

TDT4900

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## Abstract

## Acknowledgments

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# List of Abbreviations

**AD** Anno Domini. 10

**ANC** Antenatal Care. 19

**BC** Before Christ. 10

**CHD** Community Help Desk. 17, 20

**CHW** Community Health Worker. 4, 17–20

**CoIA** Commission on Information and Accountability. 12

**DHIS2** District Health Information System 2. 12

**DOT** directly observed treatment. 18

**GNI** Gross National Income. 9, 10

**HC** Health Center. 19

**HISP** Health Information System Program. 11, 12

**ICT** information and communication technology. 12

**MOH** Ministry of Health. 17

**NCD** non-communicable disease. 18

**RPF** Rwandan Patriotic Front. 10, 11

**TB** tuberculosis. 18

**UiO** University of Oslo. 12

# Chapter 1

## Introduction

### 1.1 Philosophy

I will try to take on both an interpretive and a positivist view of my research. The reason I do this is that I believe that one does not exist without the other. No one really has a shared reality, and is never completely different. The positive researcher will concentrate on the shared knowledge in a community, while the interpretive will try to harmonize the different realities. The users of the knowledge I am trying to create are the academics, focused in the field of Information Systems and Computer Science. The quality of this research is of course, only evaluated by the reader.

### 1.2 Purpose

My reason for doing this is divided. Firstly, I am a student using research to add to my own knowledge in the field of computers in order to be able to offer a better service in the computer industry. Secondly, I am trying to add to the body of knowledge in the academic literature. Starting this research project, I have the privilege to know the organization HISP. Through HISP I've been participating in the configuration and implementation of an open source software called DHIS2 in Rwanda. After a quick analysis of the requirements I took notice that the software in question should indeed be able to offer solutions to each one of them. So why is it that it is not currently doing so? So this is my purpose, to find out why a software that to me seems to support all the necessary requirements is not doing so.

## 1.3 Products of this research

By participating in the configuration and implementation of DHIS2 as an intern at the MSH, one of the products of this research will be a working computer application. The other part is an in-depth study of this process. Hopefully contributing to the collection of data existing on the topic of ICT's in developing countries.

## 1.4 Research Questions

Suggestions

1. Hva gjør det vanskelig for en bruker å benytte seg av IKT som verktøy?
2. Hva er grunnen til at en bruker, i ett land med begrensede ressurser, ikke får utnyttet IKT verktøy maksimalt?
3. Hvilke hinder er det som står imellom bruker og IKT som verktøy i et land med begrensede ressurser og i en helse-setting?
4. Hva karakteriserer utfordringen, ”å ta ibruk IKT-verktøy” i helse-sektoren i et land med begrensede ressurser?
5. I denne oppgaven, hvordan skal jeg vinkle målet med IT (Tar gjerne imot forslag)?
  - (a) Få slutt på fattigdom?
  - (b) Øke livskvaliteten til folket?
  - (c) Mer kontroll til staten?
  - (d) Øke kunnskapsbasen om informasjons systemer?
  - (e) Ved bruk av IT, kan en bruke begrensede ressurser mer effektivt?

## 1.5 Background

## 1.6 Motivation

## Chapter 2

### Literature Review

#### 2.1 Information and Communication Technologies in Developing Countries

# Chapter 3

## Case Context

Our case is located in Rwanda. Rwanda is on the border of central and east Africa and is located just south of the border of Uganda. The area is  $26338km^2$  which makes it  $\approx 7\%$  of Norway. Still their population count is over the double that of Norway's. In 2014 the population count in Rwanda was 12337138 citizens which makes their population density  $468.42citizen/km^2$ . Compared to Norway with a population density at 13.26. There are no strict criteria for calling a country a developing one, but if the term is to be used, Rwanda is one of them. Gross National Income (GNI) is a way of measure how much value is added by all producers who are resident in a country. The world bank did a GNI per. capita ranking of the world's countries in 2012 and Rwanda made it at 195th of the 213th economies ranked. The world bank categories economies in four classes:

**High Income:**  $[\$12616, \$\infty]$

**Upper Middle Income:**  $[\$4086, \$12615]$

**Lower Middle Income:**  $[\$1036, \$4085]$

**Low Income:**  $[-\$ \infty, \$1035]$

By this, Rwanda is in the lowest income category with \$600 per. citizen, and in this paper, a developing country. It is noteworthy to say that with a population density at 13.26, Rwanda's



population would be  $\approx 354509$ . Rwanda's GNI in 2012 is  $\$6858 \times 10^6$ , making their GNI per. citizen  $\approx 19345$ . This would argue for making more cost effective solutions and lowering the fertility rate in order to have a sustainable economy.

[2] [14] [17] [18]

### 3.1 Brief History

The first inhabitants of Rwanda was probably the ancestors of Twa people. Findings suggesting this goes back to somewhere between 8000 Before Christ (BC)–3000 BC. Jumping forward to around 700 BC–Anno Domini (AD) 500 there is evidence suggesting that the Bantu people entered Rwanda. The Bantu's were first farmers and then cattle owners. The Hutu's are believed to be mostly farmers and Tutsi cattle owners so it is natural to assume that this is the source for making any difference between the two peoples. There is a Tutsi rule around AD 1800, but at a conference in 1890 Rwanda was given to Germany. They favored the Tutsi people and contributed to ethnic discrimination. After World War 1, Rwanda was ruled by Belgium. They introduced identity cards that would categorize every individual as a Tutsi, Hutu, Twa or Naturalized. Under Belgium the Tutsi was still favored. In AD 1959 Hutu activists began killing Tutsi people, making 20000–100000 Tutsi flee the country. In AD 1962 Grégoire Kayibanda was the first elected president. He set out to abolish the Hutu suppression, but that led to Tutsi discrimination. In AD 1973 there was a military coup by president Habyarimana. Up until AD 1990 there was a pro Hutu discrimination. In AD 1990 the Tutsi dominant Rwandan Patriotic Front (RPF) led by Paul Kagame (current president of Rwanda) invaded Rwanda from the north. This is the start of a civil war lasting up until a peace agreement in 93. In AD 1994 president Habyarimana's plane was shot down and started the

history's most brutal genocide. 800000–1000000 Tutsi killed by Hutu in 3 months. Stopped by RPF when they entered Kigali in July the same year. The first president after the genocide was the Hutu president Pasteur Bizimungu, followed by the RPF general, Paul Kagame. After the genocide many fled the country. An estimate of 1 million Hutu fled to Zaire, now renamed and known as Democratic Republic of Congo (DRC). In 1996 Rwanda invaded DRC and assisted on allocate the president and started the first Congo war. In 1998 they were asked to back out their forces, but Rwanda refused. This was the start of the second Congo war. After peace negotiations the Rwandian forces pulled out of DRC in 2002.

### **3.2 More Recent**

[2] [16] [15]

### **3.3 Health Information System Programme**

The Health Information System Program (HISP) is a global network established, managed and coordinated by the Department of Informatics at the University of Oslo. They design, implement and sustain Health Information Systems by a participatory approach. This means including the local users when developing the system in hopes of a more sustainable and successful projects. The system developed aims for supporting health care delivery and information flows in selected health facilities, districts and provinces.

**Vision** To strengthen the development and use of integrated health information systems within a public health inspired framework in India and the South Asian region.

**Mission** To enable networks of collaborative action with like-minded actors who aspire to the ideology of open source software, open standards and decentralized decision-making to create complementary strengths in providing integrated and public health friendly health information systems.

In the 1970 and 80's the HISP approach to action research and system design was influenced by a number of union based action research projects in Scandinavia. The focus were on empowering workers who were affected or threatened by new technology. Methods may have changed over time, but the philosophy remains the same. Explore ways in which disadvantaged people could appropriate information and communication technology (ICT)'s for their own empowerment. Original key member of the HISP team had background as social political activists in the anti apartheid struggle and other social movements. DHIS, a software organized and developed within the HISP network, was actually born out of the political processes following the fall of apartheid. During apartheid and until 1994 there were 14 departments of health in South Africa. Because of this fragmentation it was a lot of different procedures, collection tools and data definitions.

[4] [3] [5]

### 3.3.1 HISP Strategy

The core focus of HISP is DHIS2. It through this software that HISP will effectively make changes. DHIS2 are now active in 46 countries around the world. This includes 70% of the global fund high impact countries and 55% of the Commission on Information and Accountability (CoIA) countries. HISP are based at the University of Oslo (UiO). This is were the core developers of DHIS2 are located.

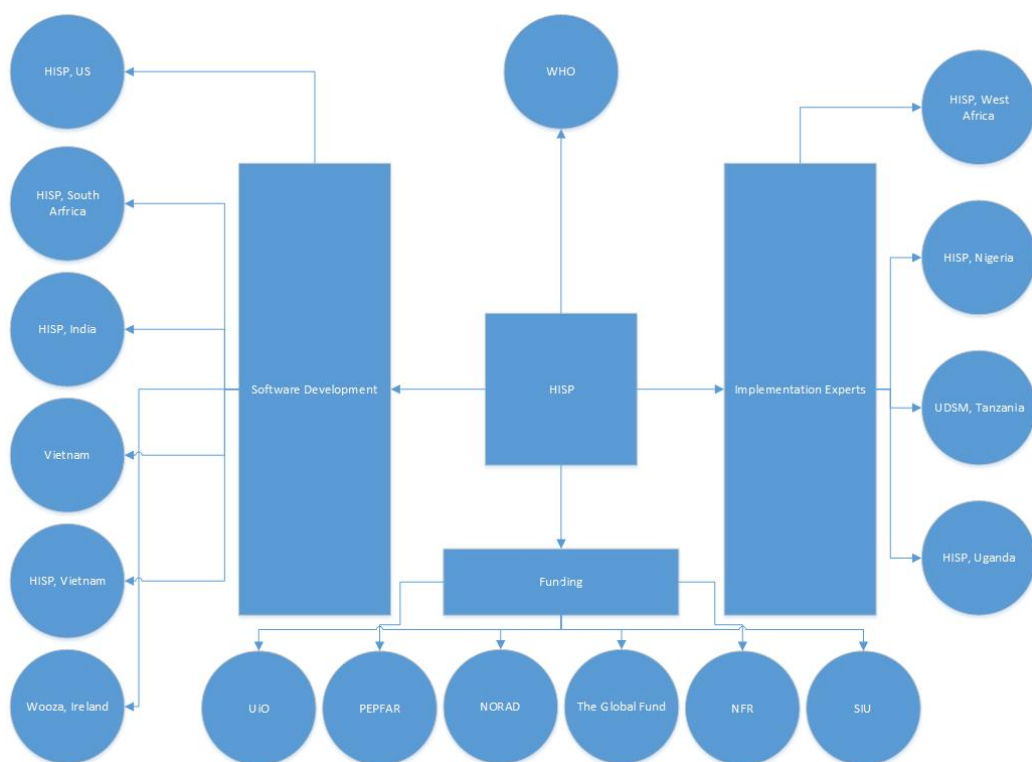


Figure 3.1: HISP Network of Action

One of HISP's biggest strengths is in their network of action. As illustrated in figure 3.1. There is a huge support network for facilitating the development and implementation of DHIS2 and is clearly one of the key success factors of why DHIS2 has been so successful in strengthening the health infrastructure world wide. Recently HISP is trying to add to network the East-Africa region. HISP East-Africa will include countries like Tanzania, Rwanda, Uganda and Kenya. Making relations between countries is essential for sustainability purposes. Sharing experiences and knowledge through neighboring countries is beneficial for sorting out local implementation problems. HISP has been able to arrange for these network building activities with DHIS2 workshops and academies. The primary focus is to train users in the use and implementation of DHIS2, but a beneficial side effect is network building cross countries. With DHIS2 there has been great progress with the process of gathering of data, but two issues remain. Data quality and using data for action. These two areas are now focus areas for the HISP-team at UiO.

[7] [6] [9]

### 3.4 District Health Information System

HISP's main product is DHIS2. In short, it is an open source software to manage health information data. It also facilitates both the gathering and presentation of the data. With the aid of this program we are able to collect data on site independent of location and to present those data on the same terms. Usually dependent on an internet connection, but it is possible to gather data on a regular Global System for Mobile (GSM) network. The importance of this last quality is *huge* in underdeveloped countries. Internet is nowadays usually taken for granted in most places, but when it comes to villages located outside internet coverage, even a mobile connection cannot be taken for granted.

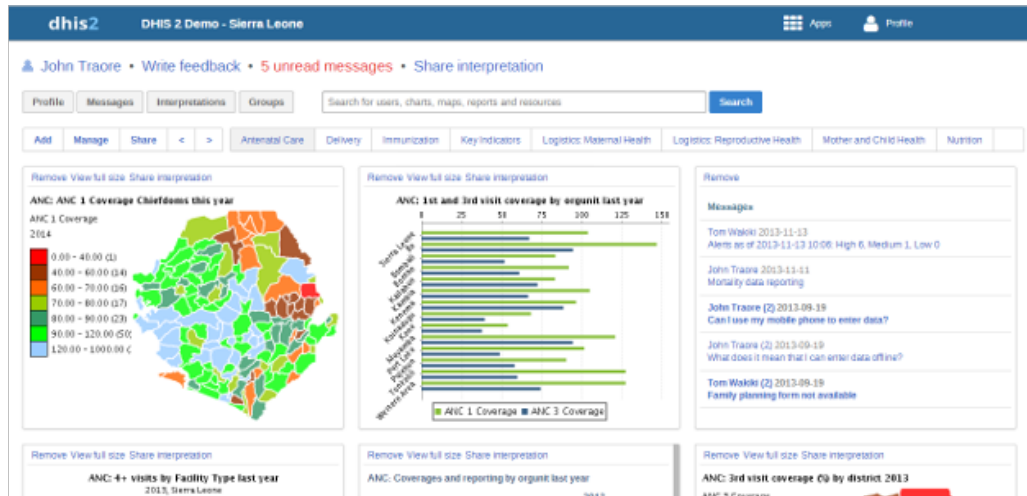


Figure 3.2: Screenshot of Dashboard

In 2012 there was an internet coverage of 33.4% of the worlds population, so assuming an internet connection when working on a global scale is unwise. The system manages data as predefined variables called data elements. These are then grouped together with formulas and description in order to adapt to a health environment. This feature makes it very adaptable to different use cases. We see new systems almost daily nowadays. The smart phone era as boomed the software development, so the need for interoperability is ever increasing. Because of this, a system must be able to work as a piece of the puzzle rather than a silo, but then again new challenges arises. Standardization across departments and health instances needs to be made and it calls for an increased level of cooperation and transparency.

### 3.4.1 Gathering

DHIS2 allows for data entry for as low-tech as SMS to the new high-tech smart phones. As mentioned earlier, SMS support is very important since over half of our population does not have internet coverage.

Phone Number:	2000
Message:	Stock condom11
	Send

Table 3.1: Example SMS

An example SMS in table 3.1. One use case is that a CHW would like to report the stock on condoms at the end of month. The user would usually go through the following steps.

1. Enter the phone number assigned the reporting service.
2. Enter the codeword for this type of report.
3. Enter the codeword for the item that is being reported followed by a integer value.
4. Hit send.

There are some extra features, but this is the basic idea. At a first glance, this seem alright, but in most cases there are more than one item involved. Let's say that our example message could represent an average reported SMS and that the standard SMS is restricted to be 160 characters long. The codeword is 5 chars. The codeword for the item is 6 and the value is 2. One would usually like to have some kind of separator for each item, so we +1 here. That makes room for approximately 17 items pr. message. I don't know about the general population, but I know it is a pain to write 160 char SMS's on a button based phone and if you have more than 17 items one has also to write another SMS. Also, it is very easy to make mistypes. So it is preferable to report using some of the more advanced devices. But, better than not being able to report. A little more sophisticated option is using a simple phone. These are still cheaper than the most basic smart phones and widely used in underdeveloped countries. They offer a basic G (GUI) that offers some

Figure 3.3: Screenshot of data entry in regular browser.

more description than the cryptic codes. A note on the SMS entry is that it is usually supplemented with a reporting card that describes the different codes. The more high-tech devices has support for modern browsers so data entry would be very similar to a any other Hypertext Markup Language (HTML) form.

### 3.4.2 Managing

Once the data are inside the system it is managed with a data structure designed specifically for DHIS2, see figure 3.4. At the bottom of the hierarchy and the most basic structure is the dataelement. It is essentially a value of a certain type. Any variable value in the system would usually be a dataelement. The dataelement also has several attributes like a datestamp, description etc. Now, with these elements, one can either combine several or make some mathematical manipulations to them. This variable are then stored indicators. Both of these data types can be grouped together in groups as dataelement group or indicator group. The indicator group can further be classified





Figure 3.4: Basic Data Structure

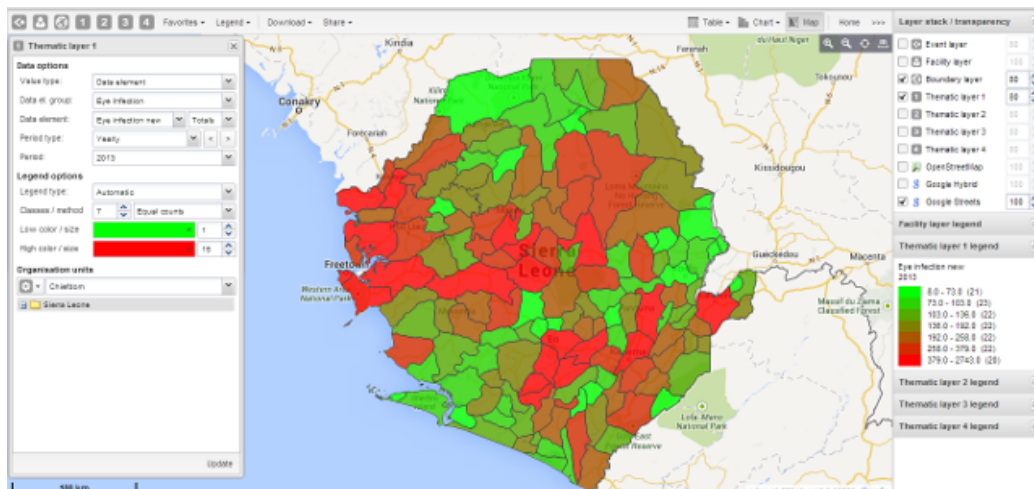


Figure 3.5: GIS Example

in indicator group set. This then a group of groups. The most frequently used group type is the data set. It can be a combination of data elements and indicators. All of these data structure comes with descriptions and other kind of meta data in order to be able to analyze the data in an efficient manner.

### 3.4.3 Presenting

There are several ways of looking at data in DHIS2. Of them the most interesting is the Geographic Information System (GIS), as seen in figure 3.5. In the figure one can see a count of eye infection in 2013 based on color and Chiefdoms. Green being low and red high. There is a sense of overview by looking at this kind of map. While getting a graphical visualization one has numbers pinpointing the exact number range. Extremely useful when in need to get an updated status on a situation. Some other tools for analyzing and visualizing data is the pivot table, the basic charts and the generation of reports.

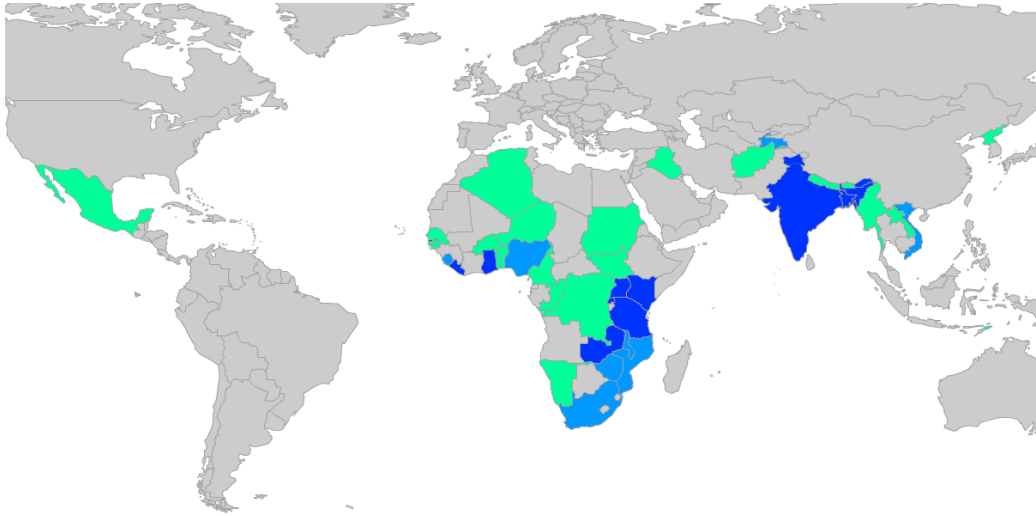


Figure 3.6: (Blue, National rollout)-(Light-Blue, Programs/partial)-(Green, Pilot/early phase)

#### 3.4.4 Application Development

DHIS2 is meant to be a platform for health information. As a result from silos forming in different departments of the health sector, the choice of health information systems are different. This causes a fragmentation that makes interoperability between systems hard to achieve. As a response to this problem, DHIS2 is now being designed to work much like an appstore. This allows users to develop their own applications that meets their specific needs while keeping the core functionality of DHIS2. Not only does this benefit the users, but makes collaboration between developers much easier.

[1] [8]

### 3.5 Administrative Structure

Rwanda has a strict hierarchical structure in their country. The country is divided in Provinces, Districts, Sectors, Cells and Villages.

<b>Complete national implementation</b>	<b>Adoption by programs or partial national roll-out</b>	<b>Pilot stage or early phase in roll-out</b>
Bangladesh Ghana India Kenya Liberia Rwanda Tanzania The Gambia Uganda Zambia Zanzibar	Colombia Laos Malawi Mozambique Nigeria Sierra Leone Solomon Islands South Africa Tajikistan Vietnam Zimbabwe	Afghanistan Algeria Benin Bhutan Burkina Faso Cameroon Congo Brazzaville Cote d'Ivoire DRC Guinea Bissau Iraq Mexico Myanmar Namibia Nepal Niger North Korea Samoa Senegal South Sudan Sudan Timor Leste Togo Vanuatu

Table 3.2: Countries using DHIS2



Figure 3.7: Africa



Figure 3.8: East Africa

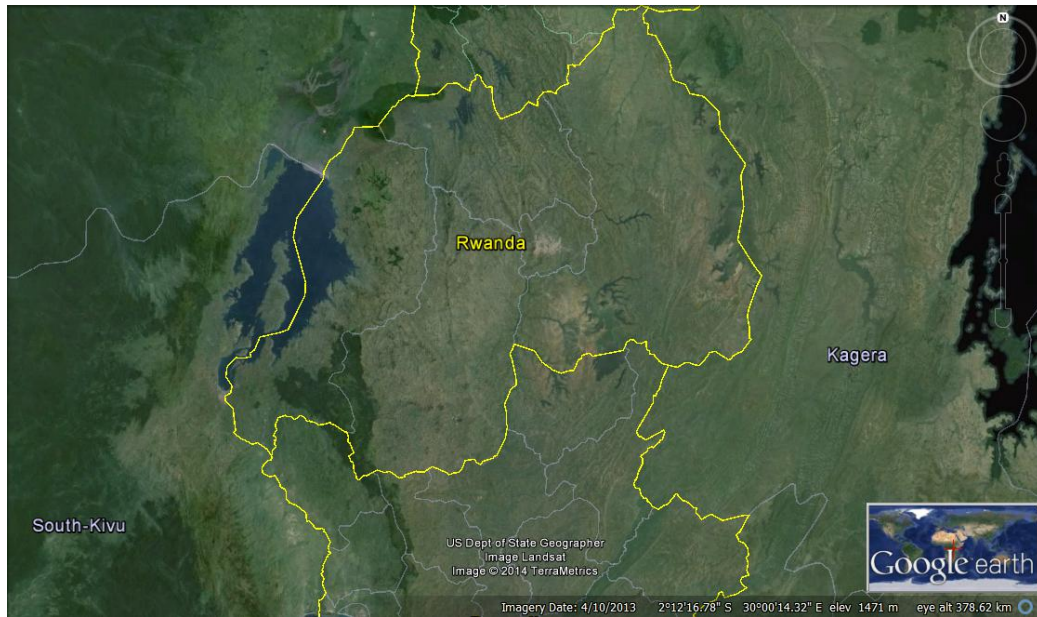


Figure 3.9: Rwanda

The level closest to the people is the Village. Here problems, priorities and needs of the people at a grass root level are identified and addressed. Above is the Cell level. Cells are managed by technicians and and a political team. Technical and key political matters are managed here. Further up in the hierarchy is the Sector level. The people participate here through their elected representatives. Sectors are collected in Districts which are the basic political-administrative unit in the country. Just under the national level the country is divided into five provinces. These serves mainly as advisor to the decentralized entities and coordinates development activities. [12]

This division is used to make areas more multi-ethnic and to decentralize power as an attempt to address problems that arose from the genocide in 1994.

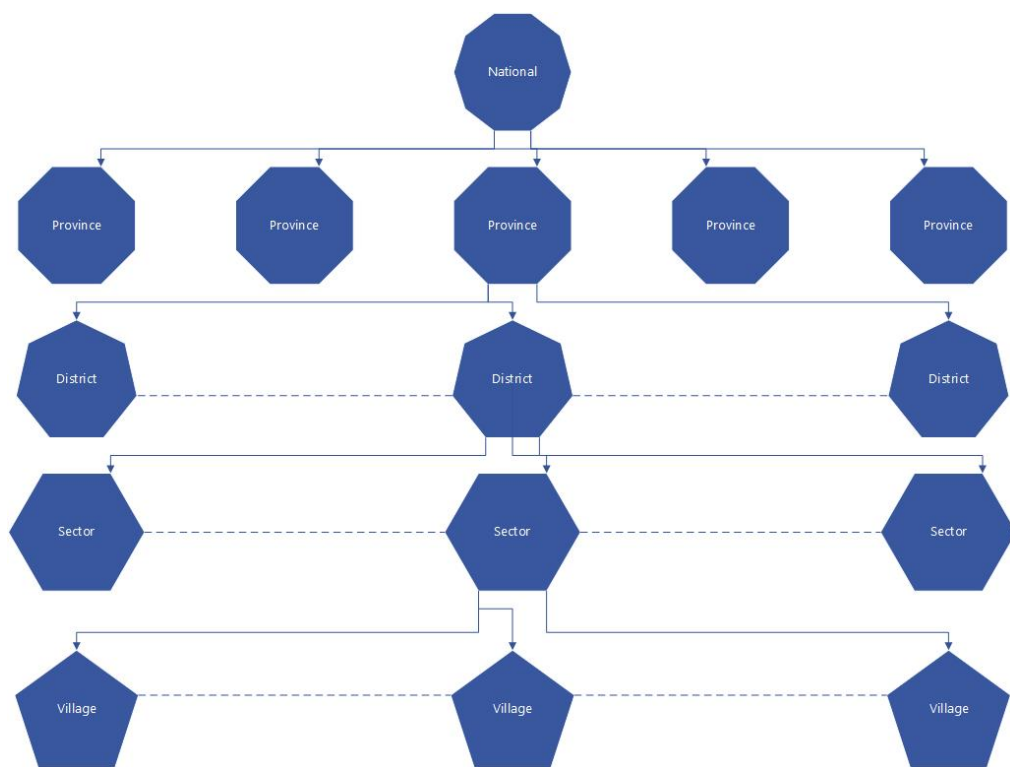


Figure 3.10: Rwandas Administrative Structure

Qualifications	
Read	Willing to volunteer
Write	Honest
20-50 years old	Reliable
Living in the village	Trusted by the community
Elected by the village members	

Table 3.3: CHW Qualifications

## 3.6 Health Management Information System in Rwanda

The Health Management Information Systems (HMIS) follows the administrative structure in Rwanda very closely.

## 3.7 Ministry of Health

## 3.8 Community Health Desk

The Community Help Desk (CHD) is in charge of managing community health activities. This includes planning processes, monitoring, implementing and evaluating.

[13]

### 3.8.1 Community Health Workers in Rwanda

The community health program started in 1995, endorsed by Ministry of Health (MOH), as a way to bring health care closer to the communities. The program was also a way to address the shortage of health care provider work force. In 1995, the number of CHW's was approximately 12000. Ten years later the number had grown to 45011. In 2013 there were 3 CHW's pr. village which is approximately 45000 CHW's. These are coordinated by the CHD.



<b>Multi disciplinary</b>	<b>Maternal</b>
Integrated community case management	Follow up of pregnant women and newborns
Malnutrition screening	Malnutrition screening
Community-based provision of contraceptives	Community-based provision of contraceptives
Preventive non-communicable disease (NCD)'s	Preventive NCD's
Preventive and behavior change activities	Preventive and behavior change activities
Household visits	Household visits
directly observed treatment (DOT) for tuberculosis (TB)	

Table 3.4: CHW Tasks

At each village there are 2 women and 1 man having the qualifications listed in table 3.3. The village CHW team has two roles. One man and one woman are multi disciplinary CHW's and the last woman is a maternal health CHW.

Some of their tasks are listed in table 3.4.

[13]

### 3.9 Cell Coordinators

Above the CHW's at the village level, there are two CHW's who are operating at a cell level with the purpose of strengthening CHW activities. One cell coordinator and one assistant cell coordinator. Their responsibilities are listed in table 3.5.

Cell Coordinator	Assistant Cell Coordinator
Visiting CHW's in order to monitor their activities on a monthly basis.	Monitor if the maternal health CHW has registers and that these registers are filled correctly.
Follow up and verify if CHW's has patient registers, if they are well kept and correctly filled out.	Follow up and see if the maternal health CHW refers pregnant women for Antenatal Care (ANC) visits at the Health Center (HC)
Monitor if drugs are distributed correctly, not expired and well kept.	Follow up and verify if the maternal health CHW has sent RapidSMS reports for pregnant mothers confirmed by health provider.
Compilation of reports of drugs that have been used by CHW in cell and requisition of drugs at health centers.	Verify if the maternal health CHW has Misoprostol drugs and that the drugs are not expired.
Supervision of the household that was recently attended by a CHW.	
Check if the CHW performs post-visit's for the children treated.	
Supervise CHW's on how well s/he is able to sensitize the community on family planning usage.	
Verification of reports brought for compilation if they have been sent by mobile.	

Table 3.5: CHW cell coordinator responsibilities at a cell level

# Chapter 4

## Research Methodology

### 4.1 Action Research

[11] [10]

### 4.2 Diagnosis

The diagnosis in the Action Research model is about identifying the nature of the problem situation, include all interrelated factors, develop a working theory about the situation and how it might be changed.

#### 4.2.1 Situation Report

The CHD at the Ministry of Health would like to make a system that will automatically generate reorder quantities of essential drugs to the CHW. Based on SMS reporting from the CHW's, the system will predict how much of each essential drug that are needed for the next delivery.

Videre følger en fyldig status rapport av situasjonen imens jeg var i diagnose fasen

## **4.3 Planning**

møte, møte, møte

## **4.4 Intervention**

Beskrivelse av hva vi gjorde.

### **4.4.1 Use Cases**

### **4.4.2 Configuring DHIS2**

### **4.4.3 Algorithm**

### **4.4.4 User Importer**

### **4.4.5 The Essential Predictore**

## **4.5 Evaluation**

### **4.5.1 SMS demo**

### **4.5.2 Algorithm Presentation**

### **4.5.3 Situation Report**

## **4.6 Reflection**

# Chapter 5

## Case

### 5.1 Background

There has been some interest in the area of SMS reporting from the UiO. The DHIS2 software supporting this functionality has been developed, but not yet been used. The HMIS team at the MOH in Rwanda has for some time been wanting to use DHIS2 in order to make a system for keeping track of CHW's essential drugs and supplies. The system, mmunity Logistics Management Information System), should be able to track CHW's stock and distributions of these items. The HMIS team are actually working for the CHD who are the clients in this case. The current system is primarily a pull system where CHW's make monthly visits to their local HC CHW supervisors in order to resupply.

In order for these CHW's to provide uninterrupted care to their communities, it is essential to have access to the essential drugs and supplies

these health workers dispense.

Rwanda is now in the process of rolling out a national Electronic Logistics Management Information System (E-LMIS) that is supposed to cover all levels of the health system, but this does not include the  $\approx 45000$  CHW's in  $\approx 15000$  villages. This is where the Community Logistics Management Information System comes in. With DHIS2 as a base software CHW's will be able to report data on what they receive and has in stock of the essential drugs and supplies. Further, the plan is to integrate Community Logistics Management Information System with the national E-LMIS in order to have interoperability between systems.

## **5.2 Networks of Action**

As mentioned by Eric, Jørn and Sundeeep, one key to make this possible is the network of action. As a student-researcher I've been able to get a position as an intern at Management Sciences for Health (MSH). The core of this initiative is the CHD. They have asked HMIS for support on developing Community Logistics Management Information System. The HMIS team has support from both MSH and HISP.

### **5.2.1 Description of the different participants here**

## **5.3 Objectives**

In order to make the case managable for a research project it was limited to four objectives.

**#1:** Send SMS and email notifications based on rules.

**#2:** Send SMS and email reminder if a report is more than 4 days delayed.

**#3:** If user data does not map correctly user feedback should be provided.

**#4:** A functional SMS based reporting system.

These objectives are somewhat simplified in order to be easier to work with. A more elaborate description folllows.

### **5.3.1 Objective #1**

Notifications here are meant as in the broadest of meanings. The idea is that the system should be able to communicate with the CHW's based on some configuration. In this case, a notification could mean a resupply order or an alert. Rules would then be related to thresholds or algorithms. For an example, resupply order would be generated by an algorithm that calculates how much of each supply item the CHW needs.

### **5.3.2 Objective #2**

This objective is straight forward. If a CHW in charge of reporting at a village does not report after 4 days of the previous reporting month, a reminder should be sent.

### **5.3.3 Objective #3**

Sometimes when a CHW reports data, syntax error may happen. It is also preferable to have some kind of feedback when everything is just fine. Just to know that everything is working. The appropriate instructions for fixing mistakes should also be in the feedback from the system.

### **5.3.4 Objective #4**

In this case a functional reporting system would be a system that is ready to receive SMS reports from the CHW's. These messages are stored in the Community Logistics Management Information System database ready to be analyzed.

## **5.4 Refining and Defining the Requirements**

As a part of a diagnosis we started out with trying to define usecases for each of the objectives. This would make it more clear what needed to be done in order to meet them. It was very difficult to pinpoint exactly what needed



## Community Health Worker medicines/supply chain

1 of 1

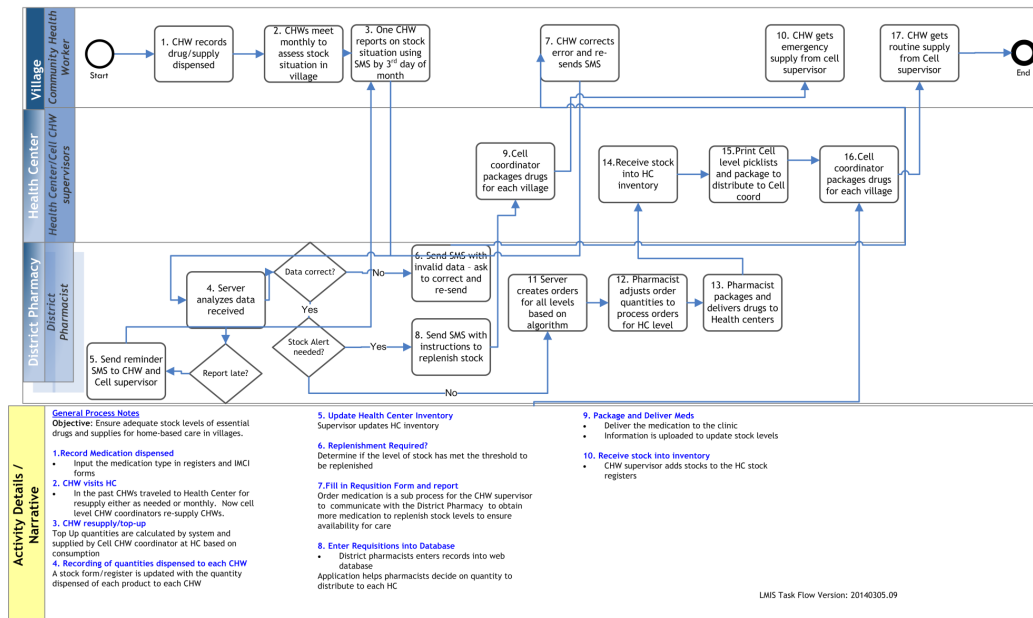


Figure 5.1: CHW Supply Chain in the Future

to be done because of the projects size. HMIS was in charge of configuring and develop the system. HMIS was doing this for the CHD, both located in the the same department, MOH. Collecting the requirements would then be based on what we understood from what the CHD could tell us. HMIS had already made some progress on this part.

Figure 5.1 shows the desired Business Process Model (BPM). The specifics did not allways match what had previously been discussed, but the important part was to get an overall picture of how thing should work. For an example we will see that the CHW's would rather report on what they receive instead of what they dispense. Af-

<b>Send SMS and Email Notifications</b>	
<b>Goal:</b>	Create orders
<b>Primary Actor:</b>	System
<b>Secondary Actor:</b>	Cell CHW Supervisor HC CHW Supervisor District Pharmacist
<b>Main Success Scenario:</b>	<ol style="list-style-type: none"> <li>1. CHW reports distributed and stock values.</li> <li>2. System processes report.</li> <li>3. System calculates essential drugs needed for each level.</li> <li>4. System sends orders to cell, sector and district.</li> </ol>
<b>Extensions:</b>	

Table 5.1: Textual Use Case: Send SMS and Email Notifications

ter analyzing the CHW supply chain BPM we found the following. Activity 1, 2, 3, 7 was supported as long as the CHW had a mobile phone. After discussing it with one of CHD’s team members, it was fairly safe to assume this. Activity 4 relates directly to objective #4. Activity 6 relates to objective #3. Activity 5 relates to objective #2 and Activity 8 and 11 to objective #1. Activity 9–10, 12–17 should supported as long as the objectives were met. This puts our objectives in context of a bigger picture.

#### 5.4.1 Use Cases

As a seen in use case tables 5.1, 5.2, 5.3 and 5.4, the specifics did change, along with the development process, but it gave us the necessary guidelines to understand

Send SMS and Email Reminders	
<b>Goal:</b>	Send reminder
<b>Primary Actor:</b>	System
<b>Secondary Actor:</b>	CHW Cell CHW Supervisor
<b>Main Success Scenario:</b>	<ol style="list-style-type: none"> <li>1. CHW misses report deadline.</li> <li>2. 5 days goes by.</li> <li>3. System sends reminder by email and SMS.</li> <li>4. Another 5 days goes by.</li> <li>5. System sends reminder by email and SMS.</li> </ol>
<b>Extensions:</b>	

Table 5.2: Textual Use Case: Send SMS and Email Reminders

Send Report Feedback	
<b>Goal:</b>	Process SMS message
<b>Primary Actor:</b>	System
<b>Secondary Actor:</b>	Community Health Worker
<b>Main Success Scenario:</b>	<ol style="list-style-type: none"> <li>1. CHW reports data incorrectly by SMS.</li> <li>2. System receives SMS.</li> <li>3. SMS triggers feedback message.</li> <li>4. CHW corrects message and re-sends report.</li> <li>5. System processes SMS.</li> <li>6. System updates database.</li> </ol>
<b>Extensions:</b>	

Table 5.3: Textual Use Case: Send Report Feedback

<b>Report Using SMS</b>	
<b>Goal:</b>	Update Database
<b>Primary Actor:</b>	Community Health Worker
<b>Secondary Actor:</b>	System
<b>Main Success Scenario:</b>	<ol style="list-style-type: none"> <li>1. CHW reports stock and distributed values of essential drugs.</li> <li>2. System receives SMS.</li> <li>3. System processes SMS.</li> <li>4. System updates database.</li> <li>5. System sends confirmation SMS to CHW.</li> </ol>
<b>Extensions:</b>	

Table 5.4: Textual Use Case: Report Using SMS

the desired outcome. The obstacles then became somewhat clearer. The CHW's needed a server to communicate with and the server needed to be able to communicate with the CHW supervisors at the different levels in the health hierarchy. The communication channels that should be used between the system and the users would be email and SMS. Email support are possible to set-up without involving any other parties, but SMS on the other hand are somewhat trickier. Here we have to include a mobile company in order to properly test the service. This service also includes using software and hardware outside of the department.

## 5.5 Planning

With the objectives put in context we could start planning the specific activities for intervention. In our case

Draft work plan for implementation of CHW LMIS on DHIS-2 platform	
#	Activity
1	<b>Design</b>
	Develop concept paper for CHW LMIS
	Create costed workplan
	Present similar experiences in other countries
	Develop detailed functional requirements for 4 customized use cases
2	<b>Infrastructure</b>
	Create new instance of DHIS-2 in NDC cloud
	Finalize contract for VPN connection between MTN and BSC for SMPP transport of SMS messages
	Assign phone shortcode to CHW LMIS
	Configure SMPP gateway in DHIS-2
3	<b>Phase 1: DHIS-2 configuration and customization</b>
	Import cell and village hierarchy into the DHIS-2
	Clean up and import all CHWs with phone numbers into DHIS-2 as users
	Create data elements for reporting (on the job training)
	Develop algorithm for estimating resupply amounts
	Design SMS alerts for late stock reports
	Translate SMS feedback messages into Kinyarwanda
	Design SMS alerts for stockout warnings to Cell and HC CHW coordinators
	Add parameters table for setting minstock, reorderlevel, defaultsupply by drug
	Design triggers to email reports to HC CHW supervisors and District Pharmacy staff
	Workshop to develop reports and dashboards (10 participants CHW desk, selected District/HC)
	Develop picklist reports, stockout reports, consumptions reports for each level
	Develop select maps and graphs for key CHWLMIS indicators
4	<b>Testing</b>
	Test sending SMS from nearby community health worker sites
	Test reorder algorithm with 3 months of test data
	Test dashboard
	Test automated transmission of reports via email
5	<b>Acceptance - presentation at eHealth TWG and sign-off by CHD</b>
6	<b>Training and documentation</b>
	Training of CHW desk data managers in maintenance of system (on the job training)
	DHIS-2 academy for data managers (2 participants x 10 days)
	Printing of plasticised reference cards (1 per village)
	ToT for District CHW supervisors (50 participants x 3 days)
	Training of CHWs - since system is very similar to RapidSMS there should be little learning curve (5000/CHW)
7	<b>System maintenance</b>
	Payment for SMS
	Monitoring of reporting completeness (quarterly feedback meetings combined with RapidSMS)
	Server Hosting charges
8	<b>Phase 2: Interoperability</b>
	Design interoperability profile with eLMIS - to Upload District Pharmacy/HC level Orders
	Adapt health facility registry synchronization for use with CHW LMIS instance
	Create mechanism to exchange updated CHW information between RapidSMS and CHW LMIS

Figure 5.2: Activity Plan For the CHW LMIS

the HMIS team made the overall plan for the project as in figure 5.2. The objectives then relates to the following points of intervention, take into account that there are dependencies along the different activities.

### **Objective #1**

- 3.4** Develop algorithm for estimating resupply amounts.
- 3.7** Design SMS alerts for stocklow warnings to Cell and HC CHW coordinators.
- 3.8** Add parameters table for setting minstock, reorderlevel, defaultsupply by drug.
- 3.9** Design triggers to email reports to HC CHW supervisors and District Pharmacy staff.

### **Objective #2**

- 3.5** Design SMS alerts for late stock reports.

### **Objective #3**

- 3.6** Translate SMS feedback messages into Kinyarwanda.

### **Objective #4**

- 3.1** Import cell and village hierarchy into the DHIS-2.
- 3.2** Clean up and import all CHWs with phone numbers into DHIS-2 as users.
- 3.3** Create data elements for reporting (on the job training).

The Community Logistics Management Information System will in its final state run on servers at the National Data Center (NDC). This would then involve another party when trying to configure and develop the Community Logistics Management Information System. Often taken for granted is stable power supply and internet access. In our case, this was not the case. One could experience power cuts on a daily basis. And working directly on a server under these circumstances is not very productive. Taking this into account we decided to set up a test environment that we could work with. Making our configurations and testing possible instantly before we make the changes on the live server at the NDC. This duplicated our work some, but makes it easier to develop and configure. For an example, one does not need to stop everybody's work if one happens to play with the database too much. Also it makes it easier to divide tasks so that they can run in parallel.

## **5.6 Intervention**

The first thing that needed to be done was to set up the test environment.

### **5.6.1 Setting up the Test Environment**

The test environment was set up using an Android smartphone and a laptop.

Figure 5.3: Figure of SMS-flow

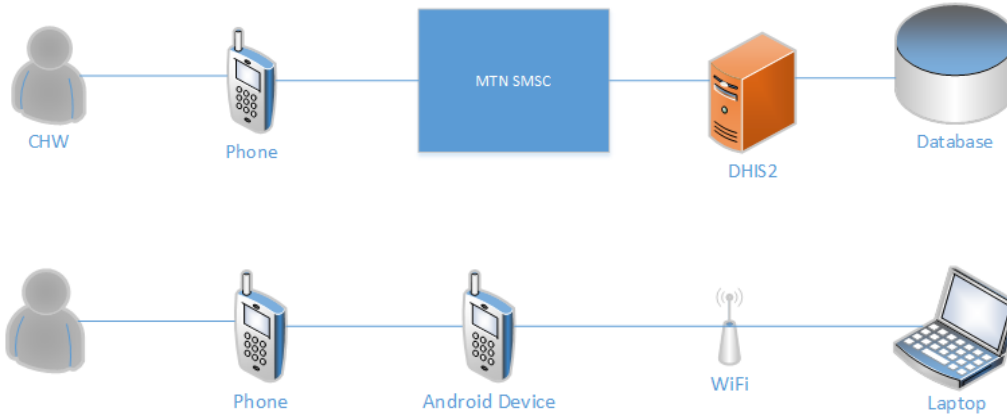


Figure 5.4: Figure of Test Environment

Based on advice from the HISP-team at the UiO we chose to use Short Message Peer to Peer (SMPP) protocol in order to transfer SMS's from the CHW's. In our case, this requires a connection with a Simple Message Service Center (SMSC) at a local mobile operator. Typically the SMS is typed in by the CHW and sent to a telephone number, usually a four digit number. The message is then received at the SMSC where it is forwarded to the server at the receiving end for processing. This is an over simplification, but gets the basic idea across. After processing the server is able to send SMS feedback to the user. In order for us to simulate this at the office space, we chose to use a SMS gateway application running on a Android device. When a SMS with the right code word is received, it forwards the SMS to the server.



Data Element Category Combination	Code
<b>Command</b>	<i>stk</i>
amoxicillin_stk_eom	am
condom_stk_eom	cm
injectables_stk_eom	dp
mebandazole_stk_eom	mb
misoprostol_stk_eom	ms
ocp_stk_eom	pp
ors_stk_eom	sr
primo_red_stk_eom	pr
primo_yellow_stk_eom	py
rdt_stk_eom	rd
sureau_stk_eom	se
zinc_stk_eom	zn

Table 5.5: Codes for Drugs and Supplies

### 5.6.2 Configuring DHIS2

In order to process the reports DHIS2 has to be ready to receive them. This involves creating user accounts with the phone number of the sender, creating data elements and sets that make meaning to the values reported and making the codes for the different supplies and drugs that the CHW reports on.

Table 5.5 shows names and codes for the drugs and supplies in our case. This is data elements for stock at the end of month. A typical scenario would be that a CHW counts each item they have at the village the end of the month. Then creates a text message that is sent to the four digit number provided by the mobile operator. Example message in figure 5.5. In the example message, *stk* is the code word that tells DHIS2 what kind of data



Figure 5.5: Example SMS report

is being reported. The first two letters in the message the maps to the different drugs and supplies in the database with the following value.

## 5.7 Demo 1

After the basic set up we had a short demo for a few members of the HMIS team. This demo showed the most the basic functionality and how we may configure it to fit our requirements. We discussed naming of the different codes and typical issues. One thing was misspelling and user feedback. One thing worth taking note of is that a common spelling error was to type the number '1' instead of the letter 'l' and the number '0' instead of the letter 'o'. We solved this by avoiding the letters in the SMS. Also, we also took note of that many of the users might not be fluid in or even speak English. The local language is 'Kinyarwanda'. An old Bantu language that is very

much used even though Rwanda is transitioning to English. DHIS2 is currently not supporting 'Kinyarwanda'.

### **5.7.1 Setting up the mobile instance**

In parallel with the setting up the test environment we began configuring the DHIS2 in the cloud service provided by NDC. We soon realized that setting up a test environment was worth the time. The NDC is being administrated and operated by another team outside the HMIS team. This caused some delays. Our first goal was to update Ubuntu on our virtual server in the cloud. This took around 6 days from the request was made. Putting this in some perspective. We updated a server during this period. It took about 3 hours. With the test environment in place we could work at our own pace and switch to update the virtual server with pre-tested solutions while work outside our jurisdiction was pending. After updating and setting up the virtual server with DHIS2 collaboration was somewhat easier. Everybody on the HMIS team had their own user accounts and it became easy to follow our progress as a team. Time spent on configuring was reduced since we already had done it in the test environment.

The Postgres CSV User Importer

Path to csv file: C:/chw.csv

Firstname: 1 ☐ csv ☐ default

Surname: 0 ☐ csv ☐ default

Username: 2 ☐ csv ☐ default + count ☒ split+count

Password: 3 ☐ csv ☒ random ☐ default+count

Phonenumber: 5 ☒ csv ☐ empty

User Role Id: 4 ☐ csv ☒ default ☐ csv code

Organization Unit Id: 6 ☐ csv ☒ default ☐ csv code

IP: localhost

Port: 5432

Database: healthfinance

DB Username: postgres

DB Password: .....

Load User Roles

Load org units

Exclude incomplete records. ☒

Make CSV of imported users. ☒

Make CSV of incomplete records. ☒

Import

Default

Figure 5.6: Screen Shot of the User Importer

The Essential Predictore

DB Type: Postgres Address: Port: DB Name:

Username: Password

Start

Figure 5.7: Screen Shot of the Essential Predictore

### 5.7.2 User Importer

#### The Essential Predictore

#### Re-Supply Algorithm

$$stk_n = stk_{n-1} + rcd_n - disp_n \quad (5.1)$$

$$reorder_n = (amc_n \cdot 2) - stk_n \quad (5.2)$$

$$amc_n = \frac{disp_{n-2} + disp_{n-1} + disp_n}{3} \quad (5.3)$$

$$disp_n = stk_{n-1} + rcd_n - stk_n \quad (5.4)$$

$$disp_{n-1} = stk_{n-2} + rcd_{n-1} - stk_{n-1} \quad (5.5)$$

$$disp_{n-2} = stk_{n-3} + rcd_{n-2} - stk_{n-2} \quad (5.6)$$

**reorder<sub>n</sub>** This variable represents the quantity of how much is needed at the next re-supply of one village.  $n$  in this case represents the last month. If in May, it represents reorder quantity for the end of month of April.

**amc<sub>n</sub>** Represents the average monthly consumption based on the last 3 months in one village. I in May, that would be the average monthly consumption based on February, March and April.

**disp<sub>n</sub>** This variable is calculated based on the the values reported and is the number of items distributed by one village during one month.

**stk<sub>n</sub>** The quantity in stock at the end of the month of one village. Usually reported within 1–5 days into the next month it represents. Stock in April is usually reported between 1st and 5th of May.

**rcd<sub>n</sub>** This variable is the sum of items received in one village during the month it represents. If a CHW receives 10 condoms 2nd of April, it should be reported the same day. If a village receives another 10 condoms the 13th of April, that should also be reported the same day it is received.  $rcd_n$  for April would then be the sum of those values, 20.

$$rcd_n = \sum_{k=1}^j rcd_{n,k} \quad (5.7)$$

.  
A more mathematical description in equation 5.7, where  $j$  represents the number of days in the month.

## Chapter 6

### Discussion Of Results

## Chapter 7

## Conclusions



# Bibliography

- [1] Countries using dhis 2. <http://www.dhis2.org/deployments>, 2014. Accessed: 22-05-2014.
- [2] Mikal Hem. Rwanda. <http://snl.no/Rwanda#menuitem0>, 2014. Accessed: 19-05-2014.
- [3] The process of developing the dhis. <http://www.mn.uio.no/ifi/english/research/networks/hisp/hisp-history.html>, 2013. Accessed: 20-05-2014.
- [4] Hisp. <http://www.mn.uio.no/ifi/english/research/networks/hisp/index.html>, 2014. Accessed: 20-05-2014.
- [5] About hisp. <http://hispindia.org/index.php/about-us>, 2014. Accessed: 20-05-2014.
- [6] Network of action. <http://www.mn.uio.no/ifi/english/research/networks/hisp/network-of-action.html>, 2013. Accessed: 20-05-2014.
- [7] Hisp uio strategy, 2014. Accessed: 20-05-2014.

- [8] Internet world stats. <http://www.internetworldstats.com/stats.htm>, 2012. Accessed: 24-05-2014.
- [9] Sundeep Sahay Jørn Braa, Eric Monteiro. Networks of action: Sustainable health information systems across developing countries. *MIS Quarterly*, 2004.
- [10] Briony J. Oates. *Researching Information Systems and Computing*. Sage Publications Ltd, 2006.
- [11] Maris G. Martinsons Robert M. Davison and Ned Kock. Principles of canonical action research. *Info Systems*, 2004.
- [12] Ministry of local government. <http://www.minaloc.gov.rw/index.php?id=450>, 2011. Accessed: 19-05-2014.
- [13] National community health strategic plan, 2013. Accessed: 19-05-2014.
- [14] Folkemengden. <http://www.ssb.no/befolkning/statistikker/folkemengde>, 2014. Accessed: 19-05-2014.
- [15] Hutuer og tutsier. [http://no.wikipedia.org/wiki/Hutuer\\_og\\_tutsier](http://no.wikipedia.org/wiki/Hutuer_og_tutsier), 2013. Accessed: 19-05-2014.
- [16] Rwanda. <http://en.wikipedia.org/wiki/Rwanda>, 2014. Accessed: 19-05-2014.

- [17] Gross national income 2012, atlas method.  
[http://databank.worldbank.org/data/  
download/GNI.pdf](http://databank.worldbank.org/data/download/GNI.pdf), 2012. Accessed: 19-05-2014.
- [18] Gross national income per capita 2012, atlas method  
and ppp. [http://databank.worldbank.org/  
data/download/GNIPC.pdf](http://databank.worldbank.org/data/download/GNIPC.pdf), 2012. Accessed: 19-  
05-2014.

# Appendix A

## Requirements Document

### A.1 The real deal is somewhere else!

### A.2 Context

This requirements document is for setting up a environment for a SMS based reporting system with the DHIS2. The system should be able to support these four use cases.

1. The users will be able to receive automated SMS and email notifications based on rules that compare database values.
2. The users will be able to receive an automated reminder if a report is more than 4 days delayed.
3. The users will be provided with a predefined format for reporting.
4. If the user reports values that does not get processed, then he/she will receive a notification of what has

happened and directions for necessary steps in order to complete the report.

## **A.3 Setting up Testing Environment**

### **A.3.1 Testing without phone**

**Operating System**

**Tomcat**

**DHIS2**

The hierarchy has to be at a village level. This is the level we want to be reporting on.

**Postgres**

**Dataelements**

When creating data elements we store the zero values.

Testing Script

<http://localhost:8080/dhis2/sms/testSMS.action>

Number	Name	
1		O
2		
3		O
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
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## **A.4 The Rights of The Participants**

**A.4.1 Not to participate**

**A.4.2 To withdraw**

**A.4.3 To give informed consent**

**A.4.4 To anonymity**

**A.4.5 To confidentiality**

# Appendix B

## Interviews

### B.1 Diagnosis

#### B.1.1 Randy

#### B.1.2 Andrew

#### B.1.3 Venuste



# Appendix C

## Journal

### C.1 Day 1

#### C.1.1 Breakfast

Missed on the time here today. Wrong time zone. I thought the devices configured themselves, so I just trusted the watch. Randy missed a part of his meeting because of that. Very embarrassing.

#### C.1.2 MSH Office

Got the first tasks. Should refine and define the requirements. I don't see any problems just yet. A little unclear just who are the ones involved. There are two guys, Patrick and Eric that i should meet with. Both working with logistics I think, at least in stock management. Haven't heard anything on the the SMPP protocol other than it should be there.

## C.2 Day 2

### C.2.1 New Office

Today we have a population count problem in DHIS2. I would try to make a postgres query to check our implementation of DHIS2. Got a temporary seat. Gloria is out in the field. Gloria is probably checking if the data is correct. I am now at the HMIS's new office. Met, Venus again, Andrew, Adolph, Erick, Olive'something, and another. Got to get better on those names. I think I'm a little further up the road from the old offices :).

### C.2.2 Beginning to collect the requirements

It seems like the solutions should in some way be more effective. I've been introduced to several people here.

<b>Names</b>	<b>Institution</b>	<b>Phone</b>	
Deogratias Leopold	ISI - SC4CCM	0788486509	
Wane Olivier	IMOH/MCH/CHD	0788358649	olig
Erick Gaju	MoH/Ehealth	0788517168	ge
Mike Misengo	MoH/CHD	0788482804	mike
Venuste Nsanzumuhire	MoH/HMIS	0788606639	venuste.n

## **C.3 Day 3**

### **C.3.1 Morning at the office**

I am still trying to figure out the requirements or wishes of HMIS. Apparently there is not very much structure. No development cycle. No requirements document. Randy proposed that we need to be able to implement an algorithm. But there is still no sign of the famous algorithm. They don't know what they want I think.

### **C.3.2 Testing**

I think we could start setting up the test environment and show what is possible so that they can see the opportunities.

### **C.3.3 Setting up the test environment with sms**

This first time we will try with the SMS function in DHIS2. We've encountered a bug in 2.12 after setting up the data elements. The elements are there and connected to a data set. While trying to browse the data elements it never stops loading. Tried clearing cache, switch browser, update resource tables. We will try to update the local version to new one, then start over. Unfortunately I were told that we are the support, so I hope the HISP team in Oslo can help.

### **C.3.4 Tasks**

I've got 2 tasks.

- Make the requirements document for the system that is being made.
- Make the testing environment.

### **C.3.5 End of the day**

Try one more time to set up the test environment for tomorrow. The requirements document should be set up by 15th of March.

Got the backup from Randy and have to remember to run the analytic.

## **C.4 Day 4**

### **C.4.1 Morning**

The driver was about 20 minutes late. My goal was to be at the office by 08:00. Maybe I should arrange for some other transportation arrangements.

### **C.4.2 Before lunch**

Will continue with trying to set up the testing environment and defining the requirements. I have a new database instance and a new database. If this works, everybody can probably learn how to do this locally, so that

testing can get done much faster. Venuste and I should be able to set up the same system. We did not manage to set up the database. Got several error messages. "psql:healthfinance2014.sql:3450210: ERROR: role "hf-readonly" does not exist"

### **C.4.3 After lunch**

I am still waiting for Randy to arrive so that he can describe the algorithm to Ola. I am really just sitting here doing nothing.

### **C.4.4 end of work day**

I think we've had a very productive day. We've got a description of the algorithm and are trying to set up the testing environment. Tomorrow I will continue setting up a local instance of DHIS2 with Venuste.

## **C.5 Day 5**

### **C.5.1 Before lunch**

Forgot my charger today. We are still trying to set up a local instance. First we had to reinstall a new operating system on Venustes computer. Now we are trying to install postgres so that we can install the database. Venuste proposed that we do not install a DHIS2 instance on all of the computers.

## **C.6 Day 6**

### **C.6.1 Getting TV**

We went to the city to acquire a tv subscription. Patricia knows a guy. We got it for 60k a month.

### **C.6.2 Market**

We shopped at Namukat. Probably the best place for getting supplies here in Kigali. Bought bread from a different store some reason.

### **C.6.3 Hash**

To of the girls got their names today. One is called bend, the other over. It was the international womens day, so one old lady did not like the names. We met at Chez Lando and started running from the facebook pub.

### **C.6.4 Casino**

I got to drunk. I got this note from this girl, Kayli. She is saying she wants to meet. I started out thinking it was not such a good idea, but later I got curios. Was afraid she might set up a kidnapping or something. She is a little bit religious I think.

## **C.7 Day 7**

### **C.7.1 Waking up**

Got up around 10:00 today. Did nothing but some texting with Kayli.

### **C.7.2 Night time**

I should remember to bring along Venustes charger tomorrow. It's in my backpack already. It would be good to continue some on my thesis. Aiming for delivery before 1. July so that I can focus on my other courses.

Would be just perfect if I got finished this summer.

## **C.8 Day 8**

### **C.8.1 Morning at the office**

Should be able to set up a local instance today. It seems like it takes up much time to set up here. I've been here for a week and still I am not able run a local instance.

Installing the software is somewhat difficult. Today I am getting this up and running. Documentation should be better and easier.

I have not yet received a permanent seat to work at.

Gloria said that the data quality was so so.

Set up the testing for mobile reporting. It works, but I cant figure out how I set the received date.

## **C.9 Day 9**

### **C.9.1 Before lunch**

Continued to add to the requirements document. I now have a 10 page document using Fowlers UML Distilled.

### **C.9.2 After lunch**

Trying to get to the core of the requirements so that we can propose a solution based on around DHIS2. Got some feedback from Eric today. It is important to take note that the difference between 0 and o and basic knowledge of Linux. We agreed on first setting up a local test environment. Then suddenly we started to set up a virtual server. I don't get an overview of the situation.

## **C.10 Day 10**

### **C.10.1 Morning at the MoH/HMIS**

Today I will continue finishing the requirements document. The en result should be something enumerated list with all the specifics. Sent a draft of the requirements to all the people that wanted to know what is going on.

I think there will be some positive feedback.

I don't really know what I am about to gather data about just yet. So any data generation methods are not appropriate yet.



## **C.11 Day 11**

### **C.11.1 Morning**

Heard that we've got the signature for the SMPP protocol last night. Eric advised me to take notice of that basic knowledge and the difference between '0' and 'o', '1' and 'l' are important. It seems like touch is neither used. Wich is the most basic thing in computers. There is alot that is not mentioned in the docuementation in DHIS2. Like how we should go about installing on a Windows machine. This might be a reason why this is not as widespread as it should be. A little note for reasearch is that communication is not the way I am used to. I am sitting very much alone without being very involved in what everyone else is doing. I think I am in the loop, but it seems like everyone is working on separete things and just reporting to each other. I don't know why, but we are still missing that signature that allows us to use the SMPP protocol.

## **C.12 Day 12**

The virtual server needs to be updated with the new Ubuntu. Unfortunately this has taken about 2 days I think. Don't know what the hold-up is.

### **C.12.1 CHW supply chain meeting**

Today I probably holding a demo showing the use case 3 and 4. Next week I will focus my attention on use case 1 and 2. If everything goes after plan, we should have everything ready in about 2 weeks. I think there was a discussion around JSI which is a system like DHIS2. I don't know if this system is already in use or not.

## **C.13 Day 13**

We climbed Visoke this day and I had some good sex. Borah is like very open about sex. I get a boner just thinking about her. Love it. She was like, "take it baby, take it". Just awesome. It's like she's giving something away. I really don't understand why, but that's the way she sees it. Probably the way all girls sees it. The more I try to define it the more difficult it gets. So, we boys are apparently trying to take the girls vagina.

That is what they are thinking. We are trying to get it. I am thinking that girls should give it if they want to. I don't want be with them if they don't really want to. It not like it is a competition of trying to get something. It's enjoying the time we spend together. Sex is definitely a part of that.

## **C.14 Day 14**

Me and Borah took a little longer than expected yesterday. I love being with her, but she spends a lot of money. For me here it's still a lot. And she like says that I should give my money away. Money in that direction is gone, no matter how much I spend. Still, I like her. Maybe I'll see her later today. We first took a cab from the hotel, don't remember it's name. Then we took the bus from wherever we where back to Kigali. The mountain we climbed was called Visoke. It is near where Dian Fossey made the documentary of the Silverbacks. We actually stayed at the same spot as she did, the hotel was the same and it was possible to rent her room.

## **C.15 Day 15**

Alright. Everyday frustrations. Internet is not working. Apparently it should take 30 minutes to update flash player. The driver was only 30 minutes late today. That is hes only job. Drive from A to B. He also took a detour so that we could spend some more time driving. My phone is not working as I paid for. Now I am using airtime in order to be connected to the internet. This was before work. Now, at work things don't run. Like the VISA, I told Felix that I did not have a VISA for my whole stay, why is it necessary for me to say that he

should fix it? It is like people don't listen. That is the essence of why things don't go the way it should. I also had to buy coffee in order to get some. Thing is. I don't think people understand if they are not able to provide for coffee, how can they really be trusted to provide a information system covering the entire nation. And we need working chairs as well as working internet. The problem is obvious, yet nobody is doing anything about it. Stable power is still an issue if one wants everyday life to go around the way we want and that affects work. One cannot separate work from everything else.

#### **C.15.1 Before Lunch**

I've got some tasks that should be accomplished.

- Import the users in the excel file.
- Make the hierarchy so that it has 8 levels instead of 6.

Apparently it is not easy to get a the address of the MSH offices. Let's take the time. 10:40. 10:50.

Alright. Now it is not possible to take advantage of technology if one does not get replies. Google maps is almost not responding. It takes forever to sync my google drive.

Internet is the building blocks of network, if this is not working then everything else will not work. The signature

for the SMPP protocol is still missing. And the virtual server is not running. The guys at the National Data Center is still trying to update from some Ubuntu version to the latest. Lunch in 2 minutes.

### **C.15.2 After Lunch**

Today I will deliver my passport to Felix so that he can extend my VISA. Then I have to change my airplane tickets so that I can go home. Looking forward to it actually.

Also I have to see what is wrong with my internet at MTN.

## **C.16 Day 16**

Allright. I'm a little puzzled by the update at the national data center. Still there is no real reason for why this is happening. Also, the requirements should clearly be stated in some computer language like UML. I came here with the impression that what was actually needed was described in UML or the like. Fortunately there were some description of what is happening, but very little. Proper documentation is obviously a key piece in order to get an overview of things. UML FTW! My bad, the virtual server is now up and running. It is a little unclear if the users are actually the HMIS or the CHW. We'll see.

I should mention in my report the process of defining the requirements.

It is a lot of noise here from the outside.

### **C.16.1 After lunch**

I will install Ubuntu on Edith's computer later. It seems like she wants to learn, which is positive. I have to restore my database so that we can find out what exactly is the motherfucking fuckup that is happening. In order to use this database I need a user I think. Maybe I can change the user password by accessing the database and give the right user rights. Probably. Eric is making the letter so that we have confirmation from the university.

I was told before I left that the whole team is in on this. But we have not yet had a meeting for how we will proceed. This is exhausting. And my driver is driving me crazy.

## **C.17 Day 17**

### **C.17.1 Morning**

Went out with Borah yesterday. It was nice, she said something about me not getting attached to things or persons. She said I did not miss her, but that is not true. I do miss her when she is not there. It bothers me that she is too busy for me. Allright. I will try to

make a database restore today. Would be nice to have a working instance. Then I should be able to import the users. I don't think they know about hash functions here. It should be noticed that DHIS2 is not being used as intended. Taking shortcuts like importing users into the database makes the users of the system not involved in the process. Venuste said that some of CHW's did not have the chance to go to school. If we take the shortcut, users will not be involved and we'll miss this opportunity. The best way to go is to involve all users in the process. This is what is needed. I think I know the problem now. DHIS2 is not being used as intended. Therefore it does not work as it should. Take the databases from last year. Four instances of the program for some reason. This is why the problems are appearing.

It would be beneficial if the team had a specialist on databases. It is weird that all work could be stopped just cause one person is gone.

### **C.17.2 After lunch**

I don't know what Randy's plan is, but I assume that after importing the users, we will have the data managers reset the password. Alright, job well done. Got the users imported, I assume that it will be no problem doing it again. I will show Venuste how we import the users using postgres in a little while.

### **C.17.3 Back home**

Seriously, people at work just does not know what they are doing. No buts, no explanation. If one is about to use a database called postgres. One should know what it is and how it works. The overall database design is a good thing to understand, but really. Being able to manipulate it and use it is the are a must.

I think now I understand.

## **C.18 Day 18**

### **C.18.1 Morning**

I maybe think I am a little hard to please. To much complaining I think. Today I will probably teach Venuste how to use postgres.

### **C.18.2 Importing Users with Postgres**

This did not happen as it supposed to. We agreed that we should meet at 09:00AM, but apperantly there was another meeting that was more important to Venuste. No point in setting time if one just books over anyway.

### **C.18.3 Generating passwords**

In order to generate passwords we need to have access to an algorithm. This is touching on some security issues



I think. I understand why it is this way. The security should be better i believe. Alright. The password should be contain 8 characters, one capital letter and a number.

#### **C.18.4 Made the Password App**

My first executable java program :) password\_encoder!  
That is awesome :)

### **C.19 Day 19**

Today I will find a way to import all the users into the database. A finished solution if you will.

#### **C.19.1 Before lunch**

Seems like we will start at the project next week. In the mean time I will get this application started so that we can just import all the users.

I am very unsure on the technical level here.

### **C.20 Day 20**

#### **C.20.1 Going to the mall**

Alright, this saturday I was at the mall with Borah. I got a little to much to drink, but it was okay I think. Chelsea won over Arsenal and Liverpool won over Cardiff. Good weekend. Also went back to Sundowner and some grill.

## **C.21 Day 21**

This sunday was tiresome. Did almost nothing. I should learn that I am useless after drinking. I will not do anything. The sex with Borah was awesome, but I want to spend some time with her not in the room. It would be better to like rent a room or something.

### **C.21.1 Havanna**

We ate at the pizza place again. Four seasons was actually perfect. Watched some tv and went to bed. Patricia got some visitor last night. Maybe she is seeing someone :)

## **C.22 Day 22**

Been here for over three weeks now. I do want something to show for. I will make the importer so that it will be easy for everybody to do this for themselves. Will try to extend my VISA today as well.

### **C.22.1 Before lunch**

Really quiet at the office. Will continue to work at the application.

## **C.23 Day 23**

### **C.23.1 In the AM**

Alright, just broke off with Borah. Seemed to me like she had some other motives. Quite convincing though. I really like her though. Today I think I am going to continue on my application so that it will work with the GUI. What else. I need to fix those requirements. Use case 3 and 4 is done. 2, the reminder, I can do through java. 1, the report should also be done through java if necessary. And the product the user importer, for the MSH.

### **C.23.2 DHIS2 interoperability MEMMS**

### **C.23.3 Proposed meeting**

We will try to nail down the requirements tomorrow. Maybe we need some other input as well.

## **C.24 Day 24**

### **C.24.1 Good Morning**

Alright, back in black. My ex had her birthday, tried to let that one just slide. My other, soon to be 'ex' had a no show yesterday, tried to let that one slide as well. She is wierd by the way. Funny, I was called that yesterday. Tomorrow there is going to be a demo. I think the following

agenda is to be used.

1. Make the data elements
2. Make the data set
3. Assign the set to organization unit on the same level as user
4. Add as a mobile data set
5. Add the command
6. Edit the command
7. Make the service
8. Start the service
9. Open the \*/sms/testSMS.action and test in data entry
10. Check data entry
11. Try to send one from mobile and test in data entry
12. Check data entry

## **C.25 Day 25**

Allright, seems like I've been living in Africa for a while. Still typing alright wrong. I'll change it, alright. There we go. So, back to the task at hand. After next week we are going to set up the DHIS2 instance. I should probably

make a painting here of the guys that are in on this, but I won't just yet. Too lazy to make a drawing. Now that I think about it, I want to draw on the computer. Then again, then I will not draw on paper. Kinda don't like that paper is going out. That would then be my hobby.

### **C.25.1 VISA**

It is actually causing some stress for me that the VISA is not ready yet. Don't really care what happens, it is just that it is not very useful to not know where I am going to be for the next week. Specifying a country would actually make things a lot better.

### **C.25.2 For my masters**

I really don't know what I will write about. Thing is, there is not very much interesting that is worth mentioning. I should send my supervisor an email. Alright, damn, wrong again, alright. Sending the email. Have no internet, so I will not send the email. Can't really do much then, so I'll make some coffee and wait for Borah!

Text you later journal.

Kenneth

PS: This is my typing program. Which means, finally I don't have to look for anything else.

!!!

## **C.26 Day 26**

Today is going to be a short day. A trip to the forest. Nyonge I think it is.

### **C.26.1 Email brief**

No problem, hi Yusuf :)

We are trying to make a sms based reporting system that will collect data from about 45,000 community health workers.

The data that we collect are stock and distribution values of 12 essential drugs. Initially it was 10, but some where added later. This can be a problem since a sms message only contains 160 characters, but we will look into that later.

We have first tested with a local instance that receives sms messages with the `"/sms/testSMS.action"` script. After getting this to work with some test data we moved on to test with the sms gateway android application. This was very usefull. We could send messages to the phone with our own numbers and see the data going into the system. This also allowed us to have a demo for the 'clients' were we sent some reports..

We are still waiting for a signature in order to test for real (with a SMPP gateway), but we are moving forward by using the android application, a server at the national datacenter and maybe a test village just outside Kigali.

We will be able to report by SMS on Friday next week which is 1 of 4 use cases/requirements. The next one we will work on is getting feedback after reporting. This is a built in functionality in DHIS2, but I have not yet tested if it works properly. After that we want to send out reminders if reports are late, by SMS and Email, and finally produce some reports based on the reported data.

## **C.27 Day 27**

The previous Saturday was awesome. Early morning, rise and shine at 4AM. The hotel was perfect, the events were perfect. Nothing to complain about.

### **C.27.1 Chimps**

First me and Judith went to see the chimps. It was alright. Very funny when the chimps started to scream and run around.

### **C.27.2 Kanaloop walk**

We walked over some bridge that hang in the air. This was probably the coolest thing to this date!

### **C.27.3 Dinner**

Perfect dinner, a little wierd. I think I was tired. It's strange, I don't feel it myself. I can like analyze it later

that it could be that. But I don't want to excuse myself for being the way I am. It's like people are looking for a reason to explain why I am the way I am. For real, I would rather just stay quiet than succumb to this.

## **C.28 Day 28**

### **C.28.1 Breakfast**

Slept almost as long as I wished. I were kind of in a hurry because Judith called and asked were I was. So I were in a hurry. Didn't like that to much, disappointed in myself in a way.

### **C.28.2 Car drive**

On out way home we had alot of fun. Singing, joking and in a way just having alot of fun :)

### **C.28.3 Museum in the old capital**

This is were the king used to live and the city of Rayon Sports, my team in Rwanda. This were the old capital.

### **C.28.4 Meeting Borah**

Met with Borah for dinner again. It was very nice. Talked a little, she asked if I fucked or kissed anybody, was kind of fun :) Probably since I didn't.



### **C.28.5 Sunburn**

Got a severe sunburn on this trip, holy moly. Alright, let's get back to work.

## **C.29 Day 29**

### **C.29.1 Good morning**

I am working on getting a average consumption by month. Not really getting a instant gratification from DHIS2. This is what we are trying to achieve.

### **C.29.2 Just got lunch**

This is beyond stupid. I've just realized that being here is almost a total waste of time. There is no collaboration here. Just a bunch of people meeting from time to time. I don't feel like being part of a team here. Anyways, I will try to make the last 3 months from the web api. This must be the least user friendly shit I've seen in a long time. Returns nothing, that's its strength. What the fuck is going on here?

## **C.30 Day 30**

### **C.30.1 Good morning**

Today is the meeting with Mike. Should design the codes and text for the Mobile Instance.

### **C.30.2 After lunch**

Ok, we are on route I think. Only thing missing now is the alerts. I refer to the use cases. Randy has skills in the query department.

### **C.30.3 Closing**

There is no culture for keeping appointments I think. Had a no show this morning and a no show later this day. This is not very likely to ensure future collaboration I think. I think it is disrespectful and don't understand the need to waste time. Think I will just say goodbye to any expectation I have from anybody. At least not worry about it anymore. Fuck it, don't care. Hasta La Vista, Baby!

## **C.31 Day 31**

## **C.32 Day 32**

### **C.32.1 Meeting with the clients**

I've got to know the clients yesterday. I was also very tired today for some reason. I basicly explained everything about the solution for Mike, Jean and Louis. After explaining how shit works, we created some data elements, data sets, mobile sets and started the SMS service. Everything went relatively fine. Tried out a test

SMS also. Got some wierd questions that made somewhat frustrated. The level here is not that good, but the that is not the problem. The problem is that some people think they know what they are doing, but in reality they don't. People that know that they can't is easy to teach, but it's harder to teach them who think they already understand. After this session I ate lunch and went home to sleep. I should mention that some people don't get that using custom made software might not work with future updates of DHIS2. This may be a problem. I should start collecting data as well as finishing the application.

## **C.33 Day 33**

Today was very productive. Got confirmation that the translation of SMS messages will be possible 2.15. Worked a lot on the java application so that importing users will be easy next week. Got internet today, that's nice.

### **C.33.1 Movie**

Going to the movies today. Watching Captain America 2. I think it will be fun.