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 exists without the other. No one really have 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 being 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 privilege to know the organization HISP. Through HISP I've been participating in the configuration and implementation of a 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 $26338 km^2$ 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 $468.42 citizen/km^2$. 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 ≈ 354509. Rwanda's GNI in 2012 is \$6858$\circ$ 10^6, making their GNI per. citizen ≈ 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 8000Before Christ (BC)–3000BC. Jumping forward to around 700BC–Anno Domini (AD)500 there are evidence suggesting that the Bantu people entering Rwanda. The Bantu's was 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 AD1800, 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. The introduced identity cards that would categorize every individual as a Tutsi, Hutu, Twa or Naturalized. Under Belgium the Tutsi was still favored. In AD1959 Hutu activist began killing Tutsi people, making 20000–100000 Tutsi flee the country. In AD1962 Grégoire Kayibanda was the first elected president. He sat out to abolish the Hutu suppression, but that led to Tutsi discrimination. In AD1973 there was a military coup by president Habyaramana. Up until AD1990 there was a pro Hutu discrimination. In AD1990 the Tutsi dominant Rwandan Patriotic Front (RPF) lead 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 AD1994 president Habyaramana's plane is 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.

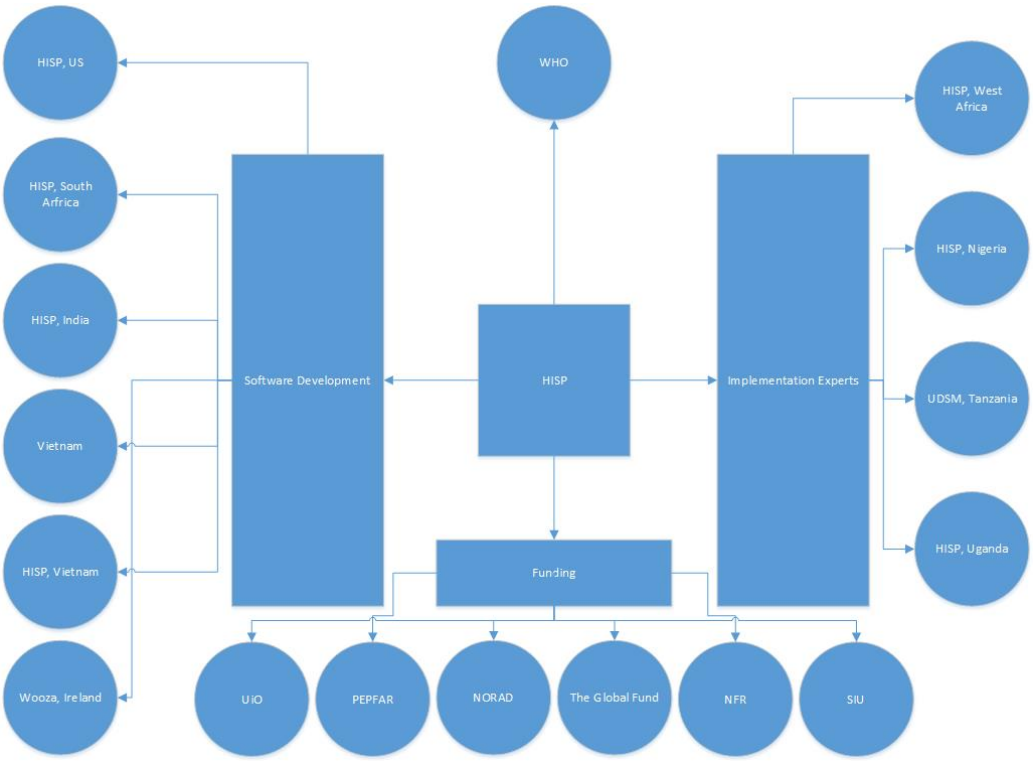

Figure 3.1: HISP Network of Action

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 to 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.

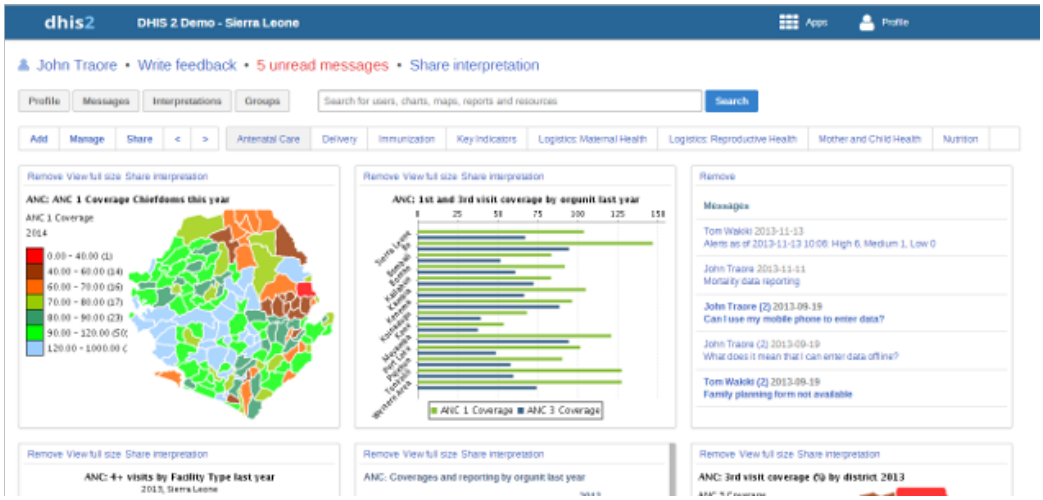

Figure 3.2: Screenshot of Dashboard

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

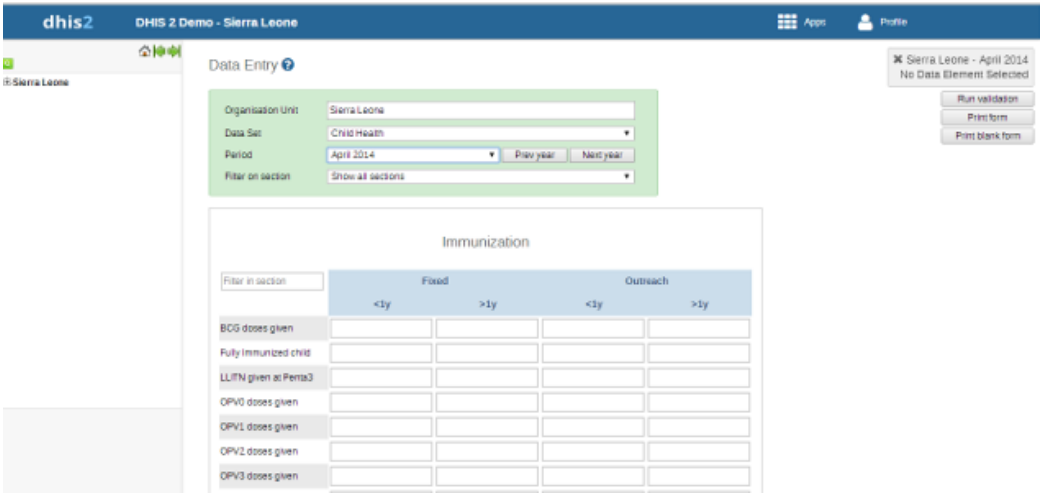

Figure 3.3: Screenshot of data entry in regular browser.

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

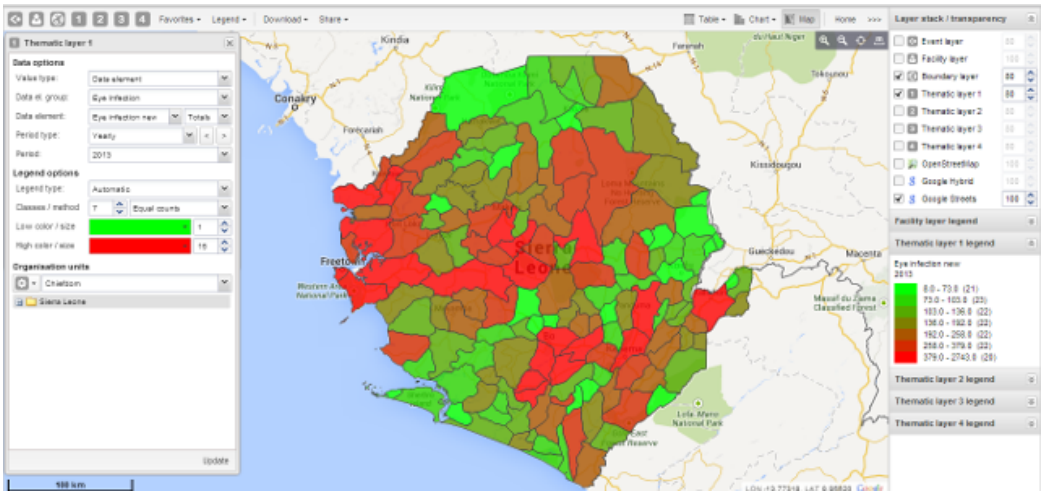

Figure 3.5: GIS Example

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 dataelements 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.

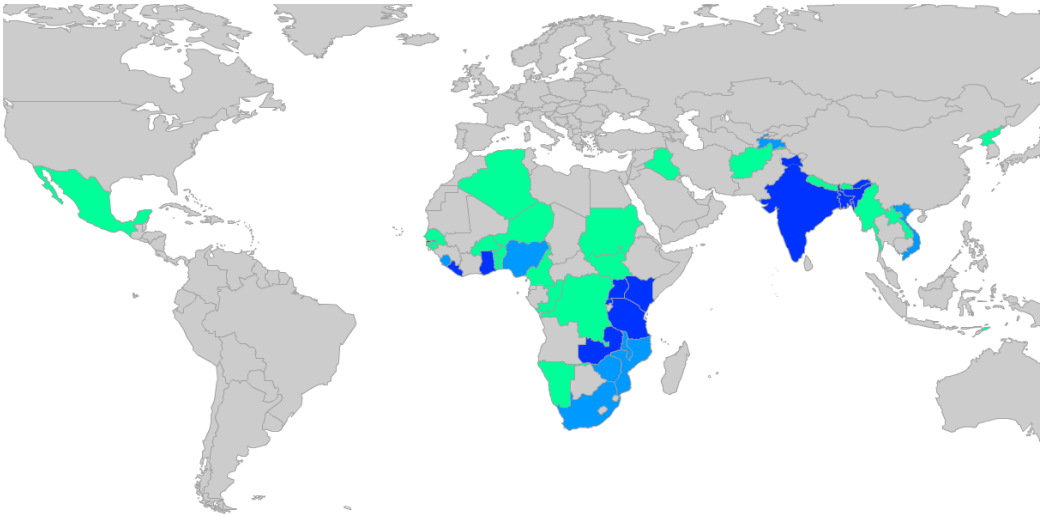

Figure 3.6: (Blue, National rollout)-(Light-Blue, Programs/partial)-(Green, Pilot/early phase)

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.

Complete national implementation	**Adoption by programs or partial national roll-out**	**Pilot stage or early phase in roll-out**
Bangladesh	Colombia	Afghanistan
Ghana	Laos	Algeria
India	Malawi	Benin
Kenya	Mozambique	Bhutan
Liberia	Nigeria	Burkina Faso
Rwanda	Sierra Leone	Cameroon
Tanzania	Solomon Islands	Congo Brazzaville
The Gambia	South Africa	Cote d'Ivoire
Uganda	Tajikistan	DRC
Zambia	Vietnam	Guinea Bissau
Zanzibar	Zimbabwe	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.

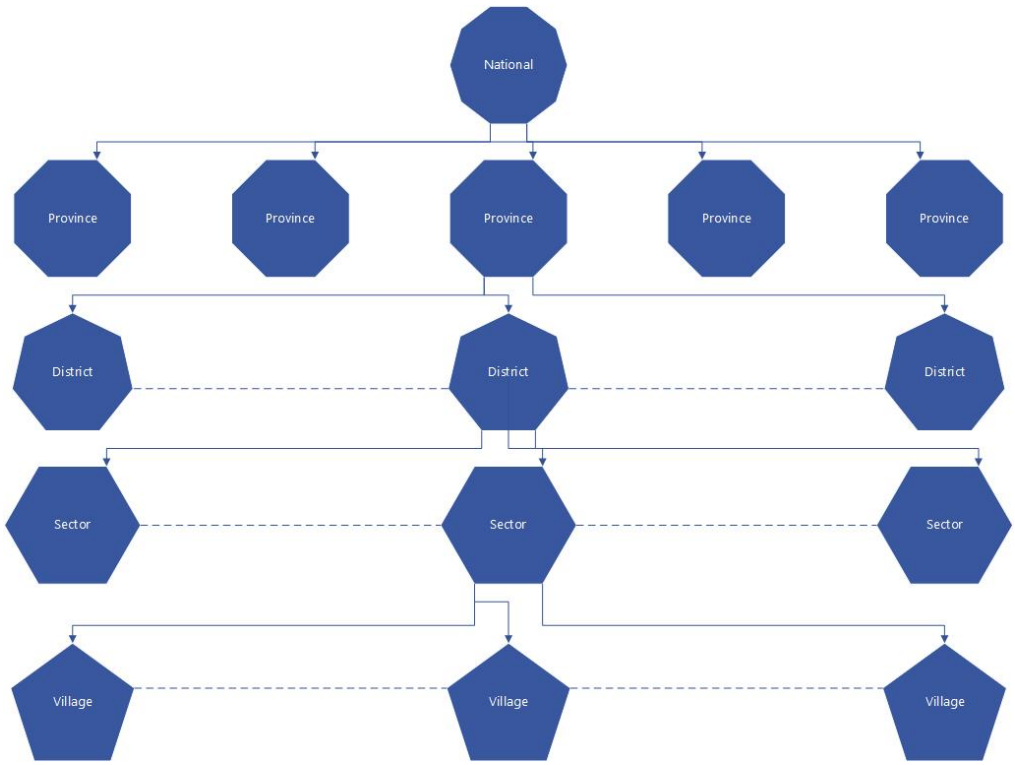

Figure 3.10: Rwandas Administrative Structure

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.

Multi disciplinary	**Maternal**
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 uninterupted 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 $\approx$ 45000CHW's in $\approx$ 15000villages. This is were 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 Sundeep, on 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 diffiult to pinpoint exactly what needed

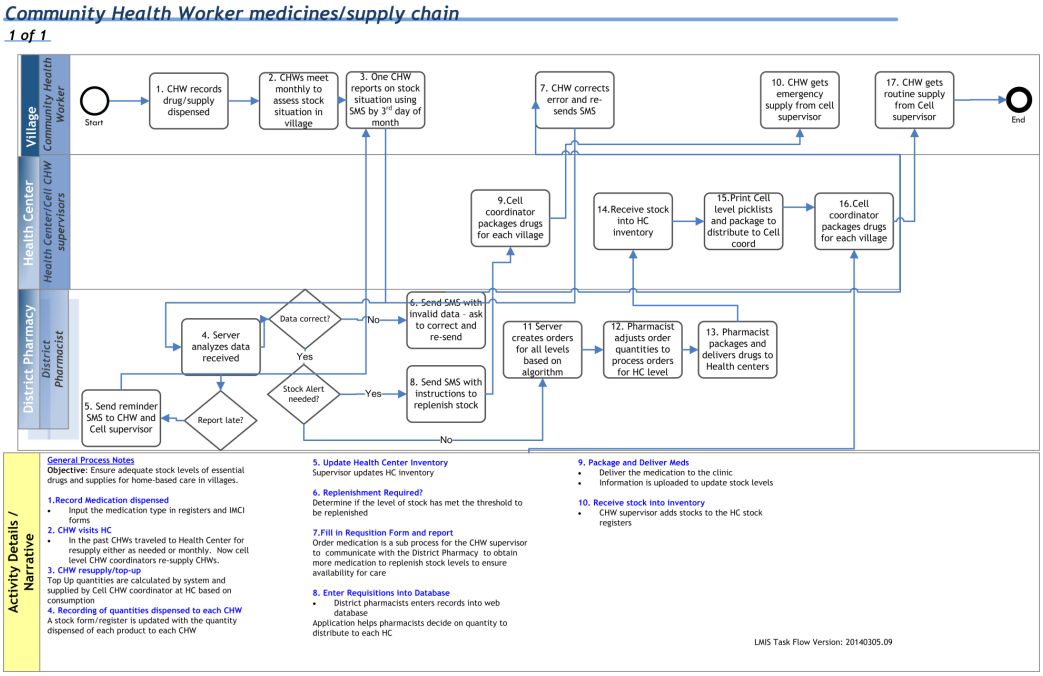

Figure 5.1: CHW Supply Chain in the Future

to be done bacause 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-

Send SMS and Email Notifications	
Goal:	Create orders
Primary Actor:	System
Secondary Actor:	Cell CHW Supervisor HC CHW Supervisor District Pharmacist
Main Success Scenario:	1. CHW reports distributed and stock values. 2. System processes report. 3. System calculates essential drugs needed for each level. 4. System sends orders to cell, sector and district.
Extensions:	

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	
Goal:	Send reminder
Primary Actor:	System
Secondary Actor:	CHW Cell CHW Supervisor
Main Success Scenario:	1. CHW misses report deadline. 2. 5 days goes by. 3. System sends reminder by email and SMS. 4. Another 5 days goes by. 5. System sends reminder by email and SMS.
Extensions:	

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

Send Report Feedback	
Goal:	Process SMS message
Primary Actor:	System
Secondary Actor:	Community Health Worker
Main Success Scenario:	1. CHW reports data incorrectly by SMS. 2. System receives SMS. 3. SMS triggers feedback message. 4. CHW corrects message and re-sends report. 5. System processes SMS. 6. System updates database.
Extensions:	

Table 5.3: Textual Use Case: Send Report Feedback

Report Using SMS	
Goal:	Update Database
Primary Actor:	Community Health Worker
Secondary Actor:	System
Main Success Scenario:	1. CHW reports stock and distributed values of essential drugs. 2. System receives SMS. 3. System processes SMS. 4. System updates database. 5. System sends confirmation SMS to CHW.
Extensions:	

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 tricker. Here we have to include a mobile company in order to proparly 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 activites for intervention. In our case

Draft work plan for implementation of CHW LMIS on DHIS-2 platform

#	Activity
1	**Design**
	Develop concept paper for CHW LMIS
	Create costed workplan
	Present similar experiences in other countries
	Develop detailed functional equirements for 4 customized used cases
2	**Infrastructure**
	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	**Phase 1: DHIS-2 configuration and customization**
	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 stocklow 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	**Testing**
	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	**Acceptance - presentation at eHealth TWG and sign-off by CHD**
6	**Training and documentation**
	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	**System maintenance**
	Payment for SMS
	Monitoring of reporting completeness (quarterly feedback meetings combined with RapidSMS)
	Server Hosting charges
8	**Phase 2: Interoperability**
	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. On could experience power cuts on a daily basis. And working directly on a server under these curcumstances 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 to much. Also it makes it easier to divide tasks so that they can run in parallell.

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 smart phone and a laptop.

Figure 5.3: Figure of SMS-flow

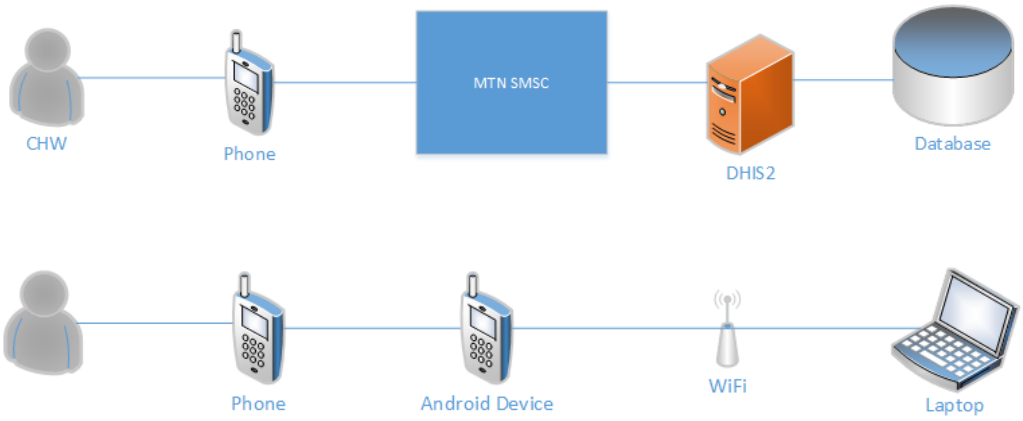

Figure 5.4: Figure of Test Environment

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
Command	*stk*
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.

5.6.3 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 Buntu language that is very much used even though Rwanda is transitioning to En-

glish. DHIS2 is currently not supporting 'Kinyarwanda'.

5.6.4 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 on the mobile instace 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. After setting up DHIS2, our progress with the mobile instance, Community Logistics Management Information System, hit the breakes. Reason for this is that the SMPP protocol agreement needed to be signed. There was a disagreement about which department should be responsible for

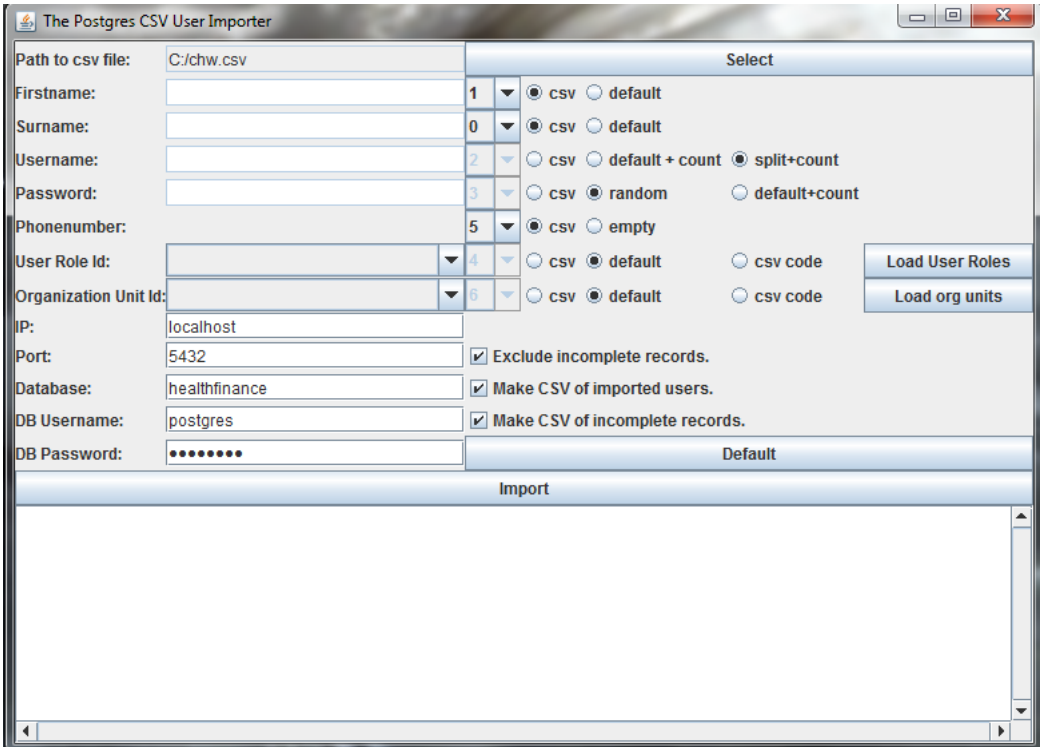

Figure 5.6: Screen Shot of the User Importer

the agreement. As mentioned, the SMPP protocol was very essential to our solution, but this had to be put on hold.

User Importer

With setting up the mobile instance we also had to create the user accounts. The usual way of registering users in the DHIS2 system is for an already registered user to navigate to the create user frame and input the information field by field. Firstname, surname, username, phone number, password and organization unit. With ≈ 45000 users spread throughout all of Rwanda, this would clearly

be a time consuming task. Fortunately we had a list of most of the CHW's currently working in Rwanda. This list included all the required fields except username and password. We therefore chose to develop a small java application that could create the user accounts in the database. This application takes a .csv file as input were each row represents a CHW. The application generates a username based on their names and a random password for each CHW. After running the application, each CHW has a user account. There are some issues with doing it this way, like not involving the users in the process of registration. This might lead to users being registered and even don't know that the system exists and further leading to the system not being accepted. After the user is registered, the system are then able to recevie SMS reports from those users.

5.6.5 Re-Supply Algorithm

The main purpose of the Community Logistics Management Information System is of course to facilitate the process of delivering supplies and drugs to the individual CHW. Stock outs in this case is especially critical! Making sure that supplies are given at the right place at the right time requires a information system. In this case we want to have the information system estimate how much each village needs based on their consumption on a monthly basis.

$$stk_n = stk_{n-1} + rcd_n - disp_n \tag{5.1}$$

In equation 5.1 we have the basic formula. How much a village have of an item at the end of month 'n' is what they had from last month, plus what they have received during month 'n', minus what they have dispensed the same month.

By reporting stk_n each month we are able to choose between either reporting the quantity of received or dispensed. By reporting what is received, when received, it is easier to track the items.

$$\begin{aligned}
reorder_n &= (amc_n \cdot 2) - stk_n && (5.2)\\
amc_n &= \frac{disp_{n-2} + disp_{n-1} + disp_n}{3} && (5.3)\\
disp_n &= stk_{n-1} + rcd_n - stk_n && (5.4)\\
disp_{n-1} &= stk_{n-2} + rcd_{n-1} - stk_{n-1} && (5.5)\\
disp_{n-2} &= stk_{n-3} + rcd_{n-2} - stk_{n-2} && (5.6)
\end{aligned}$$

Using this formula we are able to calculate both how much should be reordered and the average monthly consumption.

$\mathbf{reorder_n}$ 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$_n$ 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$_n$ This variable is calculated based on the the values reported and is the number of items distributed by one village during one month.

stk$_n$ 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$_n$ 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.

$$rcd_n = \sum_{k=1}^{j} rcd_{n,k} \tag{5.7}$$

.

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

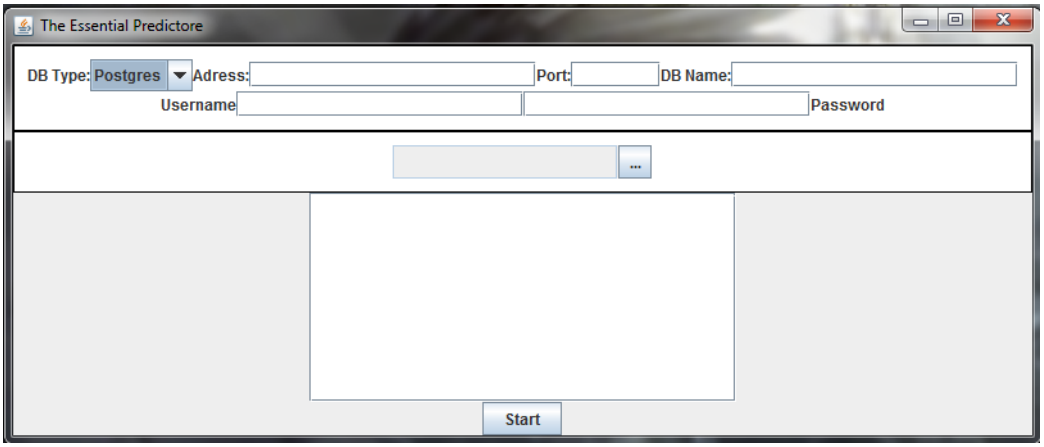

Figure 5.7: Screen Shot of the Essential Predictore

The Essential Predictore

Based on the reorder algorithm we decided to make an application that would automatically calculate both amc_n, $reorder_n$ and make them available in DHIS2. This application was partly programmed in POSTGRESQL, then wrapped in JAVA.

Chapter 6

Discussion Of Results

Chapter 7

Conclusions

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