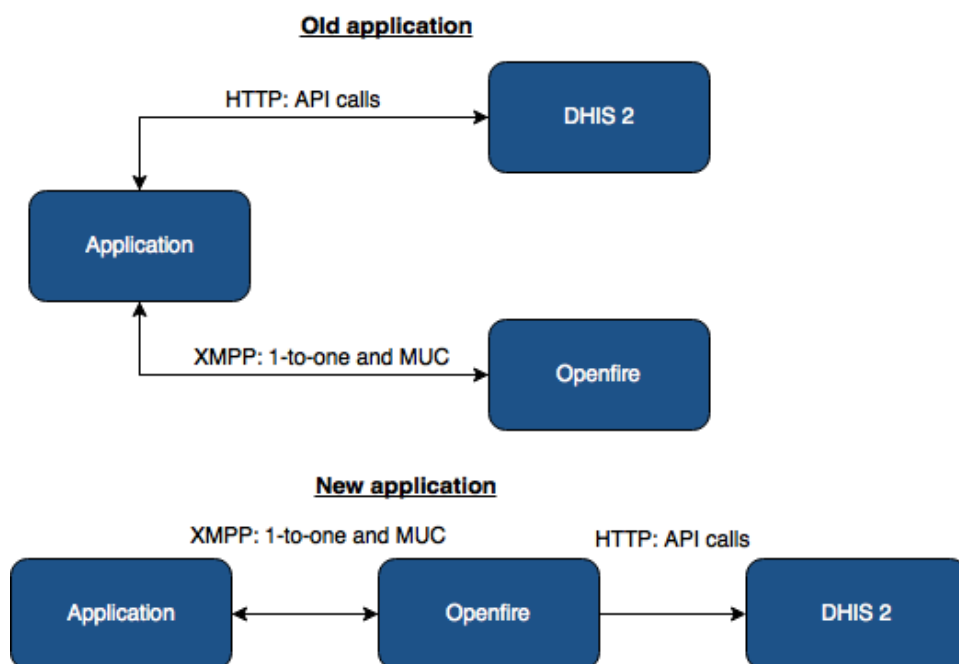
Figure 5.1: Illustration of end points for messages DHIS Chat and DHIS 2 Messenger

Although we have reflected on the degree of security in and around our IM application, we have chosen not to focus on this topic. The reasons for this is that it is a significant field of ICT and can be a master thesis of its own to develop, test and implement encryption methods. It takes time and effort to secure an instant messaging application completely.

The DHIS Chat is, however, secure to some degree, which is important also in a test phase of the applications development. The test participants used their real DHIS 2 user credentials, and the DHIS 2 interpretation data was national health data.

For API requests and responses, HTTPS is used instead of HTTP. HTTPS will automatically encrypt all data sent. We also make sure not to store user passwords or other critical information. A user also has to log in to use the application, meaning no one can see messages or data without having an account. The information flow is also restricted by only allowing DHIS 2 users to have an account.

## 5.3   DHIS Chat system

In this section, we will describe the structure and the design of the DHIS Chat system's components.

### 5.3.1 Architecture

The system we have created is based upon two already developed systems: DHIS 2 and Openfire. It consists of four parts, including DHIS 2 and Openfire. The Android application and the DHIS 2 plugin for Openfire are the two remaining parts. Halvorsen developed the first version of the DHIS 2 authorization plugin for Openfire, which has now been revised and reworked by us. We have also extended the original DHIS 2 plugin for Openfire to be able to send chat logs to the DHIS 2 API. An overview of the architecture of the DHIS Chat system can be seen in figure 5.2.
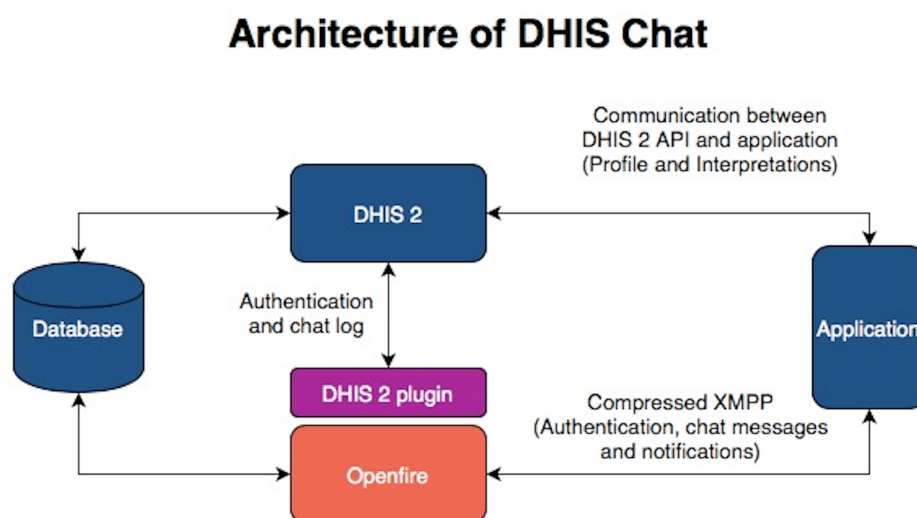


Figure 5.2: Overview of the architecture of DHIS Chat

The architecture of the system is designed to minimize the data traffic and the data consumption of the application. We have therefore limited the application to only send and receive messages through the XMPP protocol from the Openfire server. On the other hand, the application only uses the DHIS 2 API to get the profile information of the user and to fetch DHIS 2 interpretations. To further optimize the data consumption we do not request the pictures of the DHIS 2 interpretations from the DHIS 2 API before the user selects an DHIS 2 interpretation to study.

The system itself is designed to have loose connections between the components, which means that the Openfire instance does not necessarily need to run on the same server (with the same database) as the DHIS 2 instance. The thought behind this is that it makes the system much more easy to set up because every component can run independently of each other with its private database. During development, both the DHIS 2 system and the Openfire system ran on the same server and shared a database. When we tested the application in Rwanda, the only change we did to Openfire was to alter the DHIS 2 instance it was connecting to. Because of this, we did not need to install anything on the MoH servers,

which would have taken much longer.

The biggest change from an architectural standpoint between our DHIS Chats system and DHIS 2 Messengers system is the fact that we have not included GCM in DHIS Chat. The reason for this decision is that every message that is sent through the GCM system gets stored in a database in one of Google's servers. This decision draws upon the same aspect of the integrity of the system that was discussed earlier in regards to WhatsApp in section 3.5.3 on page 22. In figure 5.3, we can see an overview of the architecture of Halvorsen's system.
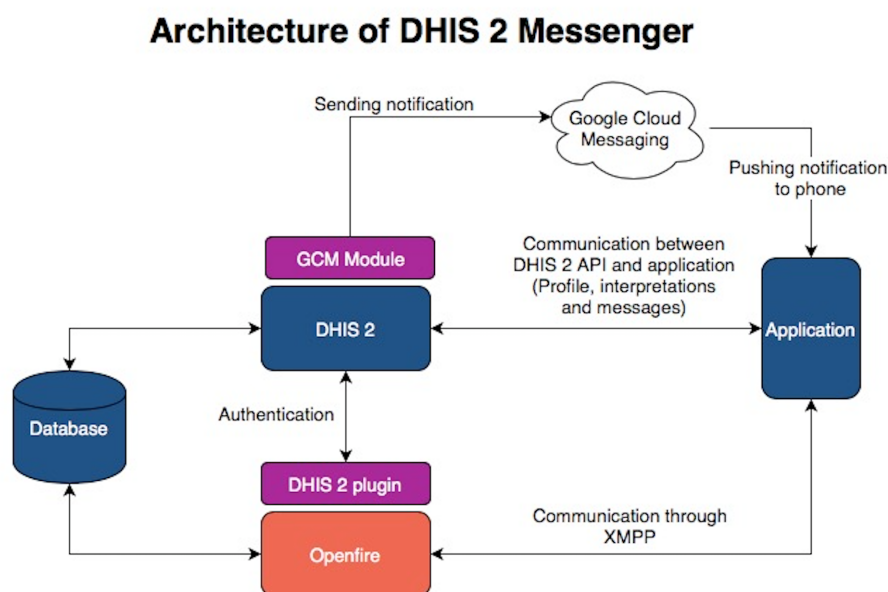


Figure 5.3: Overview of the architecture of Halvorsen's DHIS 2 Messenger. Obtained from (Halvorsen 2015, p. 37).

The implications of the decision to not include GCM is that the users do not get notifications of new messages when the application is not running. When the application is running, the notifications are handled by Openfire and the application itself. This decision does also mean that we did not need to add a GCM module to the productions instance of DHIS 2 at MoH, which we would most likely not have been able to do, as they have strict procedures for maintaining the safety and security of their production systems.

In the following sections, we will discuss the application and its environment in more detail.

### 5.3.2 Application

The application, called DHIS Chat is a cross-platform application, which has been developed for Android. DHIS Chat consists of five main fea-

tures: one–to-one chat, many-to-many groups, buddy-list, user profile and the possibilities to look at, comment on and discuss DHIS 2 interpretations.

The framework used in the development of the chat application is React Native JS, and it is written in a language called JSX, which is a mix of JavaScript and XML. React Native JS is a component-based framework, which means that views with related state and logic are split into small parts. These components can be used multiple times where it is appropriate, as we have done with our buddy-list with live search. This part was also used to search for participants to add to a group and search for a person to initiate a one-to-one chat with. Because of the component-based nature of React Native JS, it is also easy to use components from other third party libraries.

**XMPP Android module**

To communicate with the Openfire chat server, we used an XMPP library. In our research, we found a library called Strophe.js to be the best JavaScript based option. However, most of our search results mentioned Smack API. Smack is a Java framework and is often the preferred choice for XMPP on Android. It is a robust, thoroughly tested, well-documented library that has a lot of examples in regards to Openfire. This library was also the XMPP library used by Halvorsen in DHIS 2 Messenger, which we had studied thoroughly.

Although React Native JS is cross-platform, it is sometimes necessary to create separate modules specifically for each platform. These modules are called Native Modules and can be used for functionality that requires access to the file system or camera, microphone, and other mobile integrated functionality. These modules allow you to develop in the native language, which meant that we could create an XMPP module with Java and Smack.

By using this native module in DHIS Chat, our application does no longer work on iOS or Windows Phone without developing similar modules for each of them. However, we never had an intention on focusing on other OS than Android because of time constraints and the widespread use of Android in the relevant context. All of the people testing our application also only used Android phones.

What this module gave us was a clear separation between the chat-specific logic and our chat application logic. This separation means that changing the protocol and chat server will be straightforward. To modify the chat server and protocol used in DHIS Chat might be an option if the developers of DHIS 2 develop their own chat server or if an existing option proves better than Openfire.

**Data management**

Depending on the use of the DHIS Chat application, it could be a lot of data flowing to and from the phone. To limit the data consumption, we made sure to compress all data sent between the application and Openfire. This is easily done by adding `.setCompressionEnabled(true)` to the connection configuration builder.

One of Openfire's restrictions is that it does not store one-to-one messages after the recipient has received the message on their phone. Halvorsen solved this by storing these messages in the phone's memory. (i.e. until the phone was shut off or the user logged out of the application.) This solution created discontent among the application testers, because of the lack of message history and that some messages were never replied to by the recipient (Halvorsen 2015).

All chat messages sent with DHIS Chat is stored in DHIS 2, as discussed in section 5.2.5 on page 52. One possibility could have been to request for these logs each time a user logged on. However, because of the data consumption issue of Halvorsen's DHIS 2 Messenger, we decided to store all the user's chat conversations in local storage on the phone. On the one hand, this has a positive effect on the data consumption, as we did not request messages each time the user entered a conversation. On the contrary, it means that 1) if the user changes phones, the messages sent and received on the previous phone are gone, and 2) the phone's storage will be filled over the years and will eventually be at its limit.

Due to time constraints, we did not have a chance to look at these issues, but because we store the conversation logs in DHIS 2, it is possible to retrieve past messages onto new phones. It is also feasible to create a script to delete messages older than a specified time from the phones to solve these inconveniences.

**User interface**

As mentioned in section 5.3.2 on page 55, all UI elements are created as components with their own style and state. This component-based structure combined with Flexbox CSS styling allows you to create flexible and responsive user interfaces that scale depending on the size of the device and orientation. As React Native JS targets the native UI-components instead of the web it will have a quicker load time and give scrolling, navigation and keyboard behavior a smoother feel.

The DHIS Chat application is meant to assist users of the DHIS 2 platform in their work. The colors and design of the chat application is therefore inspired by DHIS 2 as you can see in figure 5.4 on the following page.

When introducing a new application, it is important that the design is

Figure 5.4: DHIS 2 and DHIS Chat login screen

straightforward and coherent. In a work environment, it is also necessary to attain your wanted feature quickly. A maximum number of touches to reach any feature is three in the DHIS Chat application, because of our menu layout. There is a navigation menu on the bottom of the page, where you can switch between the different tabs and also clearly see notifications. On the top of the page, there is a menu specified for the current page showing all options for that particular feature. Live search has also been added to help the users quickly establish contact with any particular person, as illustrated in figure 5.5.
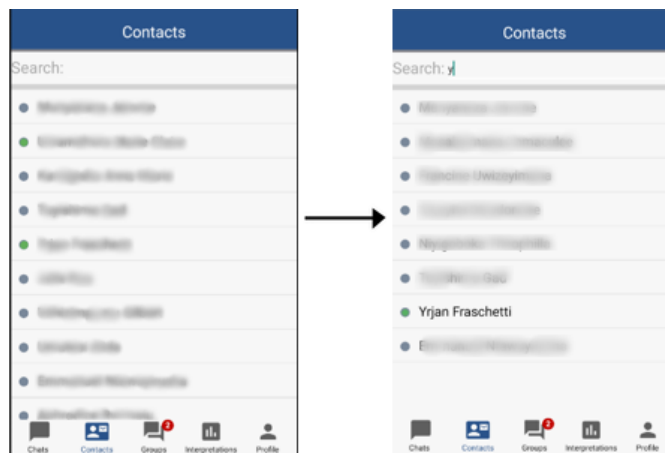


Figure 5.5: Live search in contacts list

As previously mentioned the data managers testing Halvorsen's DHIS 2 Messenger showed some confusion as to what the difference between one-to-one chat and many-to-many groups were, he also explained that one reason might be that his showing of the two was identical. With this in mind, we made some small changes in the listing views of the two types of conversations. We clearly separated one–to–one chat and many–to–many groups and marked the icon of active the tab with a different color. We also had a clear heading stating that you were looking at all chats or all groups. We decided to call the many-to-many conversations "Groups" as opposed to "Conference" as Halvorsen called it. "Group" is a common known

term for many-to-many conversation and both WhatsApp and Facebook messenger uses this term.



(a) Chat View

(b) Chat List

(c) View of Interpretation

(d) Interpretation MUC
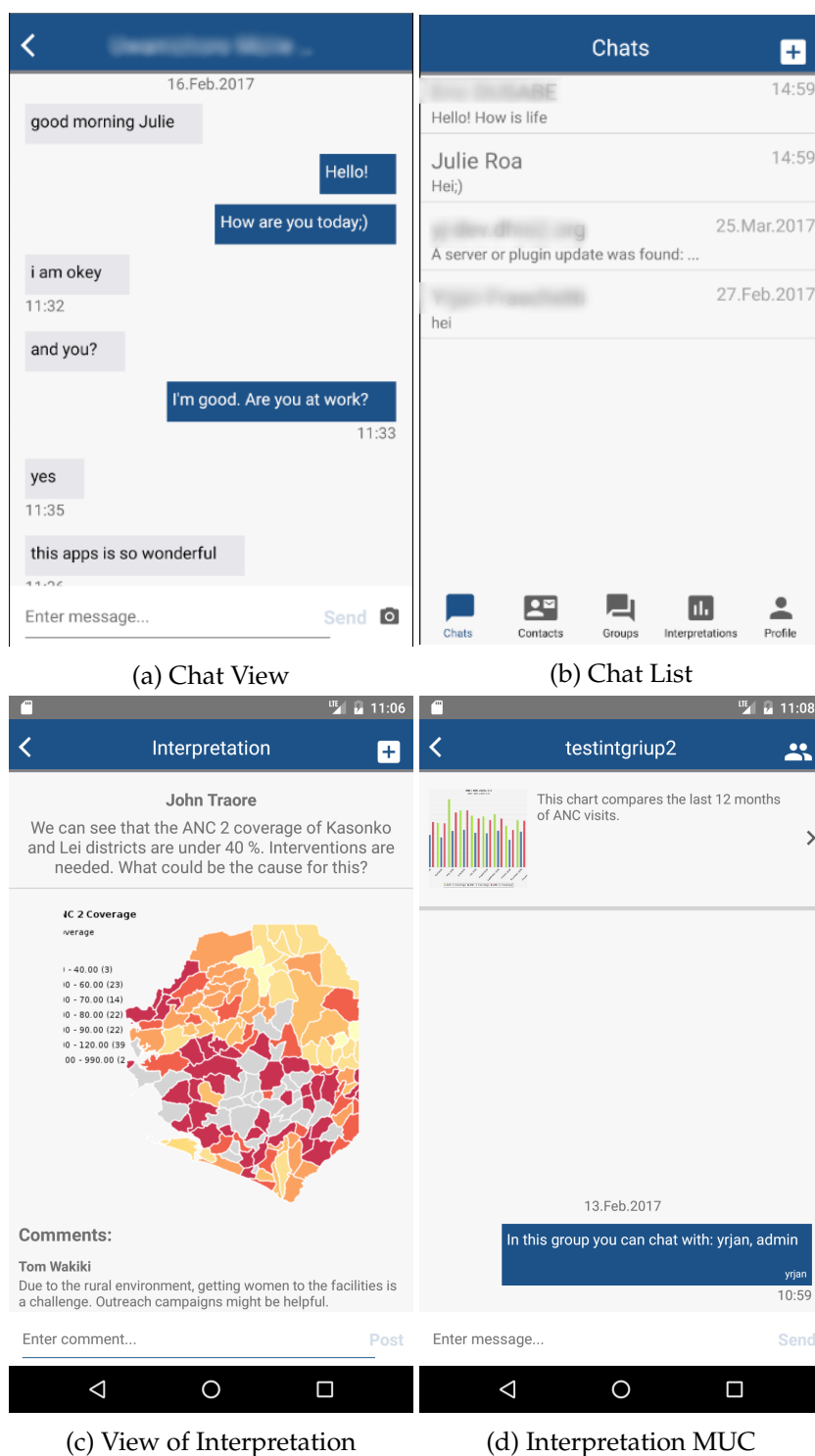
Figure 5.6: DHIS Chat UI

Additional illustrations of the GUI are found in appendix A.

**Attachments**

In the request for the updated Android application, the MoH requested functionality for sending documents and pictures. This feature was also mentioned as missing in Halvorsen's test. The MoH wanted this feature because it would help them with support (visualizing the problem) and make it easy for the end users to share critical documents.

We only had the chance to implement attachment of pictures. Openfire and XMPP support sending of other types of documents as well, but because of limitations in how Openfire has implemented this functionality, the development of this feature took much longer than expected. The fundamental reason for not being able to send other file types than images is the file system on the phones. The file systems differ in most phones, and it is time-consuming to develop an attachment functionality that enables file transfer from all folders for each possible phone.

The biggest weakness of the XMPP library's integration of attachments is the fact that both users must be online for the transfer to succeed. This vulnerability means that if one of the users (most likely the person receiving the attachment) logs out while the document/picture is being transferred, the transfer will fail. If a regular text message is sent to a person that is offline, the message is stored temporarily in the Openfire database, and forwarded to the person when he or she logs on. Why this temporary storage solution has not been implemented with document transfer, is unclear to us.

We also looked into adding attachments to the MUC, but we soon found out that this is not supported by the XMPP standard and is therefore not caused by the implementations of Openfire.

### 5.3.3 Openfire

Openfire is the system we chose as our chat server. It is a free, open-source software, distributed under the Apache license. The Apache license gives everyone the right to download, modify and distribute the software (The Apache software foundation 2004). This license matches the license that DHIS 2 is distributed under, and does therefore not go against the HISP policy of only using open source software. The Openfire server implements the XMPP protocol – a communication protocol based on XML – which is probably the most used open source protocol for IM.

Openfire was one of the systems that Halvorsen used with his DHIS 2 Messenger application. He developed a DHIS 2 authentication plugin for this system so that the users could use their DHIS 2 credentials to log in to the application. Because Halvorsen made his code public, we were able to use his work in our system. The plugin he created is used in our system, but it has been adjusted somewhat to accommodate our application. For our

Openfire system, we also developed a plugin that sends chat (one-to-one) messages to DHIS 2 as a chat log.

The Openfire plugin for DHIS 2 authentication is made to use the API of DHIS 2 to determine if the user has a user account in that particular instance of DHIS 2. The DHIS 2 API has an endpoint where one can get all the information associated with a profile. All you need to access that information is the username and password, and the API will send the information back. This feature is used in the authentication plugin because it will give an error message if the user credentials are not found in the database. After a successful first login, only the username of the user is saved in the Openfire database. A representation of how this plugin works can be seen in figure 5.7.

## Login request
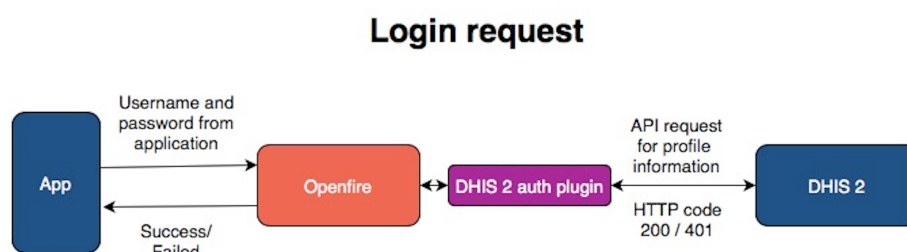


Figure 5.7: A visual description of the Openfire plugin for DHIS 2 authentication

The Openfire plugin we developed to send one-to-one chat messages to DHIS 2 uses the DHIS 2 messages API to store a chat log in the inbox of DHIS 2. The plugin intercepts chat messages before they are sent to the receiver of the message, to send a copy of it to the chat login DHIS 2. The chat log thread in the inbox of the DHIS 2 messaging system will, therefore, contain the whole correspondence between the two people. The plugin does not let you send messages to the DHIS Chat application, as it is solely meant as a log where one can see the history of the conversation. The messages are not stored anywhere else, other than the phone of the people chatting. Figure 5.8 on the next page shows how this plugin works.

The connection between the Openfire server and the DHIS 2 instance requires that all the communication between the systems use the HTTPS protocol, which is a much more secure version of HTTP that encrypts all requests and responses to and from the server.

## 5.4 Distribution

The goal of the DHIS Chat application and the system in itself is that it is meant to be an extra feature for DHIS 2. We have only used open source components, and as with DHIS 2, we want the code we have developed to be open source. Two of the reasons for this is that the project might be
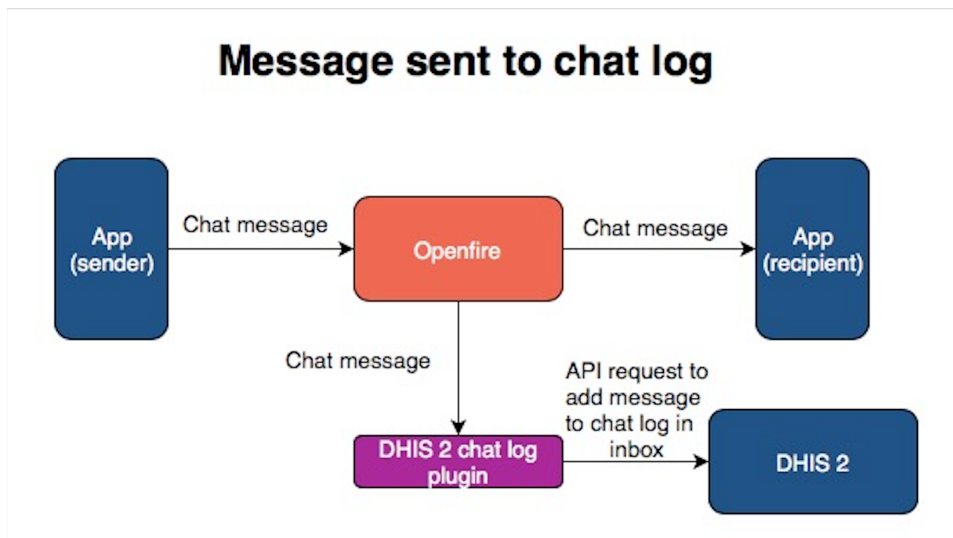
Figure 5.8: A representation of the Openfire chat log plugin

developed further by new master students and that HISP teams in Rwanda or elsewhere can use the code for inspiration or use it as a base for their own chat application. The code is hosted on GitHub in public repositories – one for the application and another for the Openfire server. The code has been refactored and commented, since the alpha and beta test in Rwanda, to accommodate new developers.

The DHIS Chat application is available for download on Google Play Store. To make the application available on Google Play Store was not something we planned initially, as we envisaged to install the application on the testers phones manually. But it quickly occurred to us that bugs had to be fixed and new features had to be added while the testing was ongoing. Hence it would be much easier to have them update the DHIS Chat themselves from the Play Store.
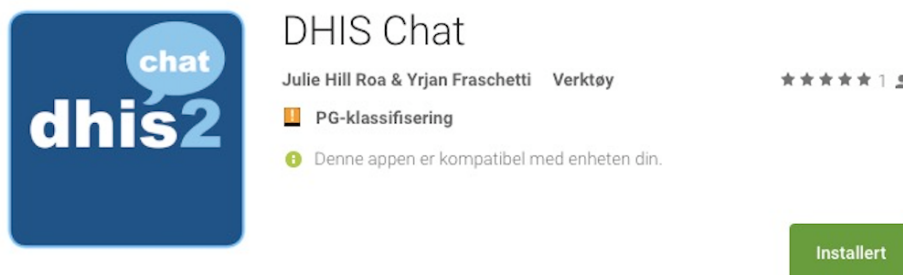


Figure 5.9: DHIS Chat listing on Google Play Store

As a bonus for uploading the DHIS Chat to Google Play Store, some statistics are available to us. The most significant find is what version of Android the users of the application were running. This statistic is important because it gives us an idea of what versions to target

the application at, which was something we could not find during the development. The most used version of Android was 4.4 with 22 downloads. The oldest version of Android discovered in the statistics is version 4.2 from 2012, DHIS Chat was downloaded 6 times with this version. The statistics can be seen in figure 5.10. Release dates for the relevant Android versions are presented in table 5.1.
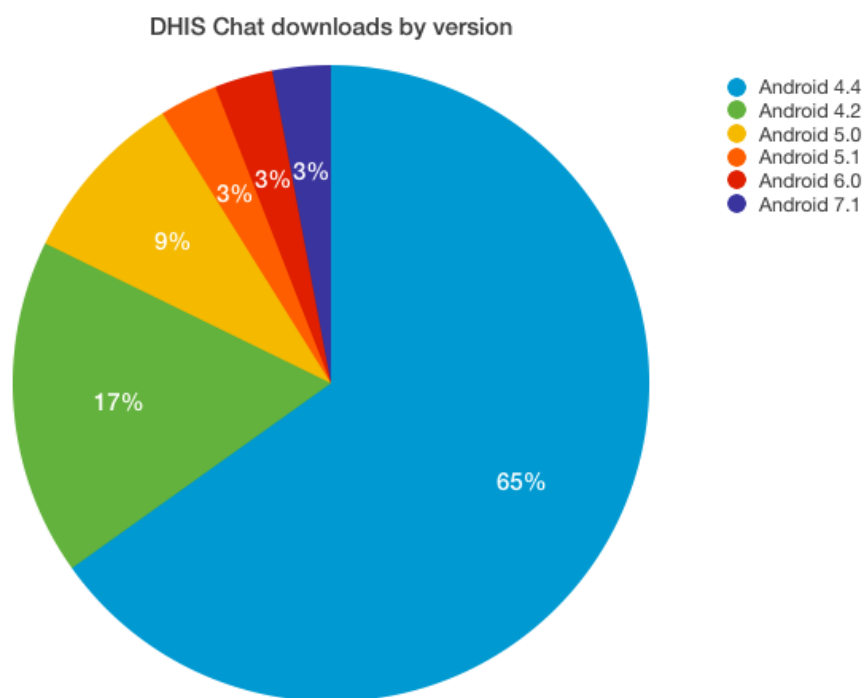


Figure 5.10: Statistics on version of Android who installed DHIS Chat

| Android version | Release date |
| --- | --- |
| 4.2 - Jelly Bean | November 13, 2012 |
| 4.4 - KitKat | October 31, 2013 |
| 5.0 - Lollipop | November 12, 2014 |
| 5.1 - Lollipop | March 9, 2015 |
| 6.0 - Marshmallow | October 5, 2015 |
| 7.1 - Nougat | October 4, 2016 |

Table 5.1: Release date of relevant Android versions (Wikipedia 2017b).

# Chapter 6

# Instant messaging as a HMIS collaborative tool in Rwanda: Execution of BIE stage

The alpha and beta tests in Rwanda was conducted in the capital Kigali over a period of 29 days, from the 1st of February till the 1st of March. Last minute development, testing and also empirical data collection with interviews, discussions, observations and gathering of statistics was performed during this period. This was done in the MoH office except for a field trip to one of the district hospitals. This chapter will introduce the timeline of our project from the preparation done prior to our time in Rwanda to the last days of the beta test.

## 6.1 Preparations

Before the primary test in Rwanda could commence, we had to perform preliminary testing as well as set up the instant messaging system to correctly fit the environment in Rwanda. In this section, we will talk about the preparation for the tests and the BIE cycles that were involved.

### 6.1.1 Cycle 1: Prototype testing

Cycle 1 mainly consisted of the development of the IM artifact, which lasted four months. Before the intervention and testing in Rwanda, we wanted to be sure that the GUI, as well as functionality, was comprehensible, straightforward and responsive so that the users would be familiar with the application from the start. Although this was a priority during development, we were the only ones testing the IM system, and the application was only tested on one phone, while the rest of the testing was done in an emulator on a computer. As a developer, it is sometimes hard to

imagine what a real end-user finds challenging and which steps is natural for them to take to reach their intended functionality. (E.g where and what they will press to create a chat) The developer knows the functionality well and might be blind to confusions in the GUI or the purpose of certain features. Aspects of an application might also be hidden behind icons or buttons a user might not notice or understand.

The week before leaving for Rwanda we gathered our supervisors and had a test of the IM system. Here we found some problems connecting all users to the same Openfire chat group, meaning not all the users were placed in the same buddy list, which in turn means that a conversation could not be created. We also found that there was confusion about how to create a group chat: an input field displayed "name" where one could set a name for the group was thought to be an input field for finding names of group members to add. We also got tips for navigation between tabs.

After the test, we evaluated the feedback. Although all feedback were important, not all the suggestions were considered a priority to implement before the testing in the actual environment, but rather something to add in the next generation of the application. The most critical bugs like the Openfire buddy-list as well as GUI confusions were transferred into cycle 2 and handled before the beta testing in Rwanda.

### 6.1.2 Introductions in Rwanda

The day after arriving in Rwanda we met the HMIS team. We started by introducing our self, the project and IM system and what we hoped to accomplish in the four weeks we were there. Later they introduced themselves and explained the HMIS team's tasks and responsibilities as well as their individual roles within the team. We also held a short demonstration of the IM system and compared our features to DHIS 2 Messenger, the application made by Halvorsen in 2015. We discussed the following weeks and how they could facilitate the alpha and beta testing of the application, with the HMIS team and the data managers respectively.

### 6.1.3 Installations

In the weeks before our trip to Rwanda, we planned to install our chat server on their local servers. As the days went in Rwanda the matter of getting access and administration rights on these servers proved difficult. In discussion with the HMIS lead, we decided to keep the chat server we used during development for the alpha and beta testing.

We also discussed the possibility of connecting our chat server to their production instance of DHIS 2. They were skeptical of this idea and were afraid of complications to their systems. Their skepticism was

understandable, and we agreed to see how the chat application behaved during the test phase before connecting to this instance. Another discussed possibility was to connect to a test instance they had, that Halvorsen used during his study in Rwanda. They were open to this idea, but again access proved difficult. We came to the conclusion that although the data in our dummy instance of DHIS 2 was fictitious and DHIS 2 interpretations were imaginary, they would still be able to test all the features of the chat application.

We were able to connect to Rwanda's main production instance of DHIS 2 the final week of our stay. The HMIS team lead was convinced that our application was secure and that the chat system would not compromise their systems.

### 6.1.4 Test phones

Nine phones were bought in 2015 for the purpose of testing DHIS Messenger. These were made available during our stay in Rwanda. We knew that not all data managers had smartphones, so our application had to work as well on these as newer ones. The phones were of type Tecno H5, a low-end phone. These phones used an operating system released in 2013. We did not have an opportunity to test DHIS Chat on such an old operating system before the alpha test. Although we had developed and tested our application on the newest Android version released in 2016 during development, almost all features work well on these phones. Some functions performed slower than on the newer phones, but this was quickly corrected and optimized before handing the phones to the data managers.

The issues found was mainly:

**Sending pictures:**
The folder of the camera roll (image folder) did not match on the test phones, sending an image would, therefore, result in a crash. This was later solved in cycle 3 – before the beta test.

**Login:**
This problem was not a bug, but an optimization issue. There is a lot that happens when you log in. For instance, the phone connects to the chat server; it gets old messages, either group messages from the server or one-to-one messages from the local storage on the phone, and the status of all your contacts. During development, this went smoothly and fast, but with the Internet connection and a slower and older phone, this took longer than anticipated. As the attachment bug, this issue was also sovled before the beta test.

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## 6.2   Cycle 2: Alpha testing

After the prototype test we continued the development of the application. The priority was mainly correcting bugs and optimizing the application for the low-end phones. After a week we felt it was time to bring the application to the real end-users for testing.

As the IT-dominant BIE cycles suggest, one should perform an alpha test in a smaller part of the organization before bringing it into a large-scale environment. As the HMIS team was one of the intended end-user groups and were accessible to us because of our shared office, they were our participants during this phase. The first week of our stay in Rwanda we had also been introduced to HISP Rwanda. Two persons from the Rwanda HISP team also joined the test session.

The alpha test proved that the chat scaled well and users were correctly placed in the same buddy-list. All the test participants were left with a good impression of the application's interface and functions. There was, however, the discovered optimization issue when logging in as mentioned in section 6.1.4 on the preceding page. The HMIS team also had comments on the lack of explicitly displayed time when each message was sent and received. At that point, only the last message showed the date and time of reception. Time and date on the messages were necessary in regards to work as to ensure that the message was received, but also to have a better sense or order in the conversation view.

## 6.3   Cycle 3 - Beta testing

In the days after the alpha test with the HMIS team, we started implementing the timestamp feature and worked on shortening the time it takes to log in. On the 15th of February, we scheduled an introductory meeting with the data managers. Before this session took place, we had to prepare our presentation of the application and make some documents that we could hand out to the data managers. The documents we created were a user guide, a questionnaire, and contract between the data managers, us and MoH. These documents are attached as appendices.

After reviewing the answers to the questionnaire, we understood that some of the data managers were not as familiar with DHIS 2 interpretations as we first had thought. This unfamiliarity was worrying, as a big focus of the DHIS Chat application is its interpretation sharing features. We also learned that, compared to Halvorsen's project from 2015 (Halvorsen 2015), fewer data managers actually owned smartphones.

During our stay in Rwanda, most of the days were used to tinker with the application and the server, fixing bugs and working on different permissions. The first permission we started to work for was to be able to connect our application to one of the HMIS production instances of DHIS

2. To get this permission was imperative to us because the data managers would not use the interpretation feature of the application before we had access to real data. Unfortunately, this permission was given to us the last week of our stay, which meant that we did not have enough time to test properly. The other permission we worked on was to be allowed to conduct several interviews with the data managers at their place of work, at the health facilities. The plan was that these interviews would be conducted in the second to last week, but that never happened. Instead, we were given the permission to meet the data managers at the district hospital after the conclusion of a monthly data review meeting.

As mentioned earlier, the group discussion at the district hospital was conducted primarily to get an overview of the data manager's thoughts on the application, whether they liked it or not, what functionality they used the most, what they thought should be changed and so on. The general feedback we got was that they liked the application and that they had a need for a tool like this. The only concern they had was that other people they work with every day, like doctors and nurses, would not be able to use the application because they do not have access to and login credentials for DHIS 2. The testers thought this was strange, as they need to be able to communicate with these people, just as much as other data managers. They also did not find the interpretation feature very useful, as it did not contain original DHIS 2 interpretations of real visualizations of data.

After the group discussion, we conducted a group interview with three data managers. Some of the things we asked about were attachments, how often they used the application, how they felt about WhatsApp and how DHIS Chat stand up against it. They told us that they had tried to send pictures with DHIS Chat, but they had not used the feature a lot. All three of the data managers said that they had used the application daily, and that they did not think it could ever replace WhatsApp for work related communication, but that it would be a tool to use together with WhatsApp.

After the visit to the district hospital, we finally got the permission to connect our application to the production instance of DHIS 2. We informed all of the data managers about the change, but sadly the interpretation feature was still not used at all. This week was also used to conduct the remaining interviews of the data managers we had not been able to interview at the district hospital. These interviews were carried out at the HMIS office at MoH. The general feedback from these interviews was much the same at with the group discussion and the group interview that followed. The findings is described in chapter 7 and will be discussed in more detail in chapter 8.

# Chapter 7

# Findings from beta testing of DHIS Chat

The findings of the beta test will be described in this chapter. As a way to compare current communication systems with DHIS Chat, we will start by outlining the findings on the use of the standard DHIS 2 messaging system, WhatsApp, and DHIS 2 interpretation. We then move on to the feedback of DHIS Chat. A section on the conversational topics found during the beta test, as well as activity statistics will also be discussed before we finish with a section on improvements in DHIS Chat compared with the currently used systems.

## 7.1 Data manager's current use of communication tools in Rwanda

To know how our application can fit in a health organization and how it can improve communication, collaboration and information use we need to understand the applications they use today – why they use it and how. We have looked at the messaging functionality within DHIS 2, WhatsApp and what their relationship is to DHIS 2 interpretations.

### 7.1.1 DHIS messaging

The questionnaire handed out to the data managers during the first day of testing, showed us that people use or have used the DHIS 2 messaging function. All, but three said they used this feature. The functionality was mostly used for communication with the HMIS team related to technical support. The data managers also stated that this was used for one–to–many conversations only. Although they regularly look for new messages, they rarely used it to initiate conversation. When asked about their preferred means of communication at work, none of the data managers mentioned

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the DHIS 2 messaging system, but rather call, SMS or chat. Also in later interviews, DHIS 2 messaging was further discussed, and when asked if they used DHIS 2 for communication the response was usually:

> "No, when I have any questions I call" and "I have used it [the DHIS messaging functionality], but I don't use it now. Most of the time I call."

Or

> "Yes, for asking technical questions to HMIS team, but I don't use often."

The general opinion of the data managers was that DHIS 2 messaging functionality is not satisfactory and that it is necessary to use other means of communication. When asked why they thought an IM application integrated with DHIS 2 was needed they replayed:

> "Because we use email once needed for technical support and some time there is a delaying in response. We hope this will help in getting quick responses."

> "Because you will ask a question to whoever and get a response immediately and you will be able to be sure who is online."

> "Yes, because we will be able to see the notification on time and also to see someone online."

> "Because you can see response directly when a colleague is online."

During the interviews, it became apparent that the reasons why the DHIS 2 messaging system was rarely used are "because the response can be very slow. It can also be hard to see the new messages because I don't get a notification" as a data manager stated and also not being able to see who is online or not.

### 7.1.2 WhatsApp

WhatsApp is used a lot for communication between the data managers, their supervisors (M&Es) and also the HMIS team. Currently, they have official groups in WhatsApp that they are a part of and use to coordinate meetings, ask questions and support related to work amongst other things. There is a hierarchy of groups where one group consist of the HMIS team and the supervisors at the district hospitals and the other groups consists of the supervisors and the data managers in their catchment area. There is also a national group of all data managers. All data managers are therefore part of at least two official groups where everything regarding them can be discussed.

WhatsApp is a messaging application with the functionality DHIS 2 messaging does not possess, but what the data managers want. In response

to why they use WhatsApp we were told:

> "WhatsApp is faster. When you see someone online, you know they will answer. When you send a message in DHIS 2, you might send a message to someone who is not online."

When sending a message to another person you can 1) see if he is online 2) see that he or she has received your message and also read your message and 3) get a notification when you get a reply (even if you are not actively using the application at that time). The notifications trigger fast response because the recipient is immediately aware of the new message.

A disadvantage of WhatsApp is the fact that messages are stored on WhatsApp's servers. Because of this, they are not allowed to discuss data or any confidential information. It can also be a distraction because WhatsApp is used by everyone, not just their co-workers.

### 7.1.3 Interpretations

The HMIS team Lead wanted the possibility of looking at, commenting on and discussing DHIS 2 interpretations. Because of this request, our initial thought was that the data managers used DHIS 2 interpretations regularly in DHIS 2 and was familiar with the feature. During our interview with the HMIS Lead, it became apparent that they did not actively use it in their work even though many of the DHIS 2 trainings was used to teach them about this specific functionality. Despite the fact that DHIS 2 interpretations are not currently used, the team Lead saw this as a good way to help the data managers improve information use and sharing of information:

> "... So the reason behind it [integrating interpretations in the chat application] is giving an open room where people share their ideas and experiences then we learn from each other. So if I have an issue, but someone encountered the same issue, there is no need of inventing when there is already a solution that has been implemented, and it worked. So just giving the open room where people share what they have used."

From the questionnaires, we found that three data managers had used DHIS 2 interpretations, while five were not familiar with it at all. The last three were familiar with the functionality, but they had never used it themselves.

For social data discussion and analysis, the data managers told us that they "sometimes print hard copies and share to all workers." Commenting on and discussing the DHIS 2 interpretations inside the DHIS 2 portal was not something they did often, as commented by one data manager: "When commenting interpretations, just we seat together as a team at work, and everyone give his/her comment." One also stated that "... I make the statistics myself in excel". These statements are an indication

that data discussion is not often prioritized and takes some effort to accomplish.

On the other hand, one of the data managers told us that he thought a mobile application that facilitates social data analysis would be very helpful in his work:

> "Mobile application will change how we interpret. Give comments will be very easy, because anywhere we are, we can give comment."

He emphasizes that that the mobility of an application like this makes it much more useful, because you are no longer tied to a desk.

## 7.2 Feedback on the chat application

By observations and interviews, we got feedback and improvement areas for the chat application. The general feedback from both the data managers and the HMIS team was that the application worked well and was useful and wanted.

### 7.2.1 Use

The most used features in the chat application were one–to–one chats and group chat, which are also the main features of the chat application. Over 40 one-to-one chats were created during the testing of the application. As we did not look at the conversations, we do not know what was chatted about or how long the conversations were. The data managers also created two groups were all the data managers were included. However, they excluded the testers from the HMIS team, HISP and us. One group was called "friends" and the other named "group2" with a total of 104 and 58 messages respectively. The name of the groups was not used as a topic for the chat. One might think that the "friends" group would be a chat with a social conversation, but when asked about what they talked about in the "friends" group the answer was work. It does not seem as though the name of the groups represented the topics in the chats, but this might be that the creator did not have a topic in mind or that they are used to have few, but large groups.

Since the earlier mentioned groups excluded us, we chose to create a group called "Global". This group included all testers from HMIS team, HISP tester and us as well as all the data managers. This group was mostly created to see that everybody got important messages like application updates and time for meetings. No real conversations were started in this group.

As a part of the contract, the data managers agreed to log on once a day, but observations of our chat server showed that the majority were logged

in several times a day. Some logged in less frequently, but this wasn't necessarily negative. When talking to one of the least active users, she said:

> "I didn't log in every day, but I used it to update myself on what others were posting, and information was very helpful. After seeing what others were saying I also commented."

We wanted a real setting where the testers were not forced to talk unless there was something to say. If all the messages that were sent were just test messages, the data would not be valuable. Because of this, we did not start conversations outside of the "Global" group and only chatted with testers who initiated a conversation with us. This approach showed us that the application is useful both as an active user, but also as a passive one.

### 7.2.2 Groups

Even though the group chats had fewer messages in total than one-to-one chat, the group chat functionality was reported as the most used and liked feature by the data managers. Statements like

> "I use both [one –to-one and group chats], but mostly groups" and "I like most of the functionality, but groups were amazing and wonderful. I appreciated it 100%."

made it clear that this was a good feature. When asked why the groups were a useful tool, one of the data managers said:

> "…. Because if one ask a question in a group, for example, the other could answer that question and when another have that question without go and ask, he can go on old message and get that response from the answering on that last question."

As we will discuss in section 7.3.1 on page 80, technical support is essential, and in groups, they can help multiple people who are struggling with the same issues. They can also help each other and get answers from more than one person.

#### Privacy

During the testing of Halvorsen's application in 2015, no group messages in group chats were sent. His group chats were open groups, which everybody could join. Everyone could see the content and actively respond to any message. His research found that the data managers wanted private conversations, (i.e. invite only) like they were used to in WhatsApp.

Our testing of group chats support his findings. In contrast to Halvorsen's group chat functionality, our groups were private, and through statistics and interviews, we found that groups were actively used and a great tool

for coordination. When asked about the interpretation MUCs they also liked the idea of a private group to discuss data and share information and ideas.

> "Yes because in private groups you can say the truth and get the real cause of the gap and take a good decision."

> "Private interpretations depends on number of persons who is discussing privately. Suppose that group of 10 workers gives interpretation for they own graphic, it will be better. It can improve data quality."

These quotes imply that private groups can allow the data managers to speak freely and discuss more in-depth the meaning and cause of DHIS 2 interpretations and data trends. The fact that it is given an example of 10 workers instead of "many", or "the data managers in the district" might argue that there is a need for the possibility of smaller groups.

**Small groups**

In section 7.1.2 on page 72, groups in WhatsApp was mentioned. The data managers said that they liked the idea of having multiple small groups with different topics in contrast to only having the two big groups they currently use.

> "Yes because we have groups on WhatsApp which connect all users of DHIS 2, all workers that work on that area we use to talk about everything. But now on DHIS 2 [chat application], we can create groups which is about work, where the discussion is about work. One for the problems and the issues and the answers and one for new information. It could be good when DHIS 2 is connected all the users of the DHIS 2 system".

There is no divide in topics in the WhatsApp groups, but with smaller groups, one can get a better structure of discussions, as well as technical support and coordination. It is also easier to restrict information to relevant co-workers only.

### 7.2.3 Interpretations

No interpretation MUCs were created during the test phase. After two weeks of testing, it became apparent that the data managers would not show interest in this functionality. We, therefore, decided to go thoroughly through this feature after the in-depth interviews with the data managers and explain how it works and the purpose of the feature. We also asked them to create their own DHIS 2 interpretations and a group for discussion of the data during the next weeks. One data manager created a group, but there was nothing said in this chat. The in-depth interview also included

questions of both the DHIS 2 interpretations in DHIS 2 and our application. What we found were mixed opinions on DHIS 2 interpretations.

> "Yes, I understand them better [than the application from 2015]. Much more interested now. I want to use it."

> "... It can help us with our knowledge and improve our job."

> "I know how to use interpretations, but I have not tested in the app. I understand if I see the graphs."

There were several reasons why the data managers did not use the DHIS Chat interpretation functionality. One reason is the general lack of DHIS 2 interpretation use as a data manager stated:

> "It [interpretations in chat application] is not difficult, but we don't understand even on DHIS 2 system. We don't use it in our work."

Another reason might be the lack of real data because we started the test phase connected to our own DHIS 2 instance, not the Rwanda production instance. The data were from no later than 2014 and as mentioned based on dummy data and might not be something the data managers were interested in discussing. Later we were able to connect to Rwanda's production server. Rwanda has seven production DHIS 2 instances for different purposes and problem areas. We connected to the one where all the data managers had an account and could connect. This instance, however, did not have any DHIS 2 interpretations created after 2014 either. That might be the cause of the comment a data manager made:

> "Interpretations are very difficult to explore... It would be better if you get the new interpretations first. "

The fact is that in the application the most recently created DHIS 2 interpretations are the first ones appearing in the application. However, since there were no updated DHIS 2 interpretations on either of the DHIS 2 instances, it might have caused some confusion. To summarize, MoH in Rwanda would like to support data use through sharing of DHIS 2 interpretations, for instance through the DHIS Chat, but for this to happen, some DHIS 2 interpretation/data use needs to be in place already. This is a chicken and egg problem.

### 7.2.4 File attachments

The attachments functionality was tested a lot during the first day of testing. During the next weeks, however, it was not used at all. Some said they did not need to send a picture, while others thought it was a good feature and could be useful in the future.

The way these attachments are sent is not restricted to only pictures, so this feature can be used to send other documents as well. The only restriction

is the location of where to find the attachments on the system. One of the data managers had tried to use the feature but found it too limited:

> "... It limited me to only one folder. I tried to take a picture from another folder, for example, one made from WhatsApp, if I can take another picture and share it using the application. But it told[/showed] me only the folder of the photos I have taken with my phone."

This quote suggests that it is necessary to have flexibility and a choice of where to find the image to send. It also implies that this is important for the feature to be useful. The data managers also thought that the possibility of sending PDF's and other files interesting, which should be a priority in a later version of the application.

### 7.2.5 Data consumption

During our testing at UiO, we found that all our messages, except for images, used less data than WhatsApp. Nevertheless, it did not prove that the application could be utilized in a country like Rwanda where WiFi is not as common and mobile data is more expensive than in developed countries.

As a motivation to use the application more, we gave each of the data managers data bundles for 5000 RWF, which relates to 2 or 3 GB depending on options of weekly or monthly distribution. The data managers reported that these data bundles were spent before the testing was over, but as a data manager commented, "it is hard to know if it is only the chat app that uses bandwidth because we use other applications also."

Two of the data managers also tested Halvorsen's application in 2015. We asked for their opinions on the data consumption in comparison to the old application. Their answers were:

> "It uses much more than WhatsApp, but less than the DHIS 2 messenger from 2015."

> "The old application was very heavy. It used long time to log in. This app is much lighter; the login is fast and very responsive. This app uses much less data."

The other data managers were also asked about the data consumption, but they did not have any complaints and thought it used the same as WhatsApp and other similar applications.

### 7.2.6 Buddy-list

The buddy-list with presence awareness is a popular feature when using IM. The data managers also appreciated this, and found that "it is very

easy to see others in our field." In Halvorsen's thesis, it is mentioned that contacting the data managers was difficult. In WhatsApp, it is only possible to add contacts that already have a WhatsApp account, and in DHIS 2 there are restrictions on sharing contact information depending on the user's role.

When a DHIS 2 user installs the application on their phone and logs in, he or she is a part of all the other contacts buddy-list. Because of this, the buddy-list contains all users one can expect to have the IM client. With one touch one can start a conversation with anyone with a DHIS 2 user account and DHIS Chat. Personally saved contact information on the phone or a specific role, like administrator, is not needed to get in contact with the intended person.

For a buddy-list to fulfil its potential, people have to be active. During the beta test, the statistics showed that only four users were online simultaneously. This is not uncommon with few test participants, but in a national roll out with 800 data managers and their supervisors as well as the HMIS team the buddy-list can be a more practical and a tool for connecting the DHIS 2 users.

The data managers seemed optimistic about the instant messaging application and the buddy-list:

> "We need this app because it connects all users of DHIS 2 it could be good and better when all the users of DHIS 2 has one app to connect together."

However, the buddy-list or rather, who is included in the list, is restricted to those who have a DHIS 2 account. This restriction implies an exclusion of nurses and others employees that the data managers have to interact with during a day. An interview with a data manager enlightened us about the fact that DHIS Chat can never fully replace WhatsApp:

"Because this application can be used by me because I have username and password for DHIS 2. Someone at my work can't be, can't know about this application. For us, with access to the app it can work, but in my institution, I use WhatsApp or call".

He later explained that he had to interact with other health workers to validate the data before entering it into DHIS 2. This find raises the question of who the application is for and the intended purpose. By opening the application, and allow for anyone to create a user, the purpose of control and confidentiality is quickly lost. As the section on the motivation for this application states (See section 1.1 on page 2), the intended goal is experience sharing and data discussion, not validating. More to the point discuss data already entered in DHIS 2 or how to enter the data and what kind of data, not if the specific source or number is correct. It is also a potential replacement of the more asynchronous message functionality in the DHIS 2 portal.

## 7.3 Conversational topics in DHIS Chat during beta test

The themes of the conversations that took place during the test period are manifold, but the general theme is work. Our findings show that some of the most important topics of the conversations were agenda for meetings, DHIS 2 and other systems the data managers use at work. The data managers also reported that they used the application to share ideas and information.

When asked what they use the app to talk about, if it was work only or also social, one of the data managers responded:

> "Yes, only about work on this app. Because the other chat apps we talk about life and about other things without talking about work. I use this app when I want to talk about work, on work issues. When I want to ask someone a question about work I ask them through this app."

Another data manager responded in a similar manner:

> "As data managers, we talk about our job. If we have some questions, some ideas we share information."

The work related conversations in DHIS Chat, more precisely for technical support and coordination, will be described in more detail in the next subsections.

### 7.3.1 Support

As with Halvorsen's application and testing (Halvorsen 2015), we found that support was one of the main topics. There are two main aspects of support: centralized and decentralized. Centralized support means that a central participant, like the HMIS team at MoH, is contacted either directly or indirectly (e.g. in a group conversation). Decentralized support can be seen as a collective peer effort to solve the problem, in this case, the data managers themselves

**Centralized Support**

We visited Rwanda and MoH in a hectic period, where new servers replaced old servers. Staff from the World Health Organization (WHO) assisted the HMIS team at MoH to set up these servers. Because of this, the HMIS team itself had a lot going on while our application was being tested. As an extension of this, the HMIS team only sent a total of 18 messages in the test period. The low activity of the HMIS team is an indicator of a lack of centralized support via the DHIS Chat, because of

the data manager's emphasis on fast response and that they only contact people who are online.

**Decentralized Support**

While we did not find that centralized support took off during the test period, decentralized support was the most significant findings in regards to the topic of conversations. The application became a platform for support in group chat. On the first day of testing, one of the data managers created a group for all the data managers in the test. This group became the main communication channel for all the data managers during the test. In this group, the data managers who needed help, either technical or non-technical asked the other data managers for help. The likelihood that one of the other data managers has encountered the same problem is large, and many problems were fixed by their collaboration in this group. Some support may also have occurred in one-to-one chat, but the feedback we got suggested that groups gave the best results as many people could help with the problems.

The response from our interviews supports that the data managers used decentralized support. When questioned about whether they had asked anyone for help using the application, two of the data managers responded the following:

> "Yes. I asked data managers"

> "Yes, I did. We are launching a new reporting system, so I asked about login to that system. Also, I asked about the registration system."

This shows us that the most common way of support in our testing was decentralized support, because the data managers helped each other.

## 7.3.2 Coordination

Data managers work closely with each other, even though they are situated at different health facilities around the country. To be able to gather the data they need and report this data back to the central level, as well as keeping up to date on the newest information, the data managers need to communicate. Both with each other and the higher levels like M&Es and MoH. Coordination is therefore vital. During the testing of this application, the data managers had a monthly meeting at the district hospital. After the meeting, we had a group session with the data managers where, among other things, one of the data managers said:

> "For example, today we were here at the district hospital for a meeting, so we were discussing about the time of the meeting, the venue and so on."
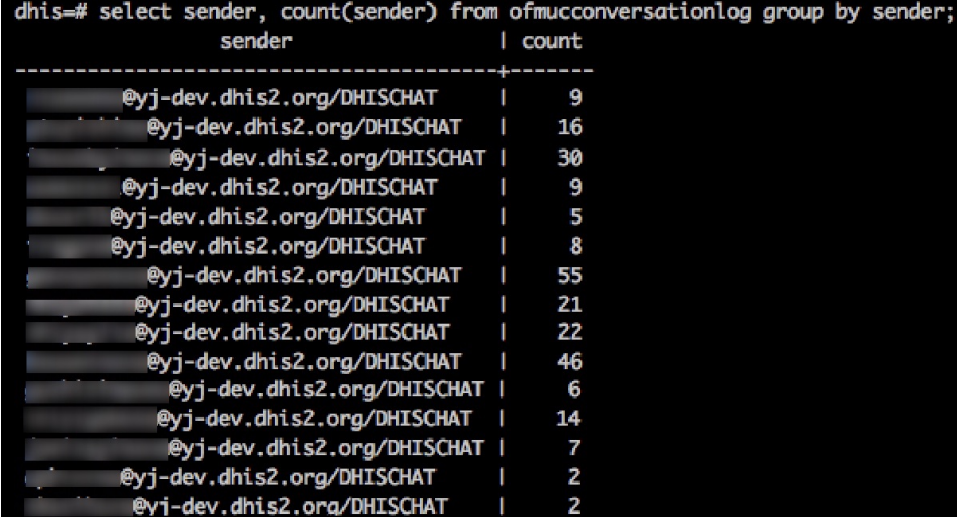
At an individual interview some days later, another data manager told us about the topics of their conversations. One of them was about meetings:

> "For the app, working and the program of work, program of meeting, and about DHIS."

From these quotes we get an understanding of how they used the application for coordination. If anyone had questions about when or where the meeting were to take place, they just asked another data manager.

## 7.4 Activity statistics

In this section, we will show and discuss the activity statistics from the beta test. The way we collected the data presented in this section was by counting recorded sent messages from the Openfire database. This method was not used by Halvorsen (Halvorsen 2015). Instead, he collected all the data from each phone. As we expected more of the data managers to use their own phone, we came to the conclusion that it would be less intrusive to use a database count instead. This means that we do not have any quantitative data about how long the users stayed active. In the case of MUC, the data we got from the database can be seen in figure 7.1 on page 82.

```
dhis=# select sender, count(sender) from ofmucconversationlog group by sender;
             sender                  | count
-------------------------------------+-------
        @yj-dev.dhis2.org/DHISCHAT   |     9
        @yj-dev.dhis2.org/DHISCHAT   |    16
         @yj-dev.dhis2.org/DHISCHAT  |    30
       @yj-dev.dhis2.org/DHISCHAT    |     9
      @yj-dev.dhis2.org/DHISCHAT     |     5
      @yj-dev.dhis2.org/DHISCHAT     |     8
        @yj-dev.dhis2.org/DHISCHAT   |    55
       @yj-dev.dhis2.org/DHISCHAT    |    21
       @yj-dev.dhis2.org/DHISCHAT    |    22
        @yj-dev.dhis2.org/DHISCHAT   |    46
         @yj-dev.dhis2.org/DHISCHAT  |     6
        @yj-dev.dhis2.org/DHISCHAT   |    14
         @yj-dev.dhis2.org/DHISCHAT  |     7
      @yj-dev.dhis2.org/DHISCHAT     |     2
       @yj-dev.dhis2.org/DHISCHAT    |     2
```

Figure 7.1: Count of messages sent in MUC sorted by sender

### 7.4.1 One-to-one

In table 7.1 on the facing page, we can see that one-to-one chat was a lot more popular than MUC was. We can also see that the data managers were a lot more active than the HMIS team were. The biggest amount

of messages that was sent during the test period by one person was 55 messages. The person that sent the most one-to-one messages was one of two data managers that tested the first application in 2015 by Halvorsen. In the interview, this person told us that he usually sent around 20 messages a day on WhatsApp, the highest number in the group of data managers. The person sending the least one-to-one messages was one from the HMIS team at MoH.

### 7.4.2 Multi User Chat

MUC was substantially less used than one-to-one chat but was still reported (in our interviews) as a very useful feature. We can see that there is a trend with data managers using the application much more active than the HMIS team. The total average of MUC messages sent is 16.8, while the data managers average is 20.7 messages sent. The largest number of messages sent in MUC was 55, and the person responsible for this was a data manager. Two people in the test only sent 2 MUC messages, one of them a data manager, the other one from the HMIS team.

| Type of message | Total | Only DM | Average | Average only DM | Max | Min |
|:---:|:---:|:---:|:---:|:---:|:---:|:---:|
| One-to-one | 411 | 369 | 26.8 | 34.4 | 55 | 3 |
| MUC | 252 | 228 | 16.8 | 20.7 | 55 | 2 |

Table 7.1: Statistics showing number of sent messages in the test period

## 7.5 Improvements

While the study of the application made by Niclas Halvorsen (ibid.) yielded a positive result, it also uncovered some problems with the application. Our task in the development of the second generation DHIS 2 messenger application was to improve these problems, as well as add new functionality requested by the MoH. In the following section, these improvements will be discussed.

### 7.5.1 Data consumption

We were not able to test the specific numbers on data consumption of the DHIS 2 Messenger, because of technical difficulties. Instead, we decided to test and compare the numbers of DHIS Chat with WhatsApp, as it is reported to be the most used chat application in Rwanda's health sector.

We tested data consumption at login, for sending a picture and a text message. The picture and the text were sent three times and the data consumption measured after every message was sent. The text we sent

was a 5 paragraph, 427 words and 2942 bytes of "Lorem ipsum", while the picture used in this test had a size of 19 kilobyte (kB)s. To measure the data consumption, we used the built-in data usage feature of Android. The data usage feature only shows how much data the whole application has used, so a shortcoming of this test is that we can not be a 100% sure that the amount of data measured only comes from the test. That is because the applications might do background work, like updating the message list, while the test was ongoing.

| Test of data usage in DHIS Chat | | | Test of data usage in WhatsApp | | |
|---|---|---|---|---|---|
| | Result of each test | Average sum | | Result of each test | Average sum |
| **Login** | | | **Login** | | |
| Test #1 | 28 kB | 28 kB | Test #1 | 179 kB | 179 kB |
| **Text message** | | | **Text message** | | |
| Test #1 | 2 kB | | Test #1 | 4 kB | |
| Test #2 | 1 kB | 1,67 kB | Test #2 | 8 kB | 5,33 kB |
| Test #3 | 2 kB | | Test #3 | 4 kB | |
| **Picture** | | | **Picture** | | |
| Test #1 | 17 kB | | Test #1 | 10 kB | |
| Test #2 | 17 kB | 17 kB | Test #2 | 10 kB | 10 kB |
| Test #3 | 17 kB | | Test #3 | 10 kB | |

Table 7.2: Results of data consumption test with DHIS Chat and WhatsApp

Table 7.2 shows the results of the test. When we measured the data used to log into the application, we found that DHIS Chat used 28 kB, while WhatsApp used 178 kB. These numbers are somewhat unclear. That is because in DHIS Chat groups are loaded from the server under login, while WhatsApp has a very tedious login process where a code is sent to the phone of the user, and the user gets the option to log in via Facebook, and so on. Just like with DHIS Chat, messages are loaded from the WhatsApp servers when the user logs in. Because of this, the data consumed at login can fluctuate with both applications.

From the table, we can see that DHIS Chat used 1,67 kB in average, while WhatsApp used 5,33 kB in average. The reason for the difference in numbers might be because of the recipt functionality WhatsApp offer of showing when a message has been delivered and read. The low data consumption of text messages in DHIS Chat is due to the stream compression that we have enabled both in the application and on the Openfire server. This stream compression can, in ideal circumstances, lower the data used by 90%. From the table, we can see that the second WhatsApp text message test doubled the amount of data compared to the two other tests. This fluctuation is most likely due to a background process sending and receiving data.

In the last test, we measured the data consumed when sending a picture of 19 kB. In both the DHIS Chat and the WhatsApp test, we can see that there is a consistency in the numbers. DHIS Chat uses 17 kB in all three tests, while WhatsApp uses 10 kB in all three tests. These figures show that the compression used on images is more effective in WhatsApp, compared to

DHIS Chat.

## 7.5.2 GUI

The main reason for the test person's inability to distinguish between one-to-one chat messages and many-to-many group chat in Halvorsen's application was the GUI. The menu was designed in a way that is not common to newer Android applications, and the menu items themselves did not give the users a sufficient explanation of what it was. MUC or groups are hidden under the "Chat" item in the menu.

As the test persons in Halvorsen's study reported to use WhatsApp on a regular basis, we set out to mimic the design menu of this application to give the users an instant recognition of the menu system. We follow the tab menu layout and try to have every feature open and easily attainable for the user. In figure 7.2, we can see a comparison of the menu in DHIS 2 Messenger, DHIS Chat and WhatsApp.
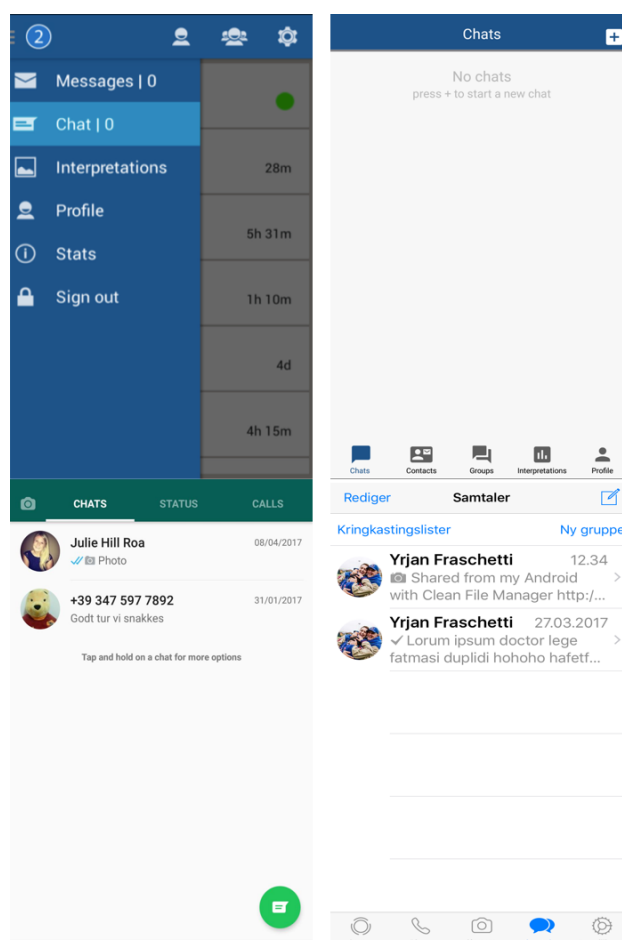


Figure 7.2: Comparison of menu layouts of DHIS 2 Messenger, DHIS chat and WhatsApp for Android and iOS

### 7.5.3 Interpretations

Interpretations are the primary data analysis tool in DHIS 2. It can be charts, maps, and tables. Halvorsen implemented DHIS 2 interpretations into the first application, with all the functionality that DHIS 2 offers, like viewing the DHIS 2 interpretation and commenting. For this new version of the application, the MoH wanted a more immersive experience. As we discussed the meaning of this with the product owner, the head of the HMIS team at MoH, he stated that he wanted the users to have "the information at their fingertips", and that they should be able to access and discuss the data as freely as possible.

Because of this, we decided to implement a particular type of MUC, that we decided to call interpretation MUC. We started by adding the functionality that Halvorsen had in his application and then added a feature that enables the users to create groups where one DHIS 2 interpretation can be discussed in privacy, without having to comment on the DHIS 2 interpretation. The thought behind this was to allow the users to discuss and analyze data collectively, and as a result, they would have a much more in-depth understanding of the data.

The way we achieved this was to add an interpretation preview inside the MUC conversation as seen in figure 7.3. This preview enables all the group members to see the interpretation in a minimized form. By pressing the interpretation preview, the whole DHIS 2 interpretation is revealed so that it can be studied more closely by the rest of the group.
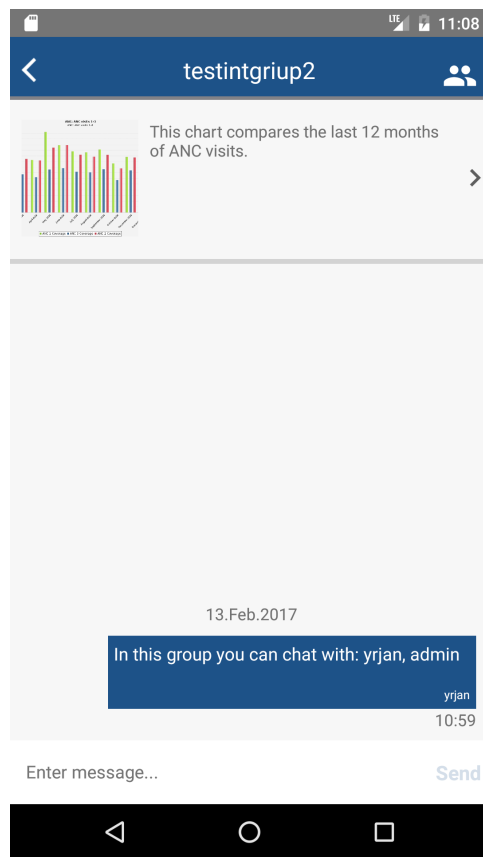
Figure 7.3: Illustration of the DHIS Chat interpretation preview

# Chapter 8

# Discussion and analysis

In this chapter we reflect on the learning from our ADR project. We relate this to the theoretical perspectives described in chapter 2. Social Presence Theory, Media Richness Theory as well as social data analysis are the basis of our discussions. Social Presence Theory: the degree of how "real" a person is perceived to be in an electronic communication medium, Media Richness Theory: The ability of the medium to convey the intended meaning and context, and social data analysis: where common ground but unique perspective, expressive spectator interface, and discovery transfer is essential. Finally, we present the design principles found to answer our research question:

> "How can mobile instant messaging facilitate and stimulate collaboration between health data managers in a low-resource context?"

## 8.1 Negotiating availability

The ADR cycles, mainly the beta testing, showed that the ability to visualize the presence of other users was significant. The main reason why phone calls and IM applications like WhatsApp were preferred over DHIS 2 messages was a faster response. A rapid response depends on two components: notifications and availability, meaning awareness that a message is received and the time it takes to write a response.

The standard DHIS 2 messaging functionality shows the number of unread messages in the dashboard of the portal. Although the message count is visible for the user, a clear notification is lacking. The number showing unread messages is not updated until the web page is reloaded and there is no sound or effect to catch the user's attention. This makes the new message hard to notice and might be a reason for the slow response in DHIS 2 messages. Another reason for a late response might be the lack of presence. In DHIS 2 messages there is no way of knowing if a person is

online or offline. If they are online, they might be busy with work related activities like data entry and will see the message as an interruption, or if they are offline, he or she will not know of the message until they log into the system. There is a lack of negotiating availability in DHIS 2 messages. If there is a pressing matter, DHIS 2 will not suffice, and the users have to turn to other means of communication to ensure fast response.
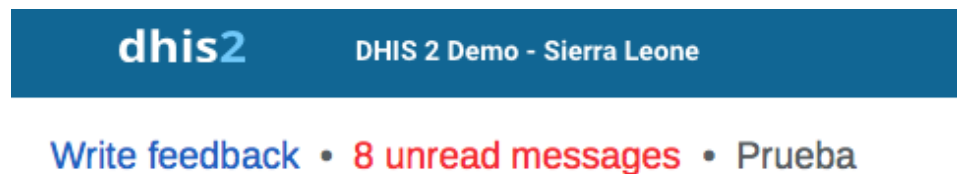


Figure 8.1: Number of unread messages in the DHIS 2 portal

In a phone call conversation, the response is immediate, and phone calls allow for good flow and the feeling of non-mediation. However, Nardini found that "about 60% of workplace phone calls fail to reach intended recipients because they are not there, or they are already talking to someone else." (Nardi, Whittaker, and Bradner 2000, p. 82). Although calls is a good medium for conversation the chances are the conversation has to take place at a later time than anticipated due to an occupied receiver.

"IM helps people negotiate availability by allowing conversation intruders judge whether recipients are online by consulting the buddy-list" (ibid., p. 83), if they are not online they can ask someone else or ask in a group. As the data managers stated during the interviews: "We only talk to people who are online," indicating that they often need to be efficient and need to get a response quickly. IM also has notifications both when active inside the application, but also in an inactive state. The notifications usually comprise of both sound, and visual effect and mobile applications will also be able to make the phone vibrate. The notification makes a user aware of received messages and can quickly type a reply.

In today's world, people are expected to be efficient and not "waste" time. In a work situation, where one is dependent on collaboration with and support from others, presence awareness in IM clients is a useful tool. There might be multiple people with the same knowledge performing the same tasks. An example might be when data managers are dependent on technical support they often call or use DHIS 2 messenger to reach the HMIS team. With phone calls, the caller might not get through to the intended person and DHIS 2 messages might not get answered. With IM's presence awareness feature, users can choose a person from the HMIS team visibly online and expect a faster response. It is also possible to quickly ask if he or she has time to talk on the phone if the conversation demands a different medium. The HMIS team, on the other hand, gets many requests during a day. A phone call might be an intrusion on their current work or viewed as "cutting in line." With IM, one has the

possibility of not responding immediately or just let the data manager know they will be helped later in the day if needed, this way "negotiating unavailability."

## 8.2 Flexible group compositions

During Halvorsen's research, he found a lack of group conversations. He concluded that the reason was an incomprehensible GUI and that the groups were open and could be joined by all users (i.e. not private with selected users). Although no groups were created, he still considered chat groups as necessary in work related IM clients regarding sharing experience and technical support. A big part of instant messaging in the workplace is multi-user groups. Our second-generation application, DHIS Chat, has private groups only. When creating a group, the members gets invited and join. Everyone in that group also has the possibility of adding additional group members at any time. The data managers of DHIS 2 are usually separated and are normally restricted to monthly meetings in regards to face-to-face communication. This makes an integrated IM application with the functionality of multi-user groups a good tool to facilitate collaboration more often and more in-depth and specific.

During the BIE cycle 2, the HMIS team Lead informed us that the data managers are active in official WhatsApp groups for work related information. We argue that this was a reason why our groups were used. They quickly created a group including all data managers participating in the beta test and were comfortable with creation and use of the functionality.

With the official WhatsApp groups in mind, we observed similar behavior in DHIS Chat. Our assumption was that they would create one for coordination of meetings, one group for technical support and maybe one for social or even divide it more with technical support for report system 1 and one for report system 2, this was however not the case. Instead of creating many groups with different topics for a simple conversation structure, they created one or two groups where all work related topics were discussed. As Straus suggests: when the size of the group increases, it might be harder to process statements and identify the source of the message and in turn, reduce effectiveness (Straus 1996). We found this to be true as the data managers asked us to display the full name of message sender instead of DHIS 2 username only.

Another interesting development was the group composition. The data managers excluded the HMIS team from their groups. This implies the wish for and a necessity of private groups, without anyone to control what is written. However, when asked if they did not need or want groups with the HMIS team or their supervisors, they stated that they needed to include them in their groups – mostly for technical support and coordination. One solution is the flexibility of choosing to create a private or open group, thus

given the opportunity to discuss in smaller or large (i.e. with everyone) groups easily depending on the topic.

Multiple studies on instant messaging has tested group work extensively (Mark Handel and Herbsleb 2002; Graetz et al. 1998; Salanova et al. 2003). There are both pros and cons of collaborating in electronic communication media, but Straus found that performance in electronic textual collaboration did not depart significantly from face-to-face collaboration (Straus 1996).

Although we might not expect electronic collaboration on complex and big tasks, sharing of experience both in regards to the system (i.e. technical support) and in health-related issues, as well as data discussion to improve data quality is important in the data manager's daily work. In chat groups there is a chance of people typing simultaneously, thus having difficulties in regards to integration and coordination of information (Graetz et al. 1998). In a face-to-face conversation, the focus is the one speaking, and people can respond in turn, in chat, however, there is no control and people might miss important messages while writing their message. This is especially true on mobile phones where there is a smaller keyboard, and a smaller screen. Hence one have to be more concentrated on the actual typing and might not see what is happening in the chat view, which in turn can lead to "attention blocking" (Straus 1996). On the other hand, to wait in turn, to speak in a face-to-face conversation might stop creativity, and the conversation might move onto other topics before the user gets to state his or her opinions and ideas. During the group discussion at the district hospital, we observed that some of the more active users of the DHIS Chat were not active in the discussion. Implying that some are reluctant to speak in a face-to-face meeting and might be more comfortable sharing behind a computer or mobile phone screen.

Group chat is textual conversations which make the production of utterance more laborious than spoken utterance, and some might avoid commenting (Graetz et al. 1998). However, unlike speaking, a text has the possibility of editing before sending, creating messages more to the point and improving quantity and quality of information. The persistent messages also allow revisiting of old subjects with knowledge of what has been previously discussed or give recently added people a chance to catch up.

The data managers firmly believe that groups can improve sharing experience and collaboration, as do we. It provides room for discussion between multiple people without scheduling a meeting, which might not be as productive as they are situated at different facilities. With the interpretation MUCs it also gives an added dimension to the discussion.

## 8.3 Social data analysis using DHIS 2 Interpretations

The DHIS Chat interpretation feature consists of the combination of conventional DHIS 2 interpretations and interpretation MUCs. This feature is what sets the DHIS Chat apart from regular MIM applications because it enables the users to analyze data on the go in collaboration with others. The interpretation feature was a request from the MoH and their rationale behind it was that it would enable sharing experience and improve data use and data analysis skills.

We designed the DHIS Chat interpretation feature with both social data analysis (ref section 2.3 on page 12) and social media (ref section 2.1 on page 7) in mind. In the DHIS 2 portal, it is possible to create, share, explore and comment on DHIS 2 interpretations. In the DHIS Chat, it is possible to explore and comment on the same DHIS 2 interpretations, but we also added the interpretation MUC where members of the group can see the interpretation preview at the top of the screen. This adds social data analysis to the application, as well as adding a new layer to the social media aspect of it because it is now possible to share interesting DHIS 2 interpretations with others.

The beta test found that some of the data managers did not know what DHIS 2 interpretations are, let alone how to use or make them. This came as somewhat of a surprise to us, as this feature was so important to the MoH. Some of the data managers who knew how to use interpretations in DHIS 2 thought that the feature would be too cumbersome to use because it still required an DHIS 2 interpretation to be made in the portal of DHIS 2. This and the fact that we were not able to use real data and DHIS 2 interpretations in the application, meant that the interpretation feature was not used during our test.

We suggest that for a feature like this to be perceived as useful, the end users must already be familiar with DHIS 2 interpretations. The HMIS Lead at MoH emphasized that the data managers learns about DHIS 2 interpretations at trainings, but from our point of view, it does not look like the time is quite right for a tool like this.

When it comes to the feature itself, it is clear that it does need some more work. At this point, it is only possible to use "pictures" of DHIS 2 interpretations (e.g graphs and maps), which means that table DHIS 2 interpretations are not available in the DHIS Chat. The reason why we chose not to add support for tables is the mere fact that a table is very hard to present in a right and responsive way on a small screen like the ones that smartphones use. As a temporary solution to this problem, we decided to add a text saying "Tables not available" in the interpretation view of the application. This means that when someone clicks on a table DHIS 2 interpretation, the table will not be visible, but the text of the table and the comments related to it is.

Since this is not a viable solution, we suggest two ways of fixing the problem. The simple solution is to add a link that takes the user to a mobile version of DHIS 2, where the table is presented. With this approach, the user has to log into the mobile version of DHIS 2, which is not desirable. The other approach is to render the table inside the application and add a table view component where the user can zoom and move the table around to see all the numbers.

To make the interpretation feature more social, and in our opinion more useful, it should be possible for the users to post new DHIS 2 interpretations to an already existing interpretation MUC. Combining multiple DHIS 2 interpretations would make the data analysis much more fluent, as the users can show what they are talking about to the other group participants as well as compare trends. This is not a feature that would have changed the outcome of our test in Rwanda, but it would most likely enhance the user experience.

## 8.4    File attachments

The requested functionality to send attachments like images and documents while chatting implied a need to be more expressive in regards to technical support. It also implied a need for a simple way to send reports, statistics or other documents efficiently. When one is in need of technical support, it might be difficult to describe the problem because one might not fully understand what is happening with the system. Error messages might not make sense to the user, or one might get unexpected results. Pictures and other attachments can help the user explain what the issue is and what they want to achieve, as well as assist in the actual support and explaining the steps to fix the current problem.

During the BIE stage images was rarely sent. During the beta test, the data managers only tested this feature the first day of testing, but no one mentioned sending images in the following weeks. The suggested reasons for this feature not being used is the restriction of only one folder to collect the image and that there was not a real need during the test period.

Even though no images were sent during the BIE cycles, the feature is desirable in regards to media richness and non-verbal cues. The more users can express themselves, context, and intended meaning the more productive and valuable the conversation is. Both in technical support and group collaboration, an image of a situation or data visualizations can be helpful in finding smart solutions and opportunities.

The HMIS team lead also wanted voice/video calls integrated. This would increase the cost of mobile airtime, which means that it might not be used very much. On the other hand, this feature would give the users another way to express themselves: verbally and visually.

## 8.5   Ministerial ban

A news article in *The New Times* reports that "The ministry made the decision to implement the policy after officials agreed that speaking for long on personal phones affects service delivery in the health sector." (The New Times 2017). The chairperson of the National Council of Nurses and Midwives tells the newspaper that "Use of personal phones has a negative impact at some point as some can use it in their personal business while at work." She adds: "However, we also use them in daily communication, so there is also need to look at how patients will not be affected due to lack of communication." (ibid.). She goes on to say that in some countries where mobile phones are prohibited at work, the staff has pagers to communicate (ibid.). As far as we can tell, no such solution is in place in Rwanda as of yet.

As we have already discussed, the data managers are organized in WhatsApp groups to get important information fast. Many of them also use WhatsApp in their personal communication, so the risk of these employees sending and answering personal messages while at work is certainly present. At the same time, the risk of under communication is high. A study by Haroon et al. from 2010 where perceptions and attitudes towards a paging system and mobile phones by medical doctors were documented, concluded that 98% of the participants used mobile phones for work-related issues (Haroon et al. 2010). All of the participants also reported that their reason for using mobile phones was that is was quicker for communication (ibid.).

Because of these issues, we suggest that a mobile chat application like DHIS Chat, that only health workers and officials use, can satisfy both the MoH and the workers. It was reported by the data managers in our test that they only talked about work when using DHIS Chat, and that they reserved social talk for WhatsApp. Whether this trend will remain if the application at some point is released nationwide remains to be seen, but the focus of the application is purely work related, so we strongly believe that it will be the case. An application like DHIS Chat can, therefore, become a solution that the MoH can approve for use in health facilities, without worrying about abundant social chatting.

## 8.6   Multiple domains

DHIS Chat is built to assist with communication and data analysis in a health information system called DHIS 2. However, would it be possible to use the application (or at least the same code) in other health information systems, or even other domains?

The way we have designed the architecture of this system makes it very easy to replace DHIS 2 with other systems that has the possibility of log in

through its API, be it a health information system or any other system. This means that whatever system the Openfire server is logging in though, users can simply log into the chat application with their username and password. The DHIS Chat is designed to be flexible and does therefore not require the users to have specific roles to create conversations.

Interpretations in DHIS Chat is not as straightforward. If the system that is connected to Openfire has any form of statistics that can be exported as pictures, the interpretation component of the DHIS Chat can easily be changed to fetch these statistics from that system. If the new system does not have any kind of statistics, the interpretations component can be removed. Because of the loose connections between the components, facilitated by React Native JS, all that has to be done is to remove the navigation item and the component itself.

With this in mind, we believe that DHIS Chat can be used both in the health sector and in other domains. It will require some changes to the code, but the changes that have to be done are so small that most of the customization would probably take less than a day to complete for someone with coding knowledge.

## 8.7 Design principles for collaborative health MIM in a low-resource context

To answer our research question "How can mobile instant messaging facilitate and stimulate collaboration between health data managers in a low-resource context?", we move into the final stage of the ADR method: Formalization of Learning. The outcome of this stage is design principles that can describe the "general solution concepts to the class of field problems." (Sein et al. 2011). In this case, the class of problems is the collaboration between health data managers in a low-resource context.

The proposed design principles are based on the findings from the research conducted in Rwanda and the following discussions and analysis. They are also based on the development of our MIM application, DHIS Chat, and the connected chat server, as well as theory introduced in chapter 2.

We have classified our design principles into three levels of generalization: design principles for MIM in low-resource contexts, design principles to facilitate MIM in collaborative work, and finally, design principles for MIM in collaborative health management work.

### 8.7.1 Mobile Instant Messaging in low-resource contexts

The study conducted by Halvorsen in 2015 found that data consumption was a significant problem during the testing of DHIS 2 Messenger. One

of our focus areas has been to reduce this by restructuring the architecture of the IM system and limit the data requests. This has proven effective in lowering the data usage of the application. Certainly, users have to afford the adoption and use of the application, however, it is equally important that the system is maintained and progresses as the use increase and new challenges arise. We argue that loose coupling between the components makes it easier to install, maintain, further develop and solve technical problems. You can also easily replace one part of the system without affecting the other parts significantly.

Our beta test in Rwanda showed that not all data managers own a smartphone. Nevertheless, the data managers did not have any problems using the chat application. Whether it was talking one-to-one or in groups. They did, however, report some confusion regarding the DHIS 2 interpretations, but emphasized that this had more to do with the DHIS 2 interpretations themselves rather than the application's functionality. We conclude that a clean, simple and self-explanatory GUI will make mobile literacy challenges less prominent. The use of icons and text describing the functionality, and a clear heading of where you are in the application gives a better understanding and user experience of a mobile instant messaging application. The replication of familiar GUI and a three-level navigation layout proved to be a factor for a coherent and familiar GUI.

Based on these empirical findings we present three design principles for MIM in low-resource contexts:

**Low data consumption**
A cost-effective system is crucial for the adoption of a MIM application in low-resource contexts. According to MyWage.org, the monthly salary of a statistician and an M&E's officer is 404 515RWF (MyWage 2017), which converts to 492USD. This implies that M&Es, as well as data managers, might not have the means to buy a large amount of data bundles of 3G or 4G. Wifi is not necessarily provided in all health facilities either in a low-resource context.

**Loose coupling**
Loose coupling is a key aspect of developing a cost-effective MIM, in regards to installations, maintenance, and further development. Installations can be performed without interfering with other systems, maintenance can be done on specific parts instead of the whole system at once, and further development of the system can be achieved without affecting prior functionality.

**Self-explanatory GUI**
Icons with descriptive text, as well as headings of location in the application, can minimize confusion even if users are not comfortable with smartphones. A maximum three levels of navigation and replication of familiar features and GUI can make it more coherent.

### 8.7.2 Mobile Instant Messaging in collaborative work

As the research on IM at work suggests, IM groups is a productive tool for collaboration, coordination, and clarifications, especially in cross-site teamwork (Ou and Davison 2011; Hudson et al. 2002; Nardi, Whittaker, and Bradner 2000). IM groups was also a feature Halvorsen proposed as part of a design principle. We take this principle further and suggest what we call flexible group composition. We found that private groups are needed for discussions of data. One data manager implied that in private groups, they could speak more truthfully and get at the real cause of "the gap". "The gap" might relate to inconsistent numbers or negative trends in statistics. In private groups, one can have fewer members with specific knowledge. Fewer people might bring more order to the conversation and give better quality. However, the possibility of adding members at a later stage provides the opportunity to request for more opinions, as well as letting left out people join. Although private groups were observed as a success, we also suggest including open groups. When it comes to technical support and coordination, it might be more practical to not having to add all data managers and restrict helpful and necessary information.

As mentioned, the data managers often called to get a quick response to technical support or other questions, instead of using the DHIS 2 messaging system. This shows that social presence is necessary for an electronic communication medium, for giving it a sense of synchronous conversation and a rapid response with the ability to negotiate availability. It will also give the feeling of non-mediation and a better quality of conversation (Churchill and Bly 1999). Regarding MIM at work, it should not only be effective during a conversation but also when trying to reach a particular person. A contact list of 800 data managers might be hard to scroll through, so a live search feature is essential in the buddy-list.

Based on Social Presence Theory, studies on IM at work, Halvorsen's findings, as well as the empirical results mentioned above, we present two design principles for MIM in collaborative work:

**Flexible group composition**
Private groups with an infinite number of possible members were found to be a useful tool for collaboration. A feature for adding members after the creation of a group and an option for open groups is suggested.

**Presence awareness**
Social presence in the form of presence awareness and live search in the buddy list is recommended for developing an effective collaborative work tool where the users can negotiate availability and thus expect rapid response and get a sense of non-mediation.

### 8.7.3 Mobile Instant Messaging in collaborative health management work

Even though we do not have data or statistics from the interpretation feature in DHIS Chat, it is still an important aspect of both social data analysis within an HMIS as well as an essential part of what MoH wanted in the MIM application. From studies on social data analysis and interviews with the data managers, we have concluded that it is beneficial to facilitate for data analysis and discussion in the MIM application. The data managers were optimistic about the idea and believed it would improve data quality and their work. By integrating the data visualizations into the IM groups, the participants will have easy access to the DHIS 2 interpretation they are discussing. We believe that adding functionality for sharing multiple visualizations in the same group will advance the discussion and the usability of this feature. Also, other file types like images and text files can enhance the contextual understanding and be helpful both in discussions, as well as other collaborative work and technical support.

In the field of ICT, security is essential, especially in health systems. During the alpha and beta tests, we observed the importance of a secure MIM application. The HMIS team Lead was highly skeptical to connect DHIS Chat to their production server and postponed this till he was sure it was secure. In regards to security in a MIM with health data, we restrict the information flow to unauthorized users. It was decided that users of the application must have a DHIS 2 account. This also takes advantage of the already installed base of users inside DHIS 2. As a second aspect of security, we store all messages on a private server. This server will be given to the HMIS in Rwanda if a national deployment will take place. A chat server supported and monitored by the owners themselves makes the MIM more secure than using WhatsApp or Facebook Messenger which is owned by other companies.

For MIMs in health information systems we found four design principles based on the theoretical perspectives from social data analysis and Media Richness Theory, as well as our observations in Rwanda:

**Statistic integration in MIM groups**
Heer, Viégas, and Wattenberg 2007 states that "combining conversation and visual data analysis can help people explore a data set both broadly and deeply"(ibid.), thus providing the potential to improve data quality. The integration of social data analysis in MIM groups can facilitate informal discussions and improve data use, as IM is known for it's casual and friendly tone and language (Nardi, Whittaker, and Bradner 2000). By implementing functionality that facilitates multiple data visualizations in a particular discussion group, the feature may be more practical because sharing of experiences and interpretations can be done more efficiently and comparisons can be achieved in the same group discussion.

**Attachment integration**

Attachments will increase media richness which in turn will increase the understanding between users. Either with technical support, data analysis or report discussion. It can also improve the ability to process large amounts of data (Heer, Viégas, and Wattenberg 2007).

**Predefined HMIS users**

Security is important when discussing national health information. We propose restricting access to information both by only using the predefined users of the HMIS as well as only seeing messages when logged in.

**Private and self-monitored servers**

We believe that using national messaging servers, preferably the national HMIS database for storing of the messages, is necessary when discussing health related data. These should neither be owned or monitored by others that the national HMIS team.

| Design Principles | Consequences | Empirical and/or theoretical grounding |
|---|---|---|
| **MIM in low-resource contexts** | | |
| Low data consumption | In a low-resource country, it is crucial that everyday use does not cost more than is affordable. Low data consumption equals more use. | Result from Halvorsen's study<br><br>Empirical findings Quantitative data |
| Loose coupling | With loose couplings between the components in the IT-artifact, it is easier and cheaper to install, maintain, and solve occurring problems. | Found during testing of Halvorsen's app and development of DHIS Chat |
| Self-explanatory GUI | Not all data managers are used to smartphones. A self-explanatory GUI will make the learning process smoother. Headings and icons can minimize confusion as to what features does and where to find intended functionality. The replication of familiar GUI and a three-level navigation layout can be a factor for a coherent and familiar GUI. | Empirical findings and observations. Users reported familiarity with GUI |
| **MIM in collaborative work** | | |
| Flexible group composition | Open groups can allow for messages to reach all users fast and efficient. Private groups, however, can create a safe environment for focused discussions. Private groups can enable only relevant people in the debate and not be disturbing others by irrelevant information. However, the possibility to add users after the creation of the group is useful for second opinions of forgotten users. | IM at Work (literature)<br><br>Empirical findings, as users wanted both private and public groups<br><br>Halvorsen's study reported private groups as a design principle |
| Presence awareness | Showing who is online often triggers faster response. If not online they can choose another co-worker to converse with. Live-search in the buddy-list enables the user to find the intended person faster amongst hundreds of users | Social Presence Theory<br><br>Empirical findings, as testers reported online status to be important for who they contact |

Table 8.1: Summary of the design principles - Part one

| Design Principles | Consequences | Empirical and/or theoretical grounding |
|---|---|---|
| **MIM in collaborative health management work** | | |
| Statistic integration in MIM groups | In our case, implementing the possibility of having the DHIS 2 interpretations to be discussed in the chat makes it easier to describe and find trends and solutions.<br><br>Separate discussion groups from coordination and other work tasks create a clear conversation structure and minimize conversational changes that might be confusing.<br><br>Multiple visualizations or statistics in one group makes it easier to compare and share experiences. | Social Data Analysis |
| Attachment integration | Images will enhance media richness and allow the user to better describe the conversational context and problems within technical support<br><br>Actual visualizations of the data like Graphs and Charts makes it easier to process large amount of data | Media Richness Theory<br><br>Social Data analysis |
| Predefined HMIS users | Restrict information flow by having HMIS users only in the MIM. National health information will not be accessed by unauthorized users. | Observations of MoHs security concerns<br><br>Development of DHIS Chat |
| Private and self-monitored servers | The nation will own the messages sent, not other companies. And information can not be monitored by others than authorized people | Observations of MoHs security concerns |

Table 8.2: Summary of the design principles - Part two

# Chapter 9

# Conclusion

DHIS Chat, a second generation MIM has been developed during this project. During development, the focus was on solving problems discovered during the development of the first generation application, DHIS 2 Messenger. Mainly data consumption and a complex GUI. Additionally, implementations of attachments and DHIS 2 interpretations as requested from the MoH in Rwanda has been prioritized. DHIS Chat has through the project, served as a tool for finding communication and collaboration weaknesses within DHIS 2 and between health workers in Rwanda. Throughout the project, ADR has been our research method and framework for testing and structure of the project. One IT-Dominant BIE stage has been conducted with three cycles. One cycle with HISP representatives at the University of Oslo, a second cycle with the HMIS team at MoH in Rwanda, before testing the application in a larger organizational setting with all data managers in one of Rwanda's health districts. During these cycles, we have collected and evaluated feedback and statistics as well as conducted a group discussion and several interviews. A questionnaire, observations and casual conversations have also contributed to the findings.

Theoretical and practical implications will further be described before our thoughts on further development will be presented.

## 9.1   Practical implications

The fact that DHIS Chat is developed based on open source technology gives an opportunity for HISP Rwanda to develop the application further and take over the project. As mentioned, we gave the code to a representative from HISP Rwanda and had two sessions with him to familiarize him with the code. By teaching the code to a local developer in Rwanda and give them the opportunity to learn new innovative technology, the believe that the project will be much more sustainable. As open source technology is free, this can be done with low resources.

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With further development of DHIS Chat, particularly on security aspects, the IT-artifact can provide the data managers, HMIS team and other DHIS 2 users with a collaborative tool with the possibility of data analysis and discussion that other MIM applications can not accommodate.

## 9.2   Theoretical implications

Our research aims to answer "How can mobile instant messaging facilitate and stimulate collaboration between health data managers in a low-resource context?" To answer this, ADR has guided our research for the class of problem: Collaboration between health data managers in low-resource countries. Nine design principles have been formed, as suggestions for principles to follow in designing and development of future MIMs that tries to solve the same class of problem.

This project showed that users of DHIS 2 are in need of communication systems with a fast response. As their current HMIS systems communication tool do not provide this, the users rely on WhatsApp, to get immediate answers. WhatsApp, however, is not recommended when discussing and collaboration on health data. The messages are stored by others, in this case, Facebook, rather than the Rwanda HMIS. The newly initiated ministerial ban on mobile phones in health facilities also underlines that personal communication during work hours is a problem. With the DHIS Chat, the users will be less distracted by friends and family on WhatsApp, as only DHIS 2 users have access to the application. WhatsApp does not have any solution for integrating statistics or data visualization either, which is what the MoH wants the data manager to discuss. This proves that there is a need for a MIM integrated with the national HMIS.

By developing a new application, organized and designed to fit the HMIS in Rwanda, we found that low data consumption and loose coupling in a MIM system with a predefined base of users can facilitate collaboration. It should also have a self-explanatory GUI to accommodate the users unaccustomed to smartphones. As a security precaution, we also recommend the servers to be private and self-monitored by the national HMIS team to allow for collaboration on health data in an electronic communication medium. This could also be beneficial to other management information systems in other domains or other countries with similar resource constraints regarding communication.

Regarding stimulating collaboration, we found that through group chats they could rely on each other in regards to technical support. This can ease some of the HMIS teams heavy workload. Group chat is an excellent tool for collaboration and an essential feature in a MIM at work. Private groups was a good feature as the data managers felt they could discuss more open than in a group where everyone can look at the content. However, there was no data analysis performed during the testing. Even so, interviews and theoretical perspectives on social data analysis, still

made us optimistic about interpretations as a feature in a MIM for health information. Attachments is a way of stimulating collaboration even more as it can substantiate textual descriptions and arguments and convey meaning quickly.

To stimulate collaboration among the health data managers, we, therefore, found statistic integration in MIM groups, flexible group composition and attachment integration as important design principles as well as presence awareness.

Former studies on IM at work and more specifically groups have mainly focused on conversational topics and use among co-workers (Isaacs et al. 2002; Hudson et al. 2002). Our research, however, has findings on group compositions and flexibility which has not, to our knowledge, been a focus area before. The main finding suggests that private groups are important to discuss work related topics open and freely. However, open groups are also advised to reach all users with essential information. Open groups save time and do not exclude anyone. All the studies on IM at work, that we found, only use open groups. We propose that private groups are as important in work collaboration.

Social presence theory has been a factor in the development of DHIS Chat. Our findings suggest that although social presence theory was introduced in 1976, it is still essential in regards to MIM. Even though the users is "always available" on the mobile phone, our research shows that the display of a user's online status was a big factor when choosing whom to talk to.

Regarding social data analysis, we do not have actual data, other than interviews, to substantiate our claim. However, the statement from the HMIS team Lead suggest that social data analysis is applicable and relevant when discussing aggregated health data:

> "... So the reason behind it [integrating interpretations in the chat application] is giving an open room where people share their ideas and experiences then we learn from each other."

Our study found that social data analysis should be a more prominent field of research. As of now, there are only two articles on this subject, but we found this to be a good framework for collaborative data analysis. We believe that especially two of the hypotheses presented by Wattenberg applies to MIM in a collaborative work context. The two hypotheses are *Combination of common ground, with unique individual perspectives* and *Discovery transfer*.

Media richness theory is the ability to express meaning in an electronic communication medium. When discussing aggregated data, images of graphs or charts can enable the users to process large amounts of data. This can also translate into complex technical problems and other more vague issues in other contexts. We, therefore, argue that attachments are an essential factor to increase the degree of media richness in collaborative

MIM.

## 9.3 Further development

Even though DHIS Chat was connected to the national instance of DHIS 2 in Rwanda, we did not inform other districts and DHIS 2 user that this application was available. This makes this a theoretical nationwide deployment, but not a practical one. We suggest some areas of improvements before DHIS Chat should become available for the entire country.

An important feature of the MIM to be a unique and useful collaborative tool for the users of DHIS Chat is DHIS 2 interpretations. We suppose making this a more prominent area of research. How can it be used more in the data manager's daily work and how to inspire them to discuss the visualized data. There might be necessary changes in DHIS Chat that need to be done to accomplish this.

In collaboration, it is important to understand the context and issues. We believe that attachments can substantiate text in conveying information in a textual conversation. Currently, attachments are limited to images only, restricted to one folder and the sender and receiver have to be online simultaneously. Attachments should be further developed to include other folders and other types of files. The method of file transfer and Openfire should be examined and, solutions to solve the issues of both parties being required to be online at the same time and enable attachments in group chats should be found.

Further, we suggest a focus on the DHIS 2 messages, and how they can be integrated without substantial data consumption. This so they can continue the conversation on a bigger screen. As another way of allowing the users to have the conversations on a computer, we suggest a development of a web-based DHIS Chat. The GUI of the MIM is written in JavaScript. Although it is written in React Native JS specifically JSX, it is based on React. Their motto is "Learn once, write anywhere," so this should be a straightforward task.

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# Appendices

# Appendix A

# Graphical User Interface
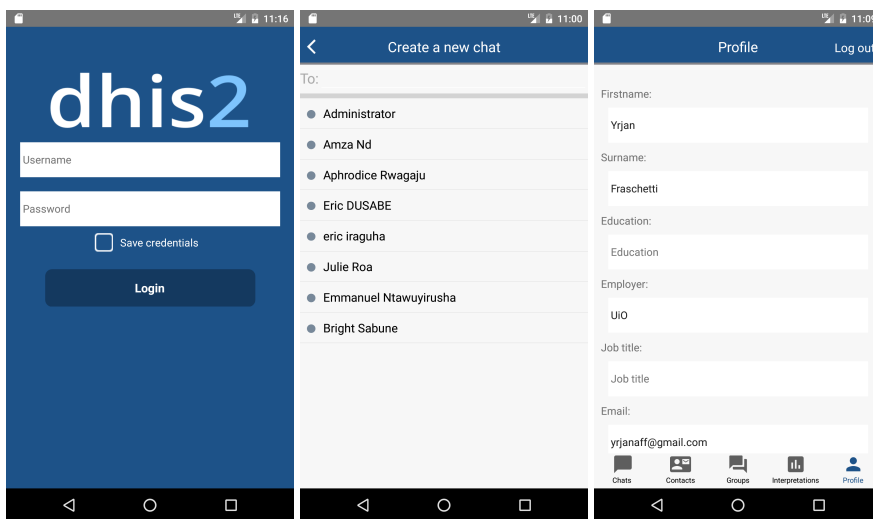


(a) Log in



(b) Contacts



(c) Profile page
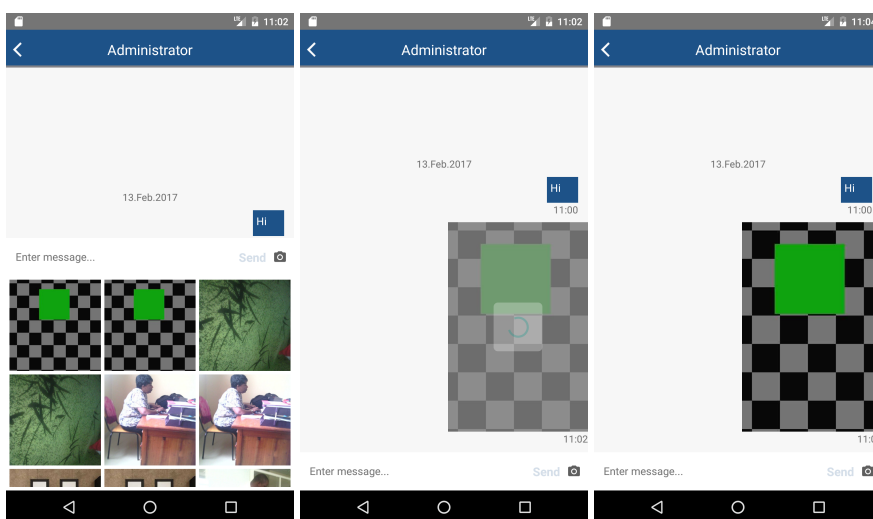


(d) Choose image



(e) Send Image



(f) Image sent
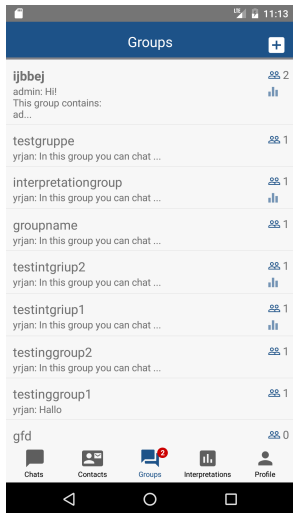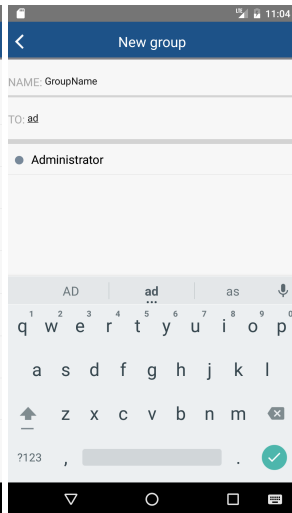
(a) Group list  (b) New group  (c) Add participant
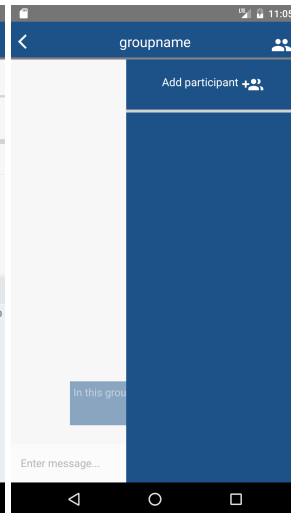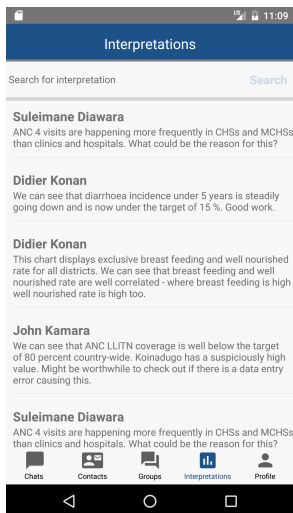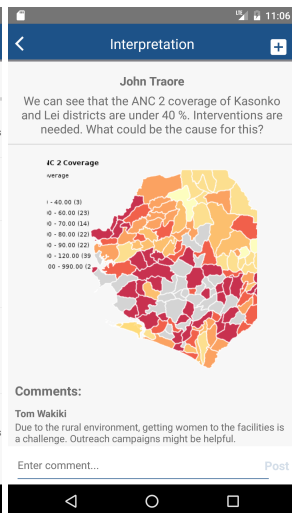
(d) Interpretation list  (e) Interpretation  (f) Interpretation group
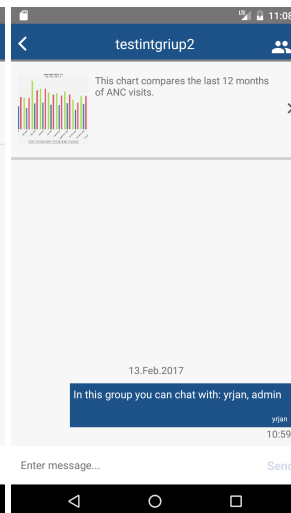
# Appendix B

# Questionnaire

1. Who are you (name), and what is your profession/position?

2. How do you interact with DHIS2 and how often do you log in?

3. How often do you use a messaging application?

   (a) Do you use messaging applications like WhatsApp or Facebook Messenger? Others?

4. What is your preferred means of communication at work? Is this the same at home? (call, chat, sms..)

5. Do you use this when communication with your co/workers? In which situations?

6. Is it allowed using WhatsApp, Facebook Messenger etc. at work? (and specifically for work related information)

7. How often do you read your DHIS messages?

8. Do you think it makes a difference if the messaging application is integrated with DHIS2, or not? why?

9. Can the application change the way you communicate at work?

10. Are you familiar with interpretations in DHIS2?

11. Do you use them at work? How?

12. How often do you read/look at interpretations?

13. How often do you comment on interpretations?

14. What is your preferred method for data analyses?

15. Do you think a mobile application with integrated interpretations will make you use interpretations more?

16. Do you think interpretations are a good way to discuss and analyze data?

(a) Do you think a mobile application is a good platform for data analysis?

17. Do you think the possibility of discussing interpretations privately/casually can improve data quality and analysis? Why?

18. In what situations is this type of app relevant for you?

19. Do you think there is a need for an application of this kind? Why?

20. How can such an app assist you in your work?

21. Do you think communication across the hierarchy will improve with a chat app or will it only improve on each level separately? (Or at all?)

# Appendix C

# User Manual

## User guide for DHIS2 Chat

The four big features of the DHIS2 Chat are one-to-one chat, group chat, DHIS2 interpretations and interpretation group chat. How these features work will be covered in this guide.

**Login**



Log in to the DHIS2 Chat with your DHIS2 (HMIS) user credentials. If you want to save your user credentials, the "Save credentials" box must be ticked. Press the Login button to log in.

**Create chat**

To start a new chat, press the "+"-sign in the top right corner. This will take you to a new screen where you can select the person you want to chat with. Search for the person you want to chat with. Then press the name. The dot before the name indicates if the person is online(green) or offline (grey).
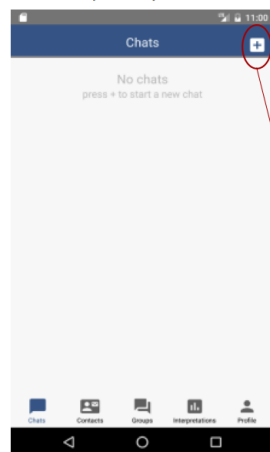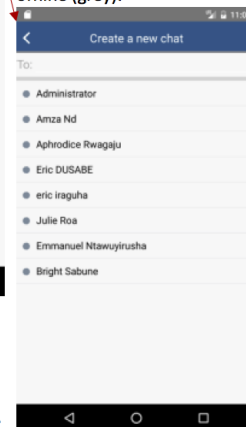




**Chat**

Now the screen shows a chat. In this chat you can send text messages, as well as pictures (this feature is only available if the other person is online)
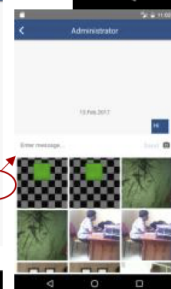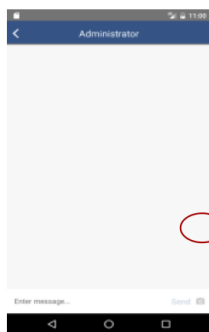




**Pictures**

A popup will appear when a picture is selected. This is to be sure that you want to send the selected picture. Press "Send", and the picture will be sent. If the picture cannot be sent, press the picture to resend.

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**Create Groups**

In the groups tab you can see all of your groups (rooms). The icon of the people to the right of the groups indicates how many people are active in the room. The graph icon indicates that the group is an interpretation group.
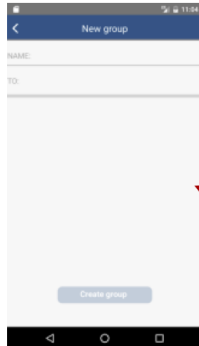
As with one-to-one chat, you can create new groups by pressing the "+" icon at the top right corner. This will bring you to the following screen:

In the "NAME" field, enter the name of the group. In the "TO" field, search for the names of the people you want to add to the group, and press their name to select them. Then press the button "Create group".
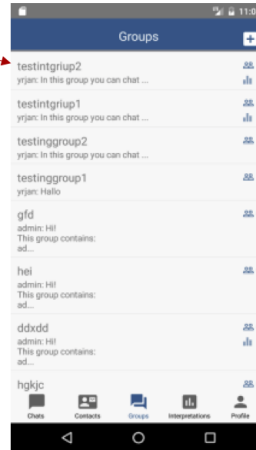
**List of interpretations**

Interpretations is a visual data analysis feature of DHIS2. The picture to the right shows the interpretation list. You can search for an interpretation in the top search bar, or load more interpretations to the list by pulling the list down and releasing. Press one of the items to see the whole interpretation.
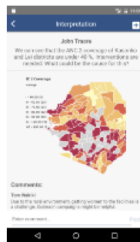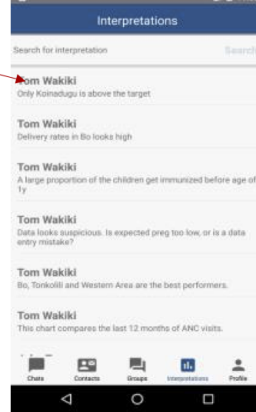
**Interpretation**

On this screen, you can see the whole interpretation. Who posted it, what he/she said about the interpretation and the interpretation itself. Under the interpretation the comments can be seen. You can also post your own comments. To create a new interpretation group, press the "+" icon in the top right corner. The steps to create an interpretation group are the same as creating a normal group (as described above).

**Interpretation group**

After creating a interpretation group you get a normal group with an interpretation preview on top. This preview of the interpretation is visible for all group participants. It shows the interpretation itself, as well as some of the text of the interpretation. Press the interpretation preview to see the whole interpretation.

**Profile**

Under the profile tab, you can edit your profile, as well as log out (in the top right corner).

Figure C.1: DHIS Chat user guide

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# Appendix D

# Test Agreement

## Agreement for testing of DHIS2 Chat

**Introduction**

An android application, called DHIS2 Chat, has been developed at the University of Oslo in Norway by two master students. Rwanda has been picked out as the testbed for this application, and we are hereby delighted to invite you to take part in the testing of this innovation.

The reason for the test/study is to gather information about work related communication habits and to assess to what extent a messaging application can support HMIS-related communication and data analysis in Rwanda. The test will be held from 15.02.17 to 24.02.17.

**Terms**

This is an agreement between the ministry of health in Rwanda, two master students from the University of Oslo, Norway and the test person.

The test person will be given a maximum amount of 5000FRW to use on a roaming data bundle. This data must only be used to test the application. After the test period has ended, the test person can keep the excess data. 3000FRW will be provided to the test person on the training, while the rest will be provided at request.

After the training day the student will be visiting the test person at their workplace to conduct a 20 minute interview. The test person will be contacted by the students to further plan the interview. The interviews will be voice recorded, and the test person agrees to this by signing this agreement. The test person is required to log on to the app at least once every day during the test period.

At the end of the test period, on Friday the 24th of February, a wrap-up meeting will be held to finalise the test and brainstorm new features and functionality as well as discuss the current form of the application.

**Contact information of test person**

Full name:_____          Place of work:_____

Gender:_____    Title/Position:_____    DHIS2 username:_____

Tel. number:_____    Email:_____    Type of phone: regular/smart(OS:_____)

**Sign**

_____          _____
Muhire Andrew, MoH                        Test person

_____          _____
Julie Hill Roa, University of Oslo        Yrjan Fraschetti, University of Oslo

Figure D.1: Test Agreement