TDT4900

Kenneth Børtveit

June 28, 2014

Abstract

Firstly we explore the current status of this area in the research community. E-health gives us an introduction to why we are trying to introduce information and communication technology's (ICT's) in order to improve health care. Work in transition strategies are relevant in the sense that these challenges have been met before when trying to upgrade current systems. Introducing ICT's in developing countries has been attempted before with little success, but have resulted in experiences that can provide us with guidelines of how to avoid the same result.

Further there is another motivation of introducing ICT's in the developing countries that relates to better the economy of developing countries which introduces the "learning economy".

Then move on to more broad contextual description of the case in order to get a sense of that there are interconnected dependencies and we are not dealing with a isolated situation. Before introducing the primary result of the study I try to elaborate on the method used. With the case in context and an understanding of the method used I introduce the case as seen from my perspective.

It builds on qualitative data collected from collaborating with professionals at the Ministry of Health in Rwanda. Combining research with everyday practice as is the main purpose of action research. In action research there are interventions that will have an effect on the problem situation. These interventions lead to the development of two applications that also are a part of this research project. The experiences from this case study are therefore useful since the interventions of the project lead to concrete products and therefore successfully introduced ICT products in the health sector.

In my opinion, the need to act on ICT's as a way of improving health services in the developing countries are long overdue.

Acknowledgments

Contents

List of Figures

List of Tables

List of Abbreviations

AD Anno Domini. 30

ANC Antenatal Care. 45

AR Action Research. 9, 10, 50–52, 69, 75

BC Before Christ. 30

BPM Business Process Model. 57

CAR Canonical Action Research. 50, 54

CDSS Computerised Decision Support Systems. 15

CHD Community Health Desk. 43, 49, 55, 57, 69, 71

CHW Community Health Worker. 4, 5, 34, 43–45, 51, 55–58, 60, 63, 65, 67–69, 72, 73, 76

CLMIS Community Logistics Management Information System. 51, 55, 56, 62, 65, 67, 69, 71, 74

CoIA Commission on Information and Accountability. 31

CPM Cyclical Process Model. 5, 51

CPOE Computerized Provider Order Entry. 14

DHIS2 District Health Information System 2. 9, 31, 33, 34, 37, 38, 55, 63–65, 68, 70–75, 77

DOT directly observed treatment. 44

DRC Democratic Republic of Congo. 30, 39

EHR Electronic Health Records. 14

ELMIS Electronic Logistics Management Information System. 55

GIS Geographic Information System. 37

GNI Gross National Income. 29

GSM Global System for Mobile. 34

GUI Graphical User Interface. 35

HC Health Center. 45, 55

HISP Health Information System Programme. 9, 31, 33, 48, 49, 62, 72, 73, 75

HMIS Health Management Information System. 41, 48, 49, 55, 57, 58, 64, 65, 69, 71, 75

HTML Hypertext Markup Language. 35

ICT information and communication technology. 9, 10, 12, 18, 19, 23, 24, 27, 31, 73, 75–78

ICT4D Information and Communication Technology for Development. 24

IS Information Systems. 9, 17–21, 75, 76

ISDC Information Systems in Developing Countries. 19, 20, 73

IT Information Technology. 73

LMIS Logistics Management Information System. 4, 60

MOH Ministry of Health. 10, 43, 49, 50, 55, 57

NCD non-communicable disease. 44

NDC National Data Center. 62, 65

PACS Picture Archiving and Communication Systems. 14

RCA Researcher Client agreement. 5, 50

RPF Rwandan Patriotic Front. 30

SMPP Short Message Peer to Peer. 62, 65, 70, 77

SMS Simple Message Service. 4, 34, 35, 55, 56, 58, 62–65, 71, 76

SMSC Simple Message Service Center. 63

TB tuberculosis. 11, 44

UiO University of Oslo. 33, 55, 62

UK United Kingdom. 46

USA United States of America. 22, 27, 46

Chapter 1

Introduction

Free and open source initiatives can provide software that before had a price tag. Technology is ever getting cheaper and internet penetration rates are ever increasing. The technical requirements are being met. Therefore there are a puzzle to me why the technologies are not being taken advantage of. It is well known that there should be a lot inefficiencies that could be remedied by introducing information and communication technology (ICT)'s in different areas. In the more developed countries of the world we have been able to apply ICT's to some level of success. In the less developed countries of the world ICT projects have a tendency to fail or the progress are not moving forward as fast as expected or should be. The overall theme of this paper is therefore;

Why is it then, that ICT have a hard time being applied when the opportunities are already there?

If the technologies are available and ready to being taken to use. This thesis will try to give an answer to this question.

The answer will be provided with an action research study taken place in one of the countries that are currently trying to take advantage of the rapid technological advancements of ICT's. The Action Research (AR) project are executed in collaboration with an organization called Health Information System Programme (HISP). They are currently trying to implement a Information Systems (IS) system called District Health Information System 2 (DHIS2) in several developing countries. This may provide insiders perspective on the current challenges we are facing in this area. The action research focus primary on introducing ICT's in the health sector of developing countries where the need for improvement are most critical. With this in mind I will also try to give answers to the following research questions:

- **How can we then improve the process of introducing new technology in developing countries?**
- **What are the necessary actions needed in order to increase the success rates of ICT initiatives?**
- **Are there any new challenges that have not yet been highlighted as a result of this AR-project?**

Chapter 2

Literature Review

Introducing innovative ICT's are a common challenge that have received a lot of attention. ICT's pervades all kinds of practices in the modern times. The health sector are one of these practices that are currently being the subject for improvement through introducing ICT's.

2.1 E-Health

E-health is defined as:

> Use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research.

E-health has many areas of application. Studies have shown that in by using electronic health records it is possible to improve staff productivity, reducing patient wait times, increase staff satisfaction and providing higher quality of data to relevant personnel. Laboratory information managements systems have decreased the time for communicating results and improved the productivity of the laboratory. Pharmacy information systems reduces time to order medications and provides easy access to past information. This is useful for forecasting medication requirements in order to get it at a lower price. Particularly relevant for drug resistant tuberculosis (TB) medications. Also reducing the number of errors. Fingerprint scanners reduced the time to locate records with 74% and barcode scanners reduced the time by 97%. The time to track patients lost to follow-up could with patient tracker systems be reduced by 20–50%. And patient reminder systems can increase attendance with up to 21%. A cost analysis of data collection systems show that it is possible to save 91% over a paper based system.

These findings clearly argue for the implementation and commitment of e-health in developing countries. Further there is a rapid development in the m-health area. Cellphones and tablets are making the networks previously accessible only to computers available on the move. In health this means that it is easier to response to crisis, talk to health personnel, both as a colleague and patient. Generally making health services more available through electronic channels. The idea of m-health is not something completely new. Just think about the primary way of responding to an accident as a citizen with your cell phone. Nevertheless, the way software are being integrated with health services today are innovative and needs attention in order to succeed. Even in the more developed countries of the world there are histories that exemplifies the difficulty of integrating health services with ICT's.

Healthcare is practiced within a highly distributed organizational network. Patients and clinical data are being sent back and fourth between specialists and generalists. Today, patients live longer and have a tendency to suffer from chronic diseases. This results in that they have to be monitored by several care providers located in different settings. If not done properly the health service will then, from a patient perspective, seem disorganized and time consuming. Hence, a lot of attention in the e-health area has been given to integrated care. Integrated care means that from a patients point of view, the health care should be seamless. This is while the care are coming from many different places and disciplines. ICT's are seen as one of the possibilities to make this a reality. ICT's can provide standardized information both faster and more accurate between the different actors in the health sector.

In a global perspective we can see that e-health are on the way. England has invested £12.8 billion in National Programme for Information Technology for the National Health Service. The Obama administration in the United States of America (USA) has committed to a $38 billion e-health investment in health care. Such large investments has been justified because technology like Electronic Health Records (EHR)'s, Picture Archiving and Communication Systems (PACS)'s, e-prescribing systems and Computerized Provider Order Entry (CPOE)'s will contribute to solve the problem of variable quality and safety in health care.

[33] [5] [30]

Some applications of ICT's being used to improve health care follows.

2.1.1 M-Health

Mobile health is a sub-field of e-health. It is health practice supported by mobile devices. These devices include:

- Mobile phones
- Patient monitoring devices
- Personal digital assistants

Essentially the use of wireless devices used to assist health care. This includes taking advantage of technologies like voice and SMS's, General Packet Radio Service (GPRS), 3G & 4G, Global Positioning System (gps) and Bluetooth. The emergence of m-health is occuring through experimenting with technologies in typical health settings. In order to fully see the benefits of m-health there is a need to move towards more strategic implementation. Policy-makers and administrators therefore needs the necessary knowledge to make the transition from pilot programmes to strategic large scale deployments. There are reports of up to six m-health programmes per country. The top m-health initiative are call centeres. The main barriers of m-health implementation are related to knowledge and information, such as assessing effectiveness and cost-effectiveness of m-health applications. Other barriers include conflicting health system priorites, lack of supporting policy and legal issues. The level of m-health activity is growing internationally, but evaluation of these activities are are very low. About 12%. Evaluation are of the inititives needs to be an incorporated part of the projects in order to ensure better results.

Data security and citizen privacy are areas that require legal an policy attention to ensure that users data are properly protected. Different countries will progress faster if they share global ICT standards and architecture. Cooporation in development of best practices will ensure that data can move more effectively between systems and applications. [20]

2.1.2 Electronic Health Records

EHR are patient centric medical records. These records can include a patients medical history and details of recent care, images, scanned documents and administrative data such as bed management and commission data. The users of EHR are usually clinicians, administrators and patients themselves. When medical records are digitized there are the added benefit of interoperability with other systems. Like with e-prescribing, linking patients with prescriptions. The benefits of implementing a EHR system are usually related to data storage and data management operations. Increased accessibility, legibility, manipulation, transportation and preservation to name a few. Leading to an overall increase in organizational efficiency and secondary uses.

The implementation of an EHR system also introduce some risks. These involve illegitimate access, increased time spent on documentation and make the patient-provider interaction seam less personal.

2.1.3 Picture Archiving and Communication Systems

PACS are clinical information systems are used for the acquisition, archival and post-processing distribution of digital images. Essentially, a system used to store medical images. Could be integrated with for an example EHR's. The benefits of implementing PACS relates to improved organizational efficient through time savings resulting from improved productivity of radiology services, reduced transit time and improved access.

2.1.4 Computerized Provider Order Entry

CPOE systems have the explicit purpose of transferring orders and return results. Clinicians typically enter, modify, review and communicate orders through this system and get laboratory test, radiological images and referrals results. The potential benefits are of course organizational efficiency as with most systems, but there are some risks involved. Like an increase of time spent on computer activity.

2.1.5 e-prescribing

E-prescribing refers to the system by clinicians to enter modify, review and communicate medication prescriptions. The system has the explicit purpose of transferring prescriptions from the prescriber to the pharmacy. These systems has the potential of reducing errors and in turn increase patient safety. There are usually an increase in productivity of pharmacists, decreased turnaround time and more accurate communication between the precriber and pharmacy.

2.1.6 Computerized decision support systems

Computerised Decision Support Systems (CDSS) uses clinical and demographic patient information to provide support for decision making by clinicians. The fundamental impact of these systems should be improved clinical decision making.

This gives an introduction to what e-health is and how it may be used, but it involves transitioning from the "old way" of doing health care to the

"new way". In health care there are little room for mistakes. Therefore the transition has to be carefully planned and closely monitored.

2.2 Transition Strategy

A transition is the process between the old and the new. The process of transforming systems. At some point one has to start using the new system and leave the old one behind. There is the source system, also referred to as the legacy system and the target system. There are different approaches to how one might go about such a task. At one end of the specter we have the Big Bang strategy, were we take on an revolutionary approach. A complete new system is developed, supporting all the required functionality. Then at some point, all actors involved switches to the new target system. This revolutionary approach usually comes with a high risk of failure. On the other end of the spectrum we have the evolutionary approach. Gradually one introduces new or equal functionality with a new system. Users of the source system has then more time to adapt to the new system before being introduced to more changes. There are some categorizations of introducing new systems, from revolutionary to evolutionary;

Redevelopment
: A complete new system is made from the ground up. Includes all activities from gathering requirements to deploying the system. Usually involves a lot of risk, but could be the most time effective solution.

Migration
: This approach tries to collect the best from both worlds. A target system are developed while the old one is running. The target system supports all functionality as the source system, but on a different platform. One can gradually make use of the new system.

Maintenance
: One makes local and minor changes to the system in order to support new functionality, but not enough to be recognized as a new system.

Wrapping
: Almost no risk, since it requires no real change to the system, but instead provides an updated interface for the source system. Although this way is low risk, this could complicate things later on. Making use of wrapping not only slows down the system, but also makes maintenance more complicated.

2.2.1 Migration

So, when redevelopment is to risky and wrapping is unsuitable, migration usually is the best way to go. This allows for both systems to co-exist while making the transition from one to the other. Good practice suggests that new functionality are not introduced while migrating to the new platform. One should wait until all of the functionality of the source system are assured to work before one introduces new functionality.

The Cut-Over

The cut-over is the last step in the migration process. It is how one chooses to shut down the old system and begin to use the new one. Here are three main approaches.

The cut and run When the target system is ready, one shuts down the source system. This makes the migration process very similar to re-development, with the exception of having source system functionality supported. Main drawback is that itdoes not give the users time to adapt.

Phased interoperability In this strategy incremental steps towards the target system is used. Replacing functionality over time and slowly moving towards target system until all functionality is replaced with the new system. Users of the system have the added benefit of gradually getting used to the new system. Also there are room for feedback from the users if they are unhappy.

Parallel operations In this strategy both systems are running at the same time. Both source and target system is operational. The target system is continually tested and only when it's fully trusted, the source system is disabled. This way we get all user on-board with the new system. Especially time consuming, but the safest way to go. Very suitable in health care situations where there are no room for errors.

[18]

2.3 Groupware

Groupware development is found among the developers. When the purchasers buy visible and expensive systems organizational change is likely. Upper managements is thus likely to commit to helping the system succeed. Social and political factors that affect the introduction of a system.

- job redesign
- job creation
- providing training
- restructuring to work around individuals who will not use the system
- positive leadership

Management is less committed to the less expensive applications or features. An organization will not restructure itself for each new application the way it does around a major new system. Therefore these systems must adapt to the organization and be fitted into existing work patterns and appealing to everyone who must support it.

2.4 Information and Communication Technologies in Developing Countries

Giving attention to ICT's in the developing countries are both rewarding and useful. The potential impact ICT's have in developing countries are much greater than in the industrialized countries. An innovative ICT's step in the industrialized countries may lead to some improvement in productivity, but focusing our efforts in the developing countries has the potential of a much bigger impact. The world problems of conflict, disease and resource depletion are first met by the poor. Although the more advanced economies of the world are not primary victims, it is beneficial to give these problems some attention. These problems may someday reach the industrialized countries someday through terror, disease epidemics and migration. Also there is the added benefit of making the poor richer leads to the poor buying more products. Win-win. In the 21st century economic, social and political life are increasingly becoming more digital. This is also the case for the developing countries. An estimate from 2012 shows that 34.3% of the global population has internet access. The computers entered the developing countries in 1954, Kolkata India. Initially computing was used in the developing countries in the public sectors for administrative tasks, but in the 1980's some saw ICT's potential for economic growth in the private sector. With the internet really catching on in the 1990's, giving much attention to ICT's and the political focusing on the international development, gave rise to Information and Communication Technology for Development (ICT4D) Initially computing was used in the developing countries in the public sectors for administrative

tasks, but in the 1980's some saw ICT's potential for economic growth in the private sector. The internet really grew during the the 1990's, giving much attention to ICT's. At the same time international development was moving up on the political agenda. Combines these two subjects gave rise the the concept of ICT4D. As a result, initiatives like telecenter was taken place. These were buildings housing computers giving people access to the world wide web. The initiative had some problems succeeding, but brought with them important lessons that are still challenges we are facing today. Sustainability, scalability and evaluation of systems in the developing countries are important topics to consider. The systems of the past had a tendency to fail to deliver, have a limited reach and was generally talked about as better outcomes than it in reality was.

The main goal of the future should be to give internet access to the remaining 65.7% of the population. With this goal in mind there are two ways to go. Either lean on existing technologies or wait for the technological innovations. Here it is possible to go both ways.

Introducing ICT's can done in three different ways. One could just set up an environment and make the users adapt to existing processes, work with the users and continually innovate making locally appropriate solutions or lastly just introduce the technology and have the users innovate on their own.

[17] [10]

The literature on the topic of ICT's in developing countries paints a gray picture. The success of IS projects are lower than those of the western countries like Europe and the USA. It is commonly dominated with themes like;

> Health information systems in South Africa: Braa and Hedberg (2002) reported widespread partial failure of high cost systems with little use of data.[9]
>
> IS in the Thai public sector: Kitiyadisai (2000) reported "failure cases seem to be the norm in Thailand at all governmental levels."[9]
>
> Donor-funded IT projects in China: Baark and Heeks (1999) reported that all were found to be partial failures.[9]
>
> World Bank-funded IT projects in Africa: Moussa and Schware (1992) reported almost all as partial— often sustainability—failures.[9]

The evidence base are unfortunately not that strong due to lack of literature and evaluation. The literature on ICT projects in developing countries

are growing, but there are a tendency to focus on case studies, this paper included. The lack of evaluation are often due to people who are performing these studies are lacking resources and capacity. Like academics. But from the literature there are some patterns seems to persist.

- Scarce resourses
- Little technology
- Missing skills
- IS-failure

In order to properly identify the different causes for failure we should try to define how something can be categorized as failure or success.

2.4.1 Success and Failure of ISDC

Total Failure An initiative that never is implemented or abandoned immediately after implementation.

Partial Failure An initiative where major goals are unattained or where there are significant undesirable outcomes.

Success An initiative where major goals are attained for most stakeholders and there are no significant undesirable outcomes.

> Focus on case studies: The literature on IS in DCs has grown, but it is a literature dominated by case studies of individual IS projects. Taken alone, these provide no basis for estimation of overall failure/success rates.[9]

Since there is a focus of case studies it is difficult to get an overall estimate for failure/success rates, but it generally points in one direction. High rates of IS-failure.

An overview of industrialized countries are presented in figure 2.1. In industrialized countries there is an estimate of $\frac{12}{60}$ to $\frac{15}{60}$ fall into the category of total failure; something like $\frac{20}{60}$ to $\frac{36}{60}$ fall in the partial failure category; and lastly the $\frac{9}{60}$ to $\frac{28}{60}$ are successes. For practical reasons like lack of technical and human infrastructure, developing countries should be performing worse than industrialized countries. Failure can be viewed as something positive. Like in a learning process, but it cannot be overlooked that continually failing keeps the under developed countries on the wrong side of the digital divide.

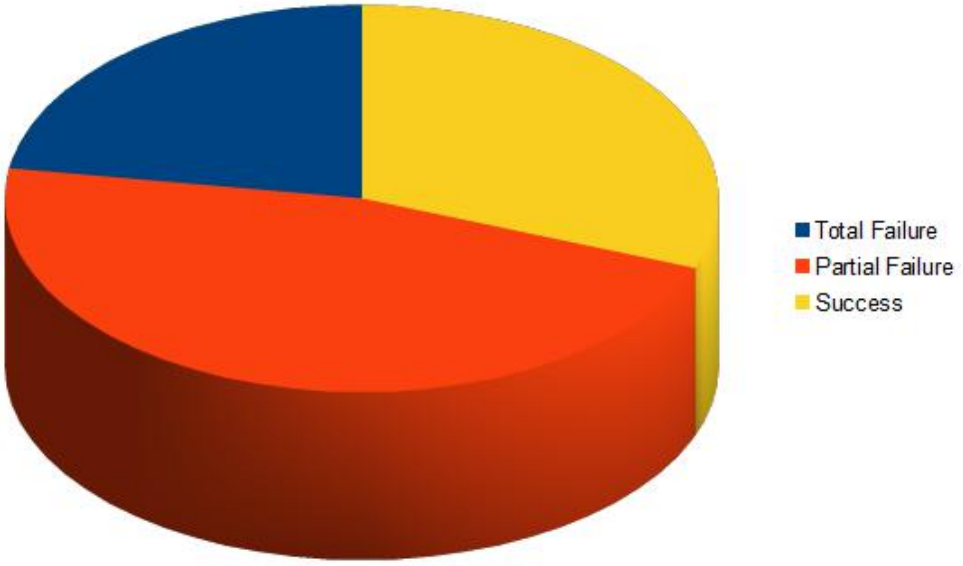

Figure 2.1: Diagram of average success and failures in **Industrialized Countries**

Borrowing terms from system transition, there are a higher risk of failure when moving to fast between source and target systems. Fast being a revolutionary approach and slow an evolutionary. Introducing ICT solutions from the industrialized countries would in fact become revolutionary seen from a developing countries perspective, even though they seem evolutionary from an industrialized perspective. The target systems are at very different stages. Introducing an ICT system in developing countries therefore involves bigger risks. ICT projects also are under a lot of pressure. Developing countries are trying to catch up with the industrialized countries, have high opportunity costs and usually have over optimistic expectations.

[9] [2]

2.4.2 Pitfalls in introducing IS in Developing Countries

The common reasons for failure are usually related to scalability, sustainability, assimilation in dysfunctional organizational processes and lack of persistence on key areas.

Scalability

Scalability failure are usually caused of waning political support, technological complexity, human resource capacity. It is the problem of moving expertise and system to new locations with the lessons learned. By conceptualize the use of ICT's one can make it easier to transfer ICT's to other locations, making it scalable.[19].

Sustainability

Common reasons for sustainability failure are by starvation of IS resources, loose political commitment and poor maintenance. There is a need to address the problem that arise when aid-funded projects stops being funded. How does one maintain a project that is built on temporary donors? One answer to this is by building on the locals capabilities and making projects that are socially embedded. The ICT project needs to be an integrated part of organizational practices, have the required financial resources, knowledge resources and political commitment in order to succeed. [19].

There are some different approaches to introduce ICT's in developing countries and some are trying to avoid the common pitfalls.

2.4.3 Discourses

The pace and direction are mostly set by the advanced economic in the world. The studies of ICT in developing countries are mostly set in Africa, Asia and Latin America. These studies highlight new topics in the ICT literature including national culture, global politics, provision of ICT resources for a community. By new topics there are also new approaches for introducing ICT's, usually with the involvement of social sciences. These three discourses generalizes these innovative approaches;

Transfer and Diffusion Discourse The Transfer and Diffusion discourse assumes that IS-innovations in developing countries are achieved by transferring technology and organizational structure from more advanced countries. Much like, "if it works here, it should work there". In order to succeed the receiving part should try to emulate what is being done in the more developed countries. Of course IS these ideas of best practice are somewhat adapted to fit their new context, but the underlying assumption is that the transferred methods result in the same outcomes.

Social Embeddednes Discourse This discourse assumes that IS innovation is about creating new techno-organizational structures given a lo-

cal social context. The new structures are built on the already existing structures and are a locally socially constructed course of action. The problems are seen from a local perspective and hence the solutions has to be an integrated part.

Transformative Discourse The last discourse is mostly concerned with creating possibilities for improvement of life conditions. It focuses on how IS can be used to facilitate deep socio-economic change. The social embeddednes discourse takes the local context into consideration, but the transformative takes it one step further and includes politics, economics and social conditions.

The transformative discourse raises more explicitly the strategic issues in the development struggle. A distinctive feature of IS research in developing countries is that it puts focus on e-governments, free and open software and the development of community resources intended to overcome the digital divide. Diffusion and transformative development does not facilitate the already existing structures of the context the technology will be placed within. The implementation of information systems from this perspective requires the environment and the people in it to adapt to the new technology. This will in turn increase the risk of the information system being rejected by the users. On the other hand, the socially embedded path will to some extent safeguard the underlying social structures by building upon what is already there. This might lead to unexpected results and be time consuming. Although, probably avoiding the sustainability pitfall.

[2]

2.4.4 Networks of Action

Networks of Action is a principle that sets out to remedy the sustainability failure of IS's in developing countries. A common problem with IS-initiatives, then especially action research initiatives, is that the fail to persist over time. Usually they fail to persist when researchers leave or donor funded projects stops. The basic principle is that the scale of the intervention will result in a more robust intervention. This changes most common perspective of seeing scale and sustainability as two different problems. Rather it views scale as a prerequisite in order to achieve sustainability. This argues for IS initiators to form alliances with surrounding network in order to succeed. Establishing networks creates opportunities for sharing experiences, knowledge and technology between different actors.

Building networks running on the same concept will make the ICT initiative more sustainable.

User participation is another tool one can use in order to make ICT initiative more sustainable. When the concept is accepted and made by the users they understand how and why it works and are more likely to accept it.

[19]

2.5 Information systems in the learning economy

In order for developing countries to take advantage of IS's, they must learn how. Research in developed countries has shown that learning is a critical factor for economic success. This is not just critical for firms and industries, but also for regions and countries. This makes learning a crucial factor for developing countries. Learning, being an interactive socially embedded process, are facilitated through the institutional setup or the national innovation system. It's efficiency very much depends on the circumstances. By making the environment facilitate learning one has the opportunity to increase learning, and in turn, better the economy and technology, making living conditions better. Through ICT, knowledge can be spread from one individual to another. By actively making ICT's available we also are making knowledge available and facilitating the learning process. So with efforts focused on ICT's, developing countries are able to learn faster by having greater access to knowledge and as a result having a better economy. This would actually just take the developing countries to a level already reached by the developing countries. So in order to really have an impact, they would need to have an advantage. Japan and USA have two very successful, but different approaches to learning. The one from USA has a focus on explicit knowledge. Here the focus is on reducing tacit knowledge into information with clearly defined processes and facts. A good example at this would be a step-by-step guide in order to learn something new. On the other hand Japan has more focus on making tacit knowledge. This is the knowledge that is almost subconscious. You don't necessarily know it as a set of instructions. This learning strategy are often built on the master-apprentice scheme focusing on co-operation, social cohesion and long-term social relationships. By acknowledging that there are two types of strategies, there must be a third that combines the best from both. Now, since success in the global economy are based on learning there are an opportunity here for the developing countries to not only advance to the level of the developed, but also have an advantage.

[23]

2.5.1 IT and Economic Growth

With IT comes the assumption that it will in some way enable economic growth [1]. Although it can be said that highly successful businesses is using IT it would be wrong to say that more IT equals more money. For an example. The simple view of IT being able to enable economic growth is not enough. It can however increase productivity in several ways by automating existing processes, but the potential of IT lies in new ways of structuring organizations. Time and space can be compromised significantly.

In the 1980's there was invested 750 billion $ in IT [1], but this only lead to 0.7% increase in productivity. This was a decrease from the previous decade. There is findings that suggests that ICT has a positive correlation with productivity. Data from 1983 to 1990 shows this for eleven Asia pacific countries [1]. May be a necessity in order to take part in the global economy and making it possible to trade. IT can also directly affect how organizations structure themselves by introducing new ways of working and increasing productivity. ICT should be used is withing the organization to enable better work processes, not automatize existing processes [8].

2.6 Outsourcing

Offshoring has it's spring from:

- globalization of trade in services
- Software commoditization
- Wage differentials
- Business friendly climate
- Growth of offshore labor pool
- Drop in telecom costs

China graduates four times more engineers than the USA pr. year. Before there were a differance in the quality of the engineering program, but the gap has narrowed. The talent was always there, but before those with talent would emigrate to industrialized countries. With globalization of trade in services we can tap into their services from anywhere. With low telecom

prizes, low wages and software commoditization industrialized countries are able to offshore their software activities more or less.

The wage factor are the most dominant factor for off-shoring. The global software work phenomenon is not the first of it's kind, but it differs in that it delivers a service rather than a specific product. It is well known that manufactoring and production are often moved to other low-wage countries. Parts of software development has now become such a commodity that firms from industrialized countries are able to outsource these tasks and keep the more high-level activity for themselves.

A useful way of understanding this context is via Vernon's *international product cycle*.

Stage 1: A new product begin with highly skilled entrepreneural activities, typically in industrialized nations.

Stage 2: Production begin to shift offshore via investments in low-wage nations.

Stage 3: As the product standardizes, it is mass produced with cheap, low-skilled labor.

Software has areas in all three stages. The high-level activities stay in stage 1 while being prepared as routine tasks of best practice, then moved towards stage 3 through stage 2.

Global Software Work opens up a market that are very different from others. The developing countries are here able compete under very different circumstances. Were the developed countries has to deal with high salaries the developing countries can benefit from having lower salaries and compete on cost. This makes the market highly dependent on the knowledge competencies. As discussed in section 2.5 a countries ability to learn has a great impact for developing the economy. Access to knowledge intuitively has a way of speeding up the learning process. And the most efficient way of getting to knowledge is through ICT's. Having the opportunity to compete on knowledge competencies can pace the way for developing countries. By focusing on learning the developing countries of the world are able to enter the market of ICT's with an advantage. Policy makers in charge of economic growth and infrastructure should therefore recognize this and facilitate both the learning process and the exportation of services. By focusing on this area of expertise development in other areas of industry are likely. Having a highly developed ICT infrastructure is likely to have spillover effects on the domestic services and production. Making opportunities for even new innovations. History has shown that there is a link between fortunes of the developed countries

and the developing. Rapid upgrades in ICT's have reduced the costs and increased the scope of operations all over the world.

A number of developing countries have nurtured software and ICT services industries able to compete in the global market, India being the most successful. Factors that account for success in the global market include technology and project management skills, copyright legislation and government industrial policy. By making an effort to outsource, there may be also be an increase to services offered to the domestic organizations. This in turn will have an impact on the overall developments of the country or region. It is hard to imagine that there are little technological use in a place that are among the top exporters of software. The spill over effect may results in local organizations running better, and this way offering better possibilities in the other fields as well.

[2] [28] [3]

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 $\$6858 \circ 10^6$, 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.

[11] [27] [34] [35]

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

[11] [32] [31]

3.3 Health Information System Programme

The 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 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.

[13] [12] [14]

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

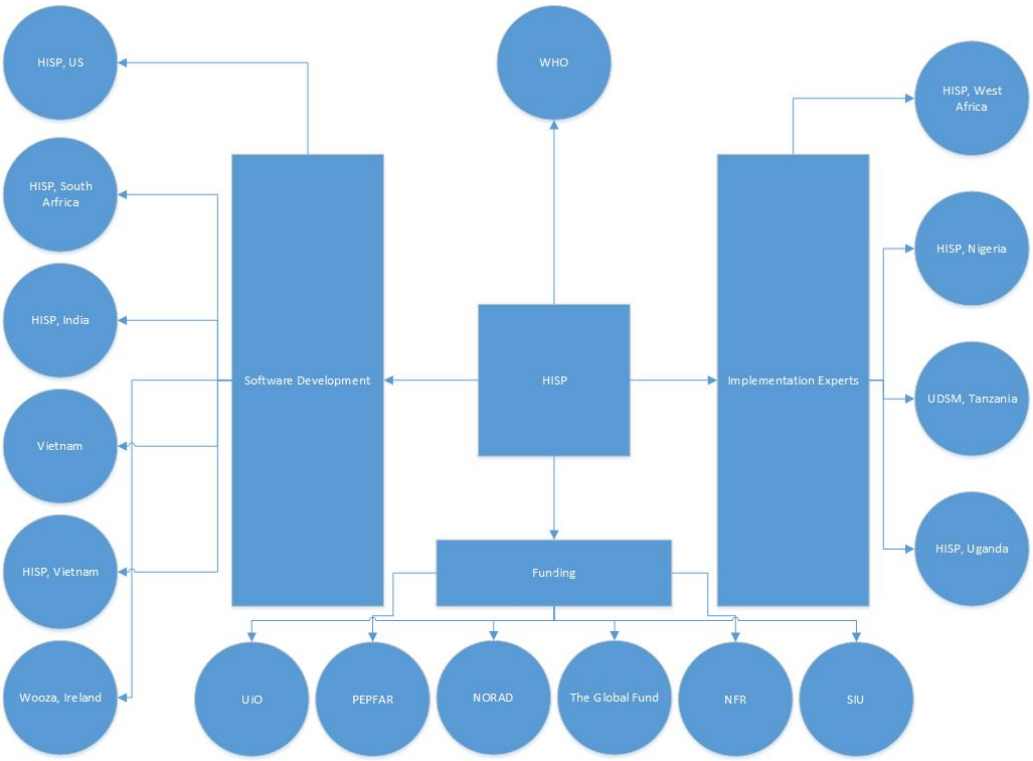

Figure 3.1: HISP Network of Action

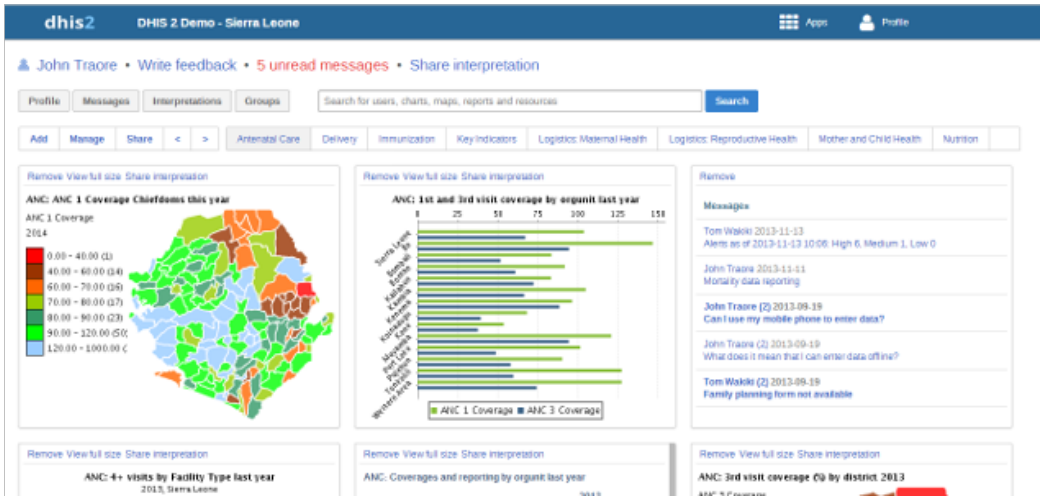

Figure 3.2: Screenshot of Dashboard

are based at the University of Oslo (UiO). This is were the core developers of DHIS2 are located.

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.

[16] [15] [19]

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

Phone Number:	2000
Message:	Stock condom11
Send	

Table 3.1: Example SMS

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. 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.

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.

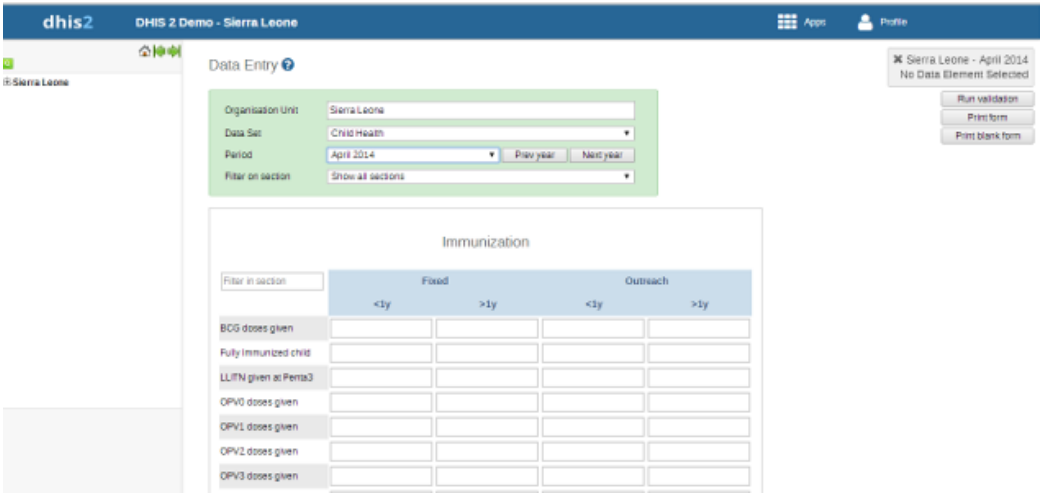

Figure 3.3: Screenshot of data entry in regular browser.

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 Graphical User Interface (GUI) that offers some 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.

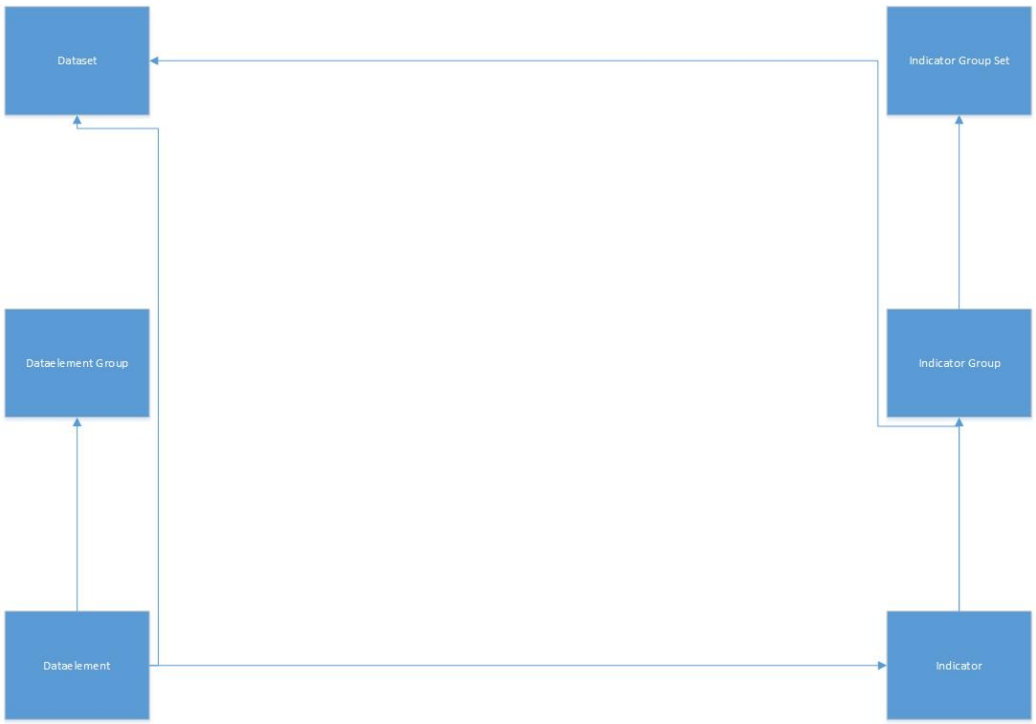

Figure 3.4: Basic Data Structure

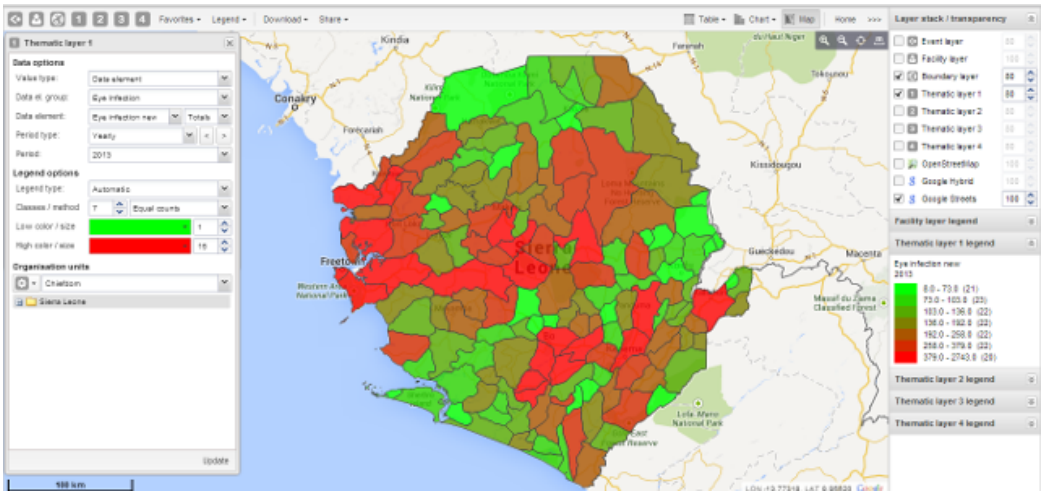

Figure 3.5: GIS Example

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 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

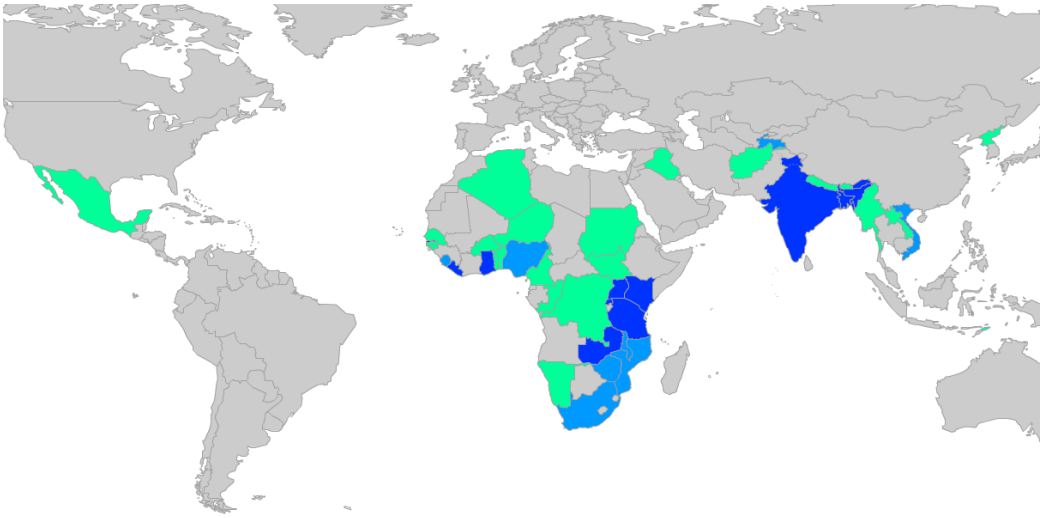

Figure 3.6: (Blue, National rollout)-(Light-Blue, Programs/partial)-(Green, Pilot/early phase)

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.

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.

[4] [17]

3.5 Administrative Structure

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

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.

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

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. [25]

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.

3.6 Health Management Information System in Rwanda

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

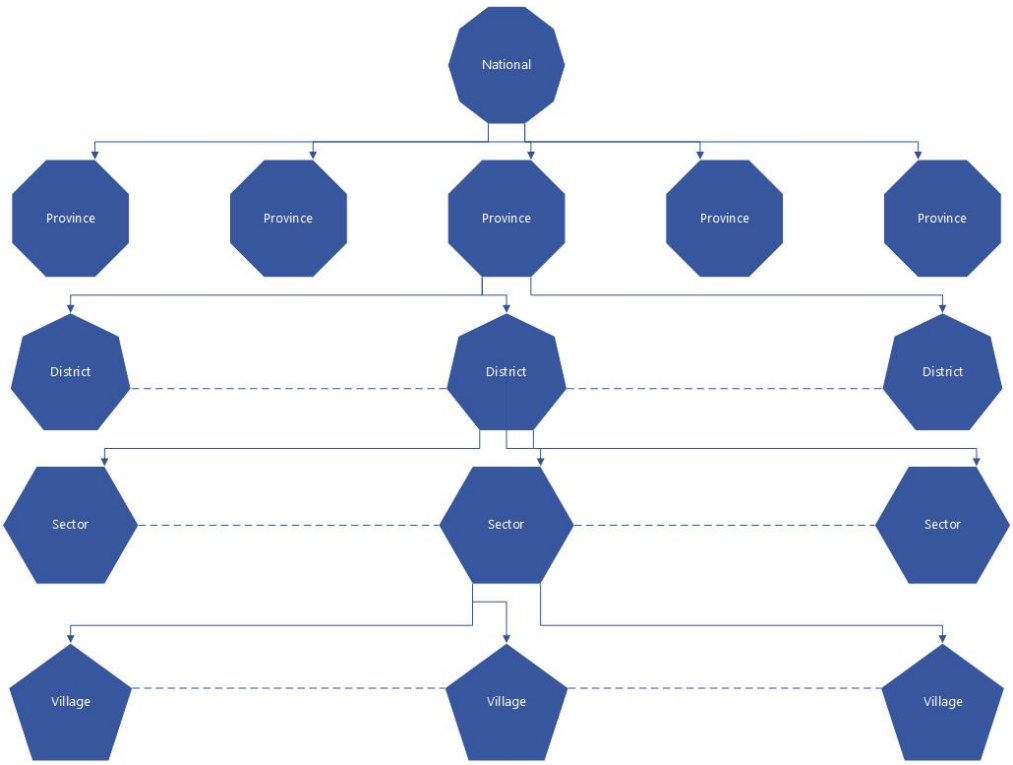

Figure 3.10: Rwandas Administrative Structure

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

3.7 Ministry of Health

3.8 Community Health Desk

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

[26]

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.

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.

[26]

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.

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 TB	

Table 3.4: CHW Tasks

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

Method

4.1 Action Research

Action research has it's origins in the USA around the 1940–50's by a guy named Lewin. He was applying social psychology techniques to practical social problems. Similar, but independently work was sone at the Tavistock Institute in United Kingdom (UK) around 1950–60's. At the institute they where trying to treat patients suffering from World War 2 experiences. They did not have a working theory of how they was going to heal the patients, but used a method that uses the basic principles of action research. They planned, acted and reflected on their interventions with their patients. By going through this cycle they were able to form a knowledge base. This knowledge base could then be applied when treating patients suffering from war trauma. Since then, action research has been used by proffesionals to investigate and improve own practises. In the most general terms, people are able to do research while doing their everyday jobs. Action research is most aplicable in problem situations where it's not has easy to use academic models like abstract hypothesis, mathematical proofs or lab experiments. Like in social settings where qualitative data are most useful while trying to make sense of the messiness of human interactions. In action research there is a focus on change and how the interventions play out in the real world. The action researcher are therefore usually a member of the team working in the chosen problem situation. This makes the researcher able to get an "inside" interpretation of the context of the problem. The action research cycle are often extended to include some extra activities. A action research project

Figure 4.1: The Basic Action Research Avtivities

Plan	Diagnose	Identifying the nature of the problem situation, including all interrelated factors and develop a working theory about the situation and how it maight be changed.
	Plan	Specifying actions that should allevieate the situation.
Act	Act	Taking action in the agreed area of application in line with the plan.
Reflect	Evaluate	Establishing whether the theoretical effects of the action were realized and whether they did indeed relieve the problem.
	Reflect	Deciding what has been achieved in terms of both practical outcomes and new knowledge. At this point there should also be decided if there is a need for another cycle.

Table 4.1: Five stage Action Research[21]

might be difficult to plan to the detail due to the nature of the problem situation. Action research takes place in a real life scenario, and are more difficult to control compared to for an example a lab. The planning of the intervention must therefore be highly adaptable.

> There is a conception that encourages a separation of theory from practice because published research is read more by producers of research than by practitioners. As a result, practitioners and their clients complain more and more frequently about the lack of relevance of published research for the problems they face and about the lack of responsiveness of researchers to meeting their needs. Action research is an answer to this problem.
>
> The term was introduced by Kurt Lewin in 1946. The process is conceibed as a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action.
>
> Action research facilitates the development of techniques which are called parctics. The practics would provide the action researcher with know-how such as how to create setting for organizational learning, how to act in unprescribed nonprogrammed situations, how to generate organizational self-help, how to establish action guides where non exist, how to review, revise, redifine the system of which we are part, how to formulate fruitful metaphors,

constructs, and images for articulating a more desirable future. Action research is a procedure for generating knowledge for understanding and managing the affairs of organizations.

4.1.1 Pitfalls

Post-rationalizing and retro-interpretations.

[24] [21] [29]

4.2 Research Analysis

This section will try to give an abstract overview of the research process in terms of activities drawn out from the content. A more descriptive representation follows in the chapter 5.

4.2.1 Diagnosis

The diagnosis activity in the action research are used to identify the nature of the problem situation. The main objective being to obtain a working theory of the context. In this research project it involved a series of steps. For starters it involved a preparing literature review that was supposed to work as a theoretical foundation from the academic community. Topics of interest were "ict4d", "ICT in developing countries", "E-health", "Action Research" and "transistion strategy". With this in mind we moved over to an introduction that was more case specific. This was provided by the HISP team in Oslo. One of the organization's involved in the problem situation. Here we discussed topics more technical and practical. Some problems that had common solutions to them were presented and a introduction to common technologies were introduced. At the same time important introductions were made so that all areas of expertise were covered before leaving from Norway to were the actual case took place, Rwanda. As a last part of the diagnosis and most significant to the problem situation were the introduction to collaborating partners of the HMIS team were I would work as member of the team while performing the action research. For starters we had meetings and briefings about the status. Documents where exchanged, introductions made and presentations where held in order to briefly get into the workings of the situation problem. In parallell with this, continuous email communication with representatives from the universities involved, the organization

HISP and the MOH. This in particular helped to smoothen out the misinterpretations that was made along the way. As a result of the diagnose a set of objectives were defined, elaborated in chapter 5.

4.2.2 Planning

While planning for the appropriate interventions we had to adjust to a plan already made by the HMIS team. Our interventions had to be aligned with the activities already agreed upon between the HMIS and the CHD. In order to achieve this we identified the parts of the plan that related to the objectives that resulted from the diagnosis. By combining the two we made it possible to combine the interests of the researcher and the organization. In order to facilitate the research process we made some adjustments to the setting of interventions. Due to critical time contraints we chose to set up a test environment to actualize the interventions rather than testing in a real scenario. Also this would make it more easy to test and make demonstrations for the clients along the way.

4.2.3 Intervention

The interventions was based on meeting the objectives resulted from the diagnosis. Actions taken were partly configuring the system already developed and partly developing new solutions. Actions concerning configurations were made by using the existing knowledge of the organization. The system was quite familiar to all of those involved. By combining the knowledge of the team and continually testing in the test-environment we were able to make evidence of our knowledge. Since some of the objectives were not supported fully, we decided to make an improvised development cycle along with the configurations. Developing supporting applications that would work as an integrated part of the system became a necessety when the objectives no longer were supported by the existing system.

4.2.4 Evaluation & Reflection

Optimaly we would have the users of the system evaluate it. Due to time constraints this was not possible for this research project. The evaluation of the project was done by presenting the solutions in the test environment in three parts. Firstly to the team members. Then to the clients and finally to the clients supervisor and advisors. The reflection part of the research cycle will come through with this paper as lessons learned. Another research cycle

1a	Did both the researcher and the client agree that CAR was the appropriate approach for the organizational situation?
1b	Was the focus of the research project specified clearly and explicity?
1c	Did the client make an explicit commitment to the project?
1d	Were the roles and responsibilities of the researcher and client organization members specified explicitly?
1e	Were project objectives and evaluation measures specified explicitly?
1f	Were the data collection and analysis methods specified explicitly?

Table 4.2: Evaluating RCA

was unfortunately not an option due to time constraints. It should be mentioned that the research looses half of it's learning potential since the cycle could not be completed within the timeframe set at the problem situation. Making the knowledge created by this research project only contributing to the academics and not the organization that hosted the project, which are in conflict with some of the problems that action research is supposed to remedy.

4.3 Evaluation of Research

Action research very loose boundries. This as caused some to argue that this type of research needs more rigor. In order to achieve this there are some helpful principles that can guide the aspiring action researcher. The prinsiples facilitate the type of action research now known as Canonical Action Research (CAR). This is the form of AR that is the most traditional. It generally has the structure outlined in table 4.1, with 5 steps in the AR cycle. In a orderly fashion we go through them here in order to get critical evaluation of the AR-project.

4.3.1 Researcher Client Agreement

The agreement between the client (MOH, glshisp) and the researcher was that the researcher should contribute to the organization as an intern. This

2a	Did the project follow the CPM or justify any deviation from it?
2b	Did the researcher conduct an intependent diagnosis of the organizational situation?
2c	Were the planned actions based explicitly on the result of the diagnosis?
2d	Were the planned actions implemented and evaluated?
2e	Did the researcher reflect on the outcomes of the interventions?
2f	Was this reflection followed by an explicit decision on whether or not to proceed through an additional process cycle?
2g	Were both the exit of the researcher and the conclusion of the project due to either the project objectives being met or some other claerly articulated justification?

Table 4.3: Evaluating the CPM

put the researcher role in the organization most suitable. As an intern the researcher would work on the configuration and development of the Community Logistics Management Information System (CLMIS) which was appropriate concerning the research approach. The project lacked specification prior to the start. This made it difficult to plan for the different preperations necessary. The client already had a big commitment to the project. Clearly a national system that would manage health supplies for the CHW's is something that are loosely commited to. Both political and technical initiatives was a driving force for progress. After the diagnosis we had pretty clear objectives that could be described as use cases. A drawback that comes from not being able to specify the focus of the project was the inability to prepare for more data generation methods. The project would tended to being focused on to much intervention which took time from the data generation and reflection part.

4.3.2 Cyclical Process Model

The project did follow the AR cycle in the beginning, but after had some deviations after the interventions started. The size of the interventions took up to much of the timeframe. It was then necessary to partly evaluate and act at the same time. Three demo's were conducted in order to evaluate our

3a	Were the project activitist guided by a theory or set of theories?
3b	was the domain of investigation and the specific problem setting relevant and significant to the interests of the researchers community of peers as well as the client?
3c	Was a theoretically based model used to derive the causes of the observed problem?
3d	Did the planned intervention follow from this theoretically based model?
3e	was the guiding theory or any other theory used to evaluate the outcomes of the intervention?

Table 4.4: Evaluating the Theory

progress. The reflection and lessons learned phase were conducted outside the organization, making another research cycle out of the question. The time frame of the project planned was therefore to narrow for the planned interventions.

4.3.3 Theory

As part of the diagnosis there was conducted a literature review that guided the research. There has been some complaints of little research data coming from developing countries. An AR project would therefore contribute to the qualitative database and should be of interest to the community. Theory have suggested that a lack of resources are a common problem in these situations and was also found to be true. Although resources here should be seen as technical expertise.

4.3.4 Change through Action

Both the client and the researcher was indeed motivated to improve the situation. The client as the initiater of the project and the researcher after investing much time found that the project was indeed worth while. The diagnisis of the project lead to clear objectives that easily could be translated to appropriate interventions. Since researcher and the client was "under the same roof" the interventions had to be agreed upon. Assessing the organizatin was done through the diagnosis. Unfortunately the lasting effects of the interventions could not be assessed. A report of the actions taken was

4a	Were both the researcher and client motivated to improve the situation?
4b	Were the problem and its hypothesized causes specified as a result of the diagnosis?
4c	Were the planned actions designed to address the hypothesized causes?
4d	Did the client approve the planned actions before they were implemented?
4e	Was the organization situation assessed comprehensively both before and after the intervention?
4f	Were the timing and nature of the actions taken clearly and completely documented?

Table 4.5: Evaluating Cange through Aciton

produces by the researcher and delivered to the organization. Like wise this paper will serve as documentation to the academics.

4.3.5 Learning through reflection

A progress report was made at the end of interventions. This was on the form of a trip report. As stated earlier, the reflection did not accour with the client and the research did not benefit from assessing the outcomes of the interventions. Through this paper and the trip report the acitvities would be documented properly.

[24]

5a	Did the researcher provide progress reports to the client and organization members?
5b	Did both the researcher and the client reflect upon the outcomes of the project?
5c	Were the research activities and outcomes reported clearly and completely?
5d	Were the results considered in terms of implications for further action in this situation?
5e	Were the results considered in terms of implications for action to be taken in related research domains?
5f	Were the results considered in terms of implications for the research community?
5g	Were the results considered in terms of the general applicability of CAR?

Table 4.6: Evaluating Learning through 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, CLMIS, 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 (ELMIS) 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 CLMIS 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 CLMIS with the national ELMIS in order to have interoperability between systems.

5.2 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.

5.2.1 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.

5.2.2 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.

5.2.3 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.

5.2.4 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 CLMIS database ready to be analyzed.

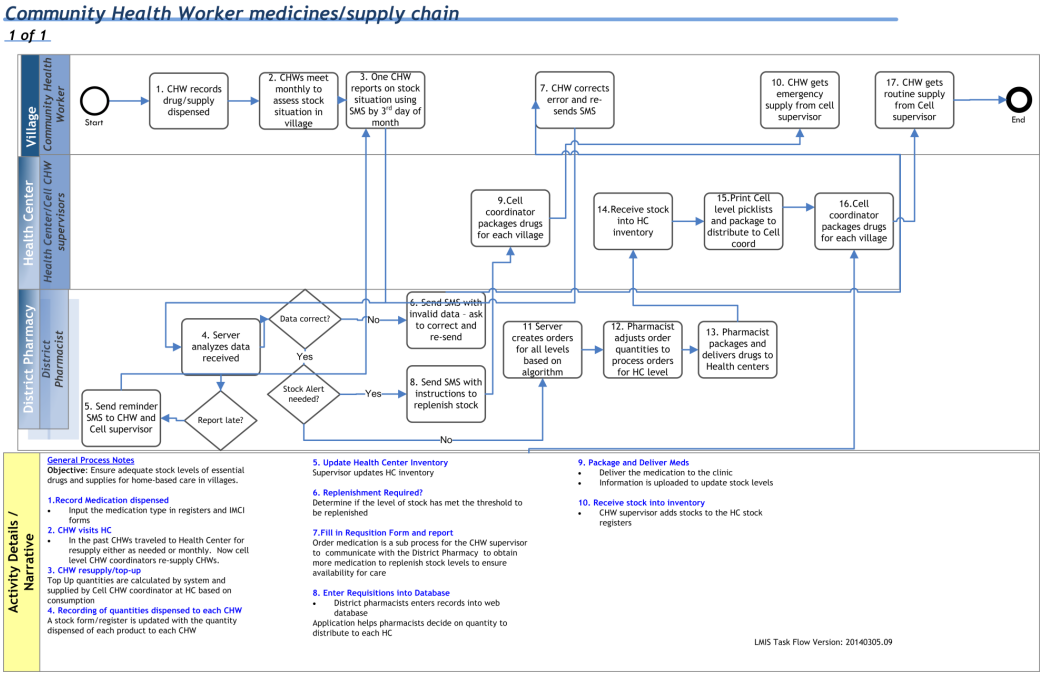

Figure 5.1: CHW Supply Chain in the Future

5.3 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 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. After 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

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

as long as the objectives were met. This puts our objectives in context of a bigger picture.

5.3.1 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 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.

5.4 Planning

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

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

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

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 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, default-supply 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).

Figure 5.3: Figure of SMS-flow

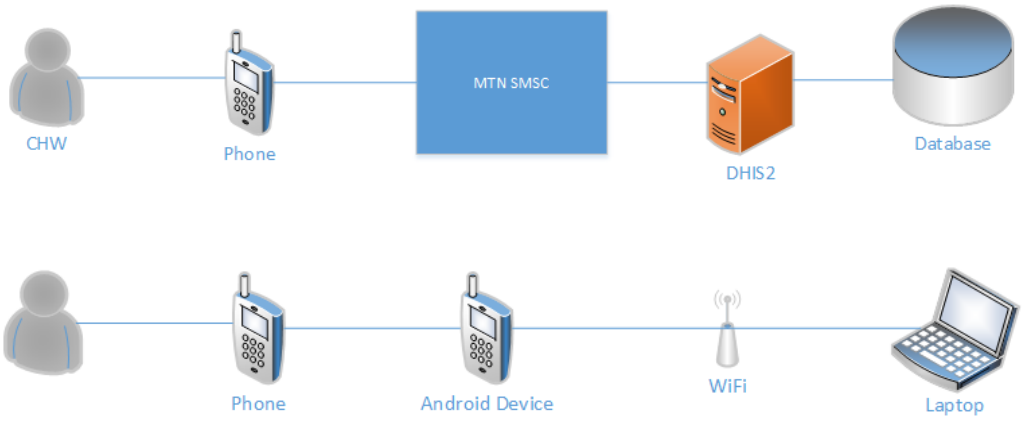

Figure 5.4: Figure of Test Environment

The CLMIS 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 CLMIS. 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.

5.5 Intervention

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

5.5.1 Setting up the Test Environment

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

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

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

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.

5.5.2 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 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.

Figure 5.5: Example SMS report

5.5.3 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 of DHIS2 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 English. DHIS2 is currently not supporting 'Kinyarwanda'.

5.5.4 Demo 2

In the second demo we presented showed how SMS reporting could be done with DHIS2. By using the test environment the users had the oppertunity to test the system for themselves. We made some codes for health supplies they suggested and showed how it was possible to report on them using different mobile phones. We took the oppertunity to show the clients some other functionality that could give them some ideas on what the data could be used for. They were pleased with the progress, but pointed out that there was a lack progress with the implementation of the reorder system.

5.5.5 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, CLMIS, 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 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 $\approx$ 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.

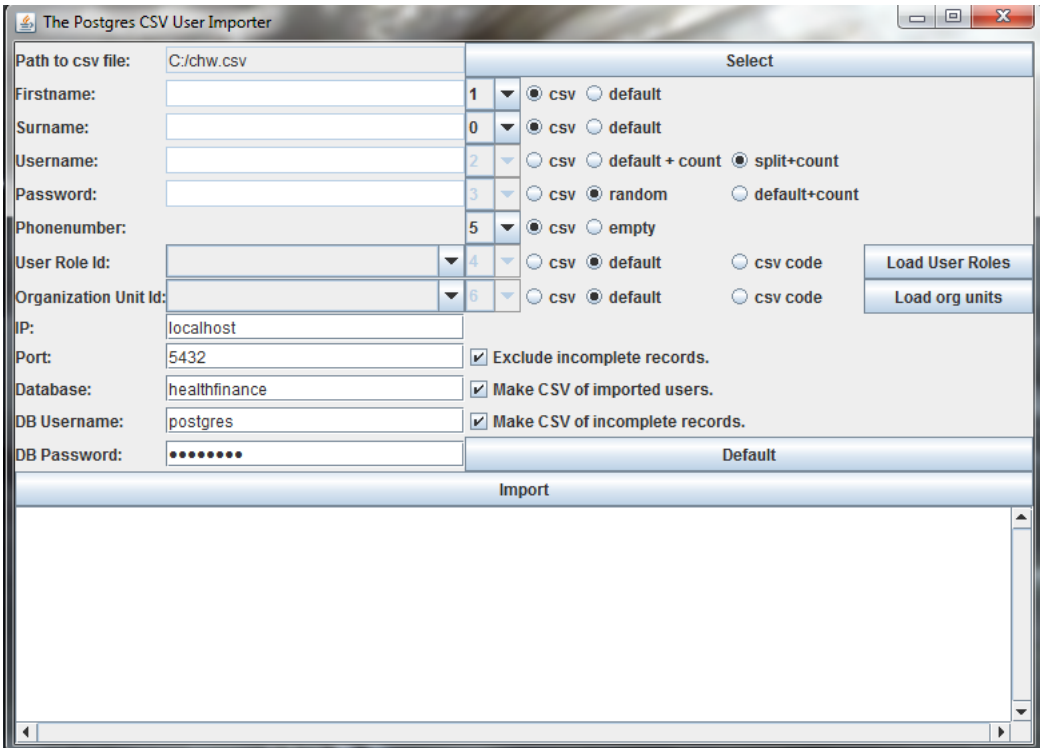

Figure 5.6: Screen Shot of the User Importer

5.5.6 Re-Supply Algorithm

The main purpose of the CLMIS 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.

$\mathbf{amc_n}$ 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.

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

$\mathbf{stk_n}$ 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.

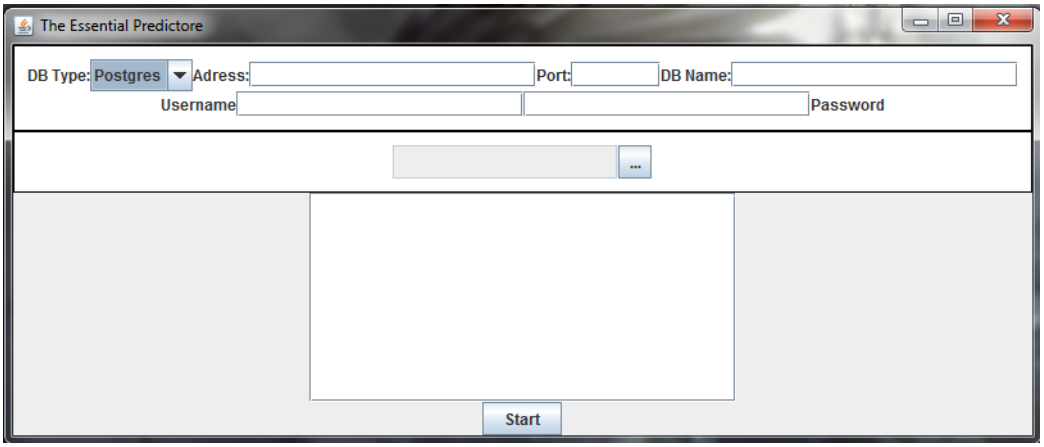

Figure 5.7: Screen Shot of the Essential Predictore

$\mathbf{rcd_n}$ 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.

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. As seen in figure 5.7, the applications takes as input the database information and a date. The application then calculates the values needed to update the tables in the DHIS2 database. DHIS2 has with the release after 2.15 made it possible to integrate DHIS2 specific applications. If there is going to be a next version of the application it's decided that this will be an integrated application rather than a stand-alone JAVA application.

5.6 Demo 3

This last demo served as an ending to the AR project. We presented the status quo and tried to find any misinterpretations between the CHD and the HMIS. The formula that was used to calculate the reorders of supplies had to be approved by two members of the CHD before it could be implemented in the CLMIS. We presented a typical scenario for a CHW one more time as in the second demo. Of course the project was far from finished, but the work that was done was approved by the members of the CHD. After the demonstration there was a discussion on how we should proceed with the work that was a consequence of the intervention. We agreed that one member of the HMIS team had the right technological expertise in order to continue the work and that the researcher should be available for a period of 6 months.

5.7 East Africa

5.8 DHIS2 Academy

Chapter 6

Discussion

6.1 Evaluation

In terms of meeting the objectives described in 5.2 there are still some work to do. In the time frame of this case we did not manage to make a system that was operable in a real scenario. This was largely due to delays in the system of bureaucracy. It cannot be stated clearly enough how this effects the development cycle of this project. This system has been planned for a long time. The first time we initiated the request for the SMPP protocol was at least 4 months prior to this particular case study. Adding 2 months during the case study we end up at 6 months of waiting. I will not go into details about the political decision making, but in order to explain why the project was mainly realized in a test environment is because of one signature that never made it to the paper. Because of this fact, I will continue to evaluate the project based on what we where able to realize in the test environment.

6.1.1 Objectives

The first objective (see 5.2) was clearly over simplified in the beginning. DHIS2 supports both sending notifications based on rules. The main problem was to generate the values the rules should use as thresholds automatically. So the objective should rather have stated that we should be able to integrate a customized algorithm that could use data from DHIS2 as input. The output should then be available in DHIS2 for presentation and further use. With "The Essential Predictore" we were able to do just this. The plan was to then use DHIS2 to send notifications based on a functionality called validation rules. We did not have the time to figure out if this was possible, but was told by the support team that it was very likely.

Objective	Category	Comment
#1	Partial-failure	We did not meet the main objective, but did clear out much of the work in order to meet the objective in the future.
#2	Total-failure	We did not meet the main objective in the time frame set for the case.
#3	Success	The main objectives were met, although only in the test environment.
#4	Success	The main objectives were met, although only in the test environment.

Table 6.1: Objective Evaluation

The second objective (section 5.2) was to send a reminder if a SMS report was late. Our initial idea was to use the validation rules in order to check if the report was sent. Like the first objective, we did not get the time to work on the validation rules and therefore were not able to implement this functionality.

The third and fourth objectives (section 5.2 5.2) were realized in DHIS2. After configuring DHIS2 we were able to both send and receive SMS in the test environment. This functionality was also presented to the CHD.

In terms of success and failure as discussed in 2.4.1 we can categorize the objectives. Assuming that the test environment is suitable to simulate reality, we have;

6.2 Reflection

The HMIS team had not only CLMIS to consider during the case study. Several projects including data quality, malaria, moving servers to the national cloud were running alongside the CLMIS-project. This resulted in divided attention of the team. Having a positive impact on the collective productivity, the divided attention also results in having to continually update team members. As a result, more meetings are needed and more presentations and more time spent.

6.2.1 Language

Language barriers are common when collaborating across borders. But in this study we found that there are also symbol barriers. Common misspellings were between the symbol for the letter 'l' and the number '1'. Also, between the letter 'o' and number '0'. These were pitfalls easy to avoid, but hard to take notice of. This was mainly resulted by the lack of schooling of the CHW's. In Rwanda there are currently three languages being spoken. English, French and Kinyarwanda. English is the working language, but both one cannot take for granted that everybody speaks it. This makes automatic feedback an issue. Developers may not be aware that the official spoken language is are not spoken by all inhabitants. DHIS2 has taken some actions to make all their messages customizable and support for customized feedback messages are just around the corner.

6.2.2 Programming

I took notice of the convenience of being able to program the software that we used. DHIS2 is an open source software with frameworks based on JAVA. Being able to customize DHIS2 on this level is essential to meet the clients and users needs. For now HISP has a developer team located in Oslo that is supporting the users requirements. DHIS2 is active in over forty countries. Clearly some local customization is in order. I would propose that every team that are using DHIS2 had some employee that are able make DHIS2 applications.

6.2.3 Power supply and Internet

Often taken for granted in the developed countries are stable internet and power supply. Every other day one could experience power cuts that lasted between 5 and 10 minutes. While not being a critical issue in these short terms, it did affect the productivity. Routers rebooting and interconnections resulting in downtime on servers are not easy to work with.

6.2.4 Creative Use of DHIS2

DHIS2 is developed to be used a certain way. All data should be located in the same database basicly being manipulated through the user interface. Our solutions to our problems did in some way circumvent this. By connecting directly to the database we were able to implement the algorithm and create bulk users. This may create some issues in the future. Like when creating

bulk users, the CHW's are not being part of the process. This may lead to unwanted outcomes on bigger perspective. The DHIS2 protocol for doing this is that someone in charge will register users in their area of responsibility. By bypassing the user involvement we are loosing the HISP characteristic of social-embeddednes.

Another example of creative use of DHIS2 is that instead of using one database several are used for different topics. Then, in order to have interoperability between instances, certain dataelements are transferred between the servers.

6.3 Rwandas ICT Transformation

The government of Rwanda has lately been wanting to become a knowledge based economy. This means that they want to trade knowledge for other kind of resources. The topic of interest is ICT's. In section 2.4.3 we talked about how ICT could be categorized into three different discourses of seeing Information Technology (IT)-innovations. The Rwandans perspective clearly have some similarities with the third discourse, *transformative Information Systems in Developing Countries (ISDC)*. Since Rwanda mainly exports coffee and tea there will be some significant changes in the way the country is both social and economical. With the goal of becoming the IT capital of Africa raises issues including social, political and economic issues. There are about 90% of the population that works in the agricultural sector where their main export are tea and coffee. Switching from agricultural to an ICT based economy will call for a large scale deep socioeconomic change.

Into this vision of Rwanda becoming a ICT/knowledge based economy, HISP fits right in. HISP's view of IT innovation is more like the social embeddedness discourse. Since these two discourses are much alike they also can co-exist. While the government is focusing the the socio-economic process the country needs to go through, it makes room for organizations like HISP to focus on the social-embeddedness of ICT innovations.

With becoming a knowledgebased economy a developing country can have great benefit from initiating projects presented in this case. Rwanda has the oppertunity to develop systems that are not yet present in the more developed countries of the world. They have the advantage of not being to reliant on legacy systems. This has the potential of making room for more advanced systems to be implemented. The knowledge and experiences that are generated by doing this can further be used to offer services that are not yet present in the developed countries. Particularly the services developed would be of benefit to other developing countries and thusly making the op-

pertunity for outsourcing possible. This of course requires a national effort in order to supply the much needed infrastructue, technology and learning oppertunities needed to take advantage. Also there are some businesses in the developed countries that are seeing developing countries as untapped markeds. Of course, some ethical problems here, but since there are businesses that see potential, local goverments should take this opertunity to take this initiative for themselves. Either by supporting local businesses or act on their own. A great deal of efforts have been done by relaunching services offered in the developed parts of the world in new areas were this type of services are seen as novelty. If there is a time when developing countries should sieze the opertunity to get on the technological train, it is now. Before outside actors take to much market shares.

[22] [11]

6.4 ICT to Facilitate Health Services

While talking to one of the doctors working as an volunteer in Rwanda she said:

> "It's hard to deliver the required services when we don't have the supplies needed in order to give them."

Another doctor said that he had over 50 patients a day.

> "I can't even treat a common cold with this amount of time"

Their was an estimate that there was about 1700 doctors in Rwanda and just under 1000 of these were practicing. A rough estimate of 12000 patients pr. doctor. Unreal, but very near reality in these type of curcumstances. This makes the community health workers an essential and vital part of the health system. In order to have these workers provide some kind of treatment they need supplies. This is what the CLMIS are supposed to facilitate. These systems are also known as pharmacy information systems. Such systems have the potential of reducing time to order medications and necessary supplies needed in order provide basic health care. Current systems implemented in Rwanda are paper based. Intuitively one can argue that an information system can greatly improve such a system. While DHIS2 are not currently designed to support all the necessary requirements of a pharmacy information system it has the potential of being able to be. It is open source and are currently supporting the local users to develop applications. Here would the local community of developing countries like Rwanda greatly benefit from

taking action. By developing their own application they are able to contribute to their body of knowledge, to their own health IS and in the future being able to offer these services to others. By implementing a pharmacy information system there are also the added benefit of getting medications at a lower price. The pharmacy information systems makes it possible to forecast medication requirements and therefore one might be able to order in bigger quantities.

6.5 Avoiding developing pitfalls

There are common pitfalls related to ICT-projects in developing countries. In this case by including the HISP-network the scale of the DHIS2 project is at a large scale. The HMIS team in Rwanda are cooperating with eats neighboring countries trying to define common indicators for the east Africa region. By scale we have effectevly bypassed the sustainability fall. HISP provides a large network that facilitates the process of continued action to meet the objectives set. Near the end of the AR-project the HMIS team participated in a East-African workshop were experiences with health information systems were shared. In the case there was a lack of development capabilities in the team. One of the key features with open source software like DHIS2 is that of being able to customize the software. This advantage was not exploited to the fullest. With a key team member that focuses on getting familiar with the source code and even being able to contribute to the further improvement of the software, the team capability would be greatly increased. This takes us to one of the common pitfalls ICT failures in developing countries. The lack of technological expertise or knowledge. During the case there were some discussion around the subject. Team members would argue that this was common wish among them, but due to attending meetings and being pulled in other directions there simply were not the time during business hours. This would then not be done within business hours, but up to the aspiring individuals to learn on their free time.

6.6 Importance of cell phones

Global internet penetration are estimated to be around 34.5%, the global mobile subscribers are estimated to be 95.5% per. hundred people. In Africa the internet reaches 15.6% of the people while the mobile should be able to reach about 69.3% per. hundred. With the introduction of smart phones, there will be a whole new line of services introduced through mobile cell

phones. Since the internet coverage are not that great in the developing countries mobile phones are a technology that effectively can reach most people. The introduction of m-health are already being rolled out in the developing nations, and are currently an effective way to offer services in the developing. There are already systems at work in the developing countries that provides some basic health care services. In our case we saw that mobile phones can be used to manage stock of supplies and medicines. With the introduction of smartphones there is an exiting future for the m-health. This will in turn provide CHW's with information of best practices and allow for pharmacy IS to become even more user friendly. As seen in the case description, the SMS based interface for the users are troublesome. There is a high chance of mispelling and writing the messages takes up much time.

[17] [6]

6.7 Vigor to developers

From the case we have that we were not able to proceed as planned because we needed support for a protocol. This is one of the cases were everything seemed to be on order, but due to critical factors that was out of awereness, we were not able to progress. This shows that there may be an organizational decision process that may need to include ICT representatives in order to achieve effective progress. It does not much good to have technology ready, but lack the vigor to act upon it. This argues for a perspective like the third discourse discussed in section 2.4.3. The people that are in fact developing the system need the right amount of vigor in ordre to implement the changes.

6.8 Transition to ICT

In developing countries we have a low level of integrated IS's compared to west. Now that the world are being more and more connected technologies are being introduced at such a rapid pace in the developing countries that it results in a revolutionary approch. This means we are know at a stage were the digital divide are pushing for change. It should be acknowledge that paper based systems are legacy systems. These systems have been by growned accustomed to by the users. The technology in the west has been adopted very fast, but it has been countinous process. The way that technology are being introduced in the developing countries can be seen an step wise, and by doing this introducing more risk for failure. As transition theory suggests, a "big bang" approach introduces more risk, while wrapping introduces the

least. Wrapping in this sense can be seen as developing countries are just using ICT to be able to communicate with the other countries and not as an integrated part of their day to day practis. The rush to decrease the level of digital divide may therfore be counterproductive. By introducing to much innovation at the same time can therefor expalain why ICT initiatives are failing. This connects the social embeddedness discourse with system migration. We therefore have in optional strategies like phased interoperability and parallell operations that could be applied to decrease the rate of failure in developing countries.

6.9 Investment

In groupware literature there is found that when purchasers buy expensive visible systems, upper management are likely to support it. This comes from the desire to get something in return for their investment. When first purchased suddenly there is a willingness to make way for redesigning jobs, create new positions, provide training and positive leadership. There are also cases were work are structured around individuals that will not use the system. [7] In our case this might be a contributing factor for why there was less interest in the attainment of the SMPP protocol. DHIS2, being an open source project, are not charging their users. This may lead to less commitment from managers and making it difficult to implement.

6.10 Knowledge resources

The type of technical expertise needed to be able to respond to continually changing requirements goes a little deeper than being able to configure one software. In the case the team had alot of knowledge relating to the software was being implemented, but there was a lack of coding expertise. This makes it difficult to take advantage of the open source software. One key feature is that on are able to custumize it as one see fit. Thats one of the areas that was missing in the team a developer or a developer team.

6.11 Untapped Marked

From a certain perspective one can see the developing countries as an untapped marked. By building up the countries infrastructure one has the opportunity to offer services that previously was not possible. Take Telenor and their agenda to offer insurance and banking services in the east. By

building up the infrastructure they can now offer their services as "mobile providers" and even expand their services to banking with a fresh market and less competition.

Chapter 7

Conclusions

Action research are definitely one of the more appropriate methods of doing research about ICT's in the developing countries. There are to many uncertainties and unexpected events that could distrupt a more strict research approach. When doing research coming from a country with more developed technology I found that I had a tendency to over simplify tasks. This lead to a unrealistic expectancy of progress and not being able achieve the right quality of research. This being a qualitative data based study, there are a need for more quantitative data studies in the literature. In the introduction I set out to find answer to why ICT's have a hard time being introduced when the technology are available. And how can we increase the success rates and improve the terms of conditions? My answer to this is that we continue to learn from our mistakes. There are language barriers that need to be addressed. People that are not yet being accustomed to the official language of both the internet and the countries. This leads to misspelling and literature being left unused. Activities like health care does not stop because English is not the spoken language, so the supporting systems have to adapt to these challenging circumstances. An uplift in technological expertise in the local area has to be lifted. While technology are presenting much opportunities like Skype and collaboration with different version control systems, it cannot fully replace the way people usually learn. Through social interactions. Therefore we have to build on the local expertise in order to really develop. This leads to the importance of social embeddedness of ICT initiatives. The development has to take on a local perspective in order to not introduce to much innovation at one time. At the same time to avoid the sustainability pitfall, innovations has to be at a large scale. Leading to a connected agenda and a deep socio-economic change that needs to be politically facilitated in order to succeed. By successfully introducing ICT's at this level the developing countries has the opportunity to become a part of the

learning economy and may be able to provide services as a knowledge based economy. Infrastructure and education are two key factors that measurable. By actively committing to improve these areas residents are presented with both the knowledge and opportunities to contribute to one of the ways out of poverty for the developing countries.

Bibliography

[1] Chrisanthi Avgerou. How can it enable economic growth in developing countries. *Information technology for development*, 1998.

[2] Chrisanthi Avgerou. Information systems in developing countries: A critical research review. *Journal of Information Technology*, 2008.

[3] Erran Carmel and Paul Tjia. *Offshoring Information Technology*. Cambridge University Press, 2005.

[4] Countries using dhis 2. `http://www.dhis2.org/deployments`, 2014. Accessed: 22-05-2014.

[5] E-health technologies show promise in developing countries. `http://content.healthaffairs.org/content/29/2/244.full`, 2010. Accessed: 10-06-2014.

[6] Global mobile statistics 2014 part a: Mobile subscribers; handset market share; mobile operators. `http://mobithinking.com/mobile-marketing-tools/latest-mobile-stats/a#subscribers`, 2014. Accessed: 25-06-2014.

[7] Jonathan Grudin and Andrew Clement. Groupware and social dynamics: Eight challenges for developers. *Communications of the ACM*, 1994.

[8] Michael Hammer. Reengineering work: Don't automate, obliterate. *Harvard Business Review*, 1990.

[9] Richard Heeks. Information systems and developing countries: Failure, success, and local improvisations. *The information society*, 2002.

[10] Richard Heeks. Ict4d 2.0: The next phase of applying ict for international development. *IEEE Computer Society*, 2008.

[11] Mikal Hem. Rwanda. `http://snl.no/Rwanda#menuitem0`, 2014. Accessed: 19-05-2014.

[12] The process of developing the dhis. http://www.mn.uio.no/ifi/english/research/networks/hisp/hisp-history.html, 2013. Accessed: 20-05-2014.

[13] Hisp. http://www.mn.uio.no/ifi/english/research/networks/hisp/index.html, 2014. Accessed: 20-05-2014.

[14] About hisp. http://hispindia.org/index.php/about-us, 2014. Accessed: 20-05-2014.

[15] Network of action. http://www.mn.uio.no/ifi/english/research/networks/hisp/network-of-action.html, 2013. Accessed: 20-05-2014.

[16] Hisp uio strategy. http://www.mn.uio.no/ifi/english/research/networks/hisp/hisp-uio-strategy-13.03.2014-2014-2016.pdf, 2014. Accessed: 20-05-2014.

[17] Internet world stats. http://www.internetworldstats.com/stats.htm, 2012. Accessed: 24-05-2014.

[18] Bing Wu Jesus Bisbal, Deirdre Lawless and Jane Grimson. Legacy information systems: Issues and directions. *Nuts Bolts*, 1999.

[19] Sundeep Sahay Jørn Braa, Eric Monteiro. Networks of action: Sustainable health information systems across developing countries. *MIS Quarterly*, 2004.

[20] mhealth: New horizons for health through mobile technologies. http://www.who.int/goe/publications/goe_mhealth_web.pdf, 2011. Accessed: 19-06-2014.

[21] Briony J. Oates. *Researching Information Systems and Computing*. Sage Publications Ltd, 2006.

[22] Overview of ict in rwanda. http://www.rdb.rw/rdb/ict.html, 2014. Accessed: 10-06-2014.

[23] Erik S. Reinert. *Globalization, Economic Development and Inequality*. Edward Elgar Publishing, 2004.

[24] Maris G. Martinsons Robert M. Davison and Ned Kock. Principles of canonical action research. *Info Systems*, 2004.

[25] Ministry of local government. http://www.minaloc.gov.rw/index.php?id=450, 2011. Accessed: 19-05-2014.

[26] National community health strategic plan, 2013. Accessed: 19-05-2014.

[27] Folkemengden. http://www.ssb.no/befolkning/statistikker/folkemengde, 2014. Accessed: 19-05-2014.

[28] Brian Nicholson Sundeep Sahay and S. Krishna. *Global IT Outsourcing*. The Press Syndicate Of The University Of Cambridge, 2003.

[29] Gerald I. Susman and Roger D. Evered. An assessment of the scientific merits of action research. *Administrative Science Quarterly*, 1978.

[30] The impact of ehealth on the quality and safety of health care: A systematic overview. http://www.plosmedicine.org/article/info%3Adoi%2F10.1371%2Fjournal.pmed.1000387, 2011. Accessed: 19-06-2014.

[31] Hutuer og tutsier. http://no.wikipedia.org/wiki/Hutuer_og_tutsier, 2013. Accessed: 19-05-2014.

[32] Rwanda. http://en.wikipedia.org/wiki/Rwanda, 2014. Accessed: 19-05-2014.

[33] Ross Winthereik and Signe Vikkelsø. Ict and integrated care: Some dilemmas of standardising inter-organisational communication. *Computer Supported Cooperative Work*, 2005.

[34] Gross national income 2012, atlas method. http://databank.worldbank.org/data/download/GNI.pdf, 2012. Accessed: 19-05-2014.

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