**UNIVERSITY OF OSLO**

**Department of informatics**

# Introducing a complex health information system in a developing country

## Case: The Gambia

Master thesis

60 credits

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# Abstract

The District Health Information System, version 2 (DHIS 2) is a complex health information system for collecting, analyzing and reporting health related data. DHIS 2 is free and open source and is implemented in many developing countries, such as Sierra Leone, Zanzibar, India and Vietnam. The Gambia implemented DHIS 2 autumn 2009/spring 2010 and is the case I've used for my research. It was the decided that DHIS 2 should be the official reporting tool for health data from January 2010. I had two field trips to the country during the spring 2010 and helped the Ministry of health in the implementation process.

The research goal of this thesis is to explore how a complex health information system can successfully be implemented, maintained and used in a context with poor ICT knowledge. In this thesis I show that conception-reality gaps when implementing a health information system play a vital role. Extensive training of health workers and computer technicians is also important to secure sustainability of the system.

I also show that data quality has been significantly increased after the implementation of DHIS 2 and that quality can be further increased. DHIS 2 has proved more user-friendly than previous reporting tools and thus contributed to ease the data entry task.

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# 1 Introduction

## 1.1 Context

The Health Information Systems Programme (HISP) was initiated as part of South Africa's Reconstruction and Development Program in 1994 (Braa et al 2004). A unified health information system (HIS) was desired to avoid fragmented information flow, and so the thought of the District Health Information Software (DHIS) was born (ibid). The first version of DHIS was based on Microsoft Access. Thus, even if DHIS itself was free, users were required to use licensed proprietary software. It was later decided that DHIS should be re-developed so it could be used without the need of proprietary software. The result was DHIS 2. DHIS 2 is web based and does not require proprietary software to run. DHIS 2 is implemented in many developing countries, such as Sierra Leone, Zanzibar, India and Vietnam (HISP 2010 a). January 2010 it was to be implemented in The Gambia.

## 1.2 Motivation

Through my studies I experienced a lot of focus on the oil industry and how to make Norway richer and better. My dreams for my future were however about how I can contribute to make the world a better place for people with lesser resources and possibilities than I have. When the research groups from the Department of Informatics presented their research fields for the new master students January 2009, all but one research group spoke about the oil industry and how the students will make a fortune when they graduate and start working. The research group that differed from the rest was the Global Infrastructure research group. When they presented their work in the third world, focusing on improving the health care situation in the countries, I had to contact them to explore the possibilities for writing a master thesis for their research group.

The head of the Gambian Health Management Information System (HMIS) discovered DHIS 2 and wanted to implement it in his country as the official health data reporting tool. The design and implementation would take place the autumn 2009, and it was decided that data should be reported through DHIS 2 from January 2010. As I finished my last courses at the University December 2009 I could thus travel to The Gambia the spring 2010 and help in the start-up period.

I was first introduced to DHIS 2 through some courses at the University and learned that if utilized good enough DHIS 2 can increase the quality of the reported data, and it can also make data collection and reporting easier for the health workers.

## 1.3 Research questions

Based on the background presented in section 1.2 I have chosen to explore the research questions presented below:

### *Research questions*

The overall research question is:

- How can a complex health information system such as DHIS 2 be implemented, maintained and used in a context with constrained and weak ICT knowledge, such as The Gambia?

To approach this question I will explore the following sub questions:

  - How can the needed human capacity be built?
  - Can the quality of the data be increased through the use of DHIS 2?
  - Can DHIS 2 ease data collection and reporting?

### *Research approach*

To answer these questions I had two trips to The Gambia with a total length of 13 weeks. In the country I worked with DHIS 2 implementation together with the HMIS head and the head of the MOH IT office. My research approach is described in more detail in section 3.2.

To learn from previous research on ICT in developing countries and the work of HISP, I have explored literature covering those topics. In more detail I have explored literature on system development in developing countries, as that is the primary field of interest for the research group I am writing this thesis for. As DHIS 2 is a health information system I have also investigated literature on health information systems in developing countries. DHIS 2 is a computer program, so I have therefore also read some literature on ICT in developing countries.

# 2 Literature review

In this section I will cover the areas of interest for my research. First, I will present literature on system development in developing countries. I will move on to ICT in developing countries, and finally I will present literature on health information systems in developing countries.

## 2.1 System development in developing countries

### 2.1.1 Design process

Prototyping and evaluation are important both in software development as well as in the implementation process of an HIS. Berg (1999) recommends an iterative approach to the analysis, design, implementation and evaluation of patient care information systems. The advantage of using an iterative approach to the design process is the early and continuous evaluation and feedback as the system is being prepared for deployment. The feedback helps reveal errors at early stages in the implementation process, lowering the cost for fixing the errors. Krutchen (2000) compares the iterative design process to the waterfall model in which, he states, "development proceeds linearly from requirements analysis through design, code and unit testing, subsystem testing, and system testing, with limited feedback on the results of the previous phases". If/when errors are discovered late in the implementation process, it will be costly to fix them, compared to if they were discovered earlier in the process.

Figure 2- 1 shows a model of a life cycle of an iterative design process. First, needs must be identified and requirements established before software design may start. Thereafter follow several work loops, consisting of prototype releases, evaluation, updating needs and requirements, redesign, new releases etc. Finally, when the last release passes evaluation, it can be deployed.

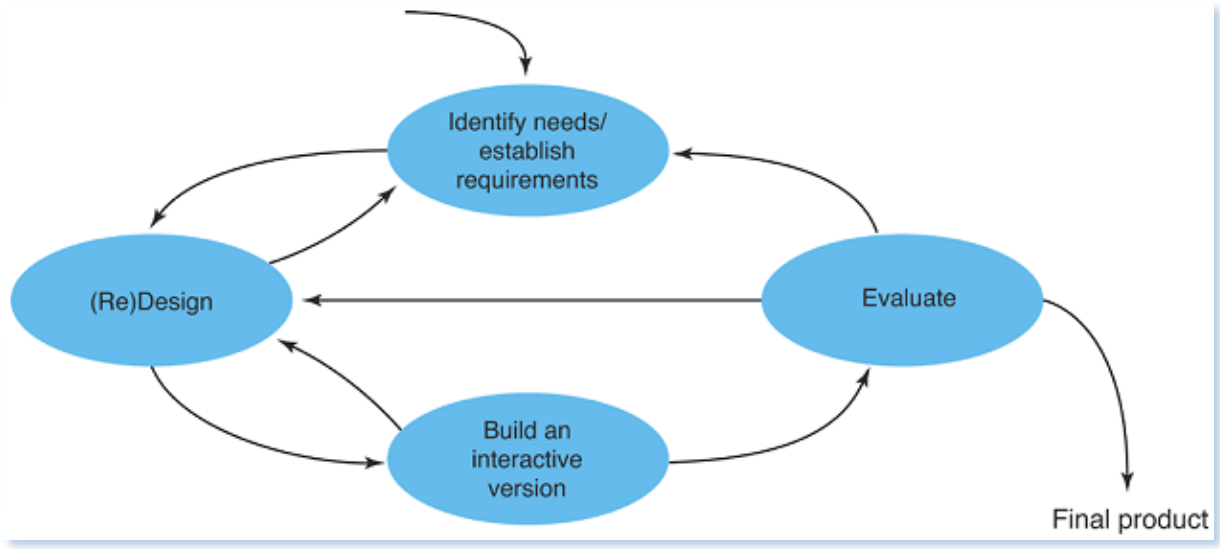


**Figure 2- 1** A life cycle model for iterative design
(Image courtesy of Sharp et al (2007: 448))

Some of the advantages of choosing an iterative design process are, according to Krutchen (2000), that misunderstandings and "inconsistencies among requirements, designs and implementations are detected early". Also he points to the fact that the workload of the testers is more evenly spread out during the lifecycle of the design process.

The overall quality of the product will in the end, he states, be better for products resulting from an iterative design process than for products resulting from a sequential design process. He explains this: "The system will have been tested several times, improving the quality of the testing. The requirements will have been refined and will therefore be more closely related to the users' real needs. And at the time of delivery, the system will have been running longer" (ibid).

### 2.1.2 Participatory design

Participatory design (PD) dates back to the 1970s, when Scandinavian research projects on user participation in system development started (Bødker 1996). Since then the attention from the Western setting has increased (Gould & Lewis 1985; Grudin 1991 a & b; Kyng 1991; Schuler & Namioka 1993). The action research had an explicit political agenda (Braa et al 2004) and "developed strategies and techniques for workers to influence the design and use of computer applications at the workplace" (Bødker 1996). Citing Nygaard, Braa et al (2004) claim that "[t]he strategy at the local level (…) was to develop knowledge about the technology in question and to actively propose alternatives to those of the management". The Norwegian Iron and Metal Workers Union (NJMF) project implemented this research approach as they "move[d] from traditional research to working *with* people, directly changing the role of the union clubs in the project" (Bødker 1996). The unions were thus able to "negotiate settlements and institutional arrangements ensuring a certain influence

over the process" (Braa et al 2004). Bødker (1996) states that the key issue of the Scandinavian action research projects was "building on people's own *experience*, providing for them *resources* to be able to *act* in their current situation".

Another central action research project is the UTOPIA project. It "was established as a response to the threat represented by new technologies to graphical workers" (Braa et al 2004). The Nordic Graphical Union and several Scandinavian research institutions were involved in the project, and they wanted to "develop alternative technologies controlled by the graphical workers' skills and perspectives". They set up a laboratory and developed prototypes, but due to the fact "that UTOPIA failed to forge alliances with a surrounding network of journalists and other professional groups", the prototype failed to be sustainable (ibid).

When it comes to software development, PD aims to involve all stakeholders when designing the software so that it can meet the users' needs and requirements (Participatory design, n.d.).

### *PD and HISP*

In a similar way as the UTOPIA project failed to forge alliances with a surrounding network, the NJMF project "failed to establish a network of workplaces pursuing similar strategies" (Braa et al 2004). Braa et al say that these experiences "identify the key criteria of a political agenda and sustainability shared by HISP" and state that a political agenda similar to that within the NJMF project is embedded in the HISP effort. The political economy of HISP, they state, is that

*"HISP represents a marginal, alternative, and, at times, opposing network relative to the significantly larger and dominating network through the WHO, various donor agencies, the World Bank, national health authorities, and large corporations selling hardware and software."*

Braa et al (ibid) claim that the HISP approach "reiterates the articulation from former Scandinavian-based action research of sustainability and scalability as key criteria in action research" as the HISP research's primary goal is to

*"design, implement, and sustain HIS following a participatory approach to support local management of health care delivery and information flows in selected health facilities, districts, and provinces, and its further spread within and across developing countries."*

Braa et al (ibid) present a figure which they say illustrate well the political agenda of HISP:

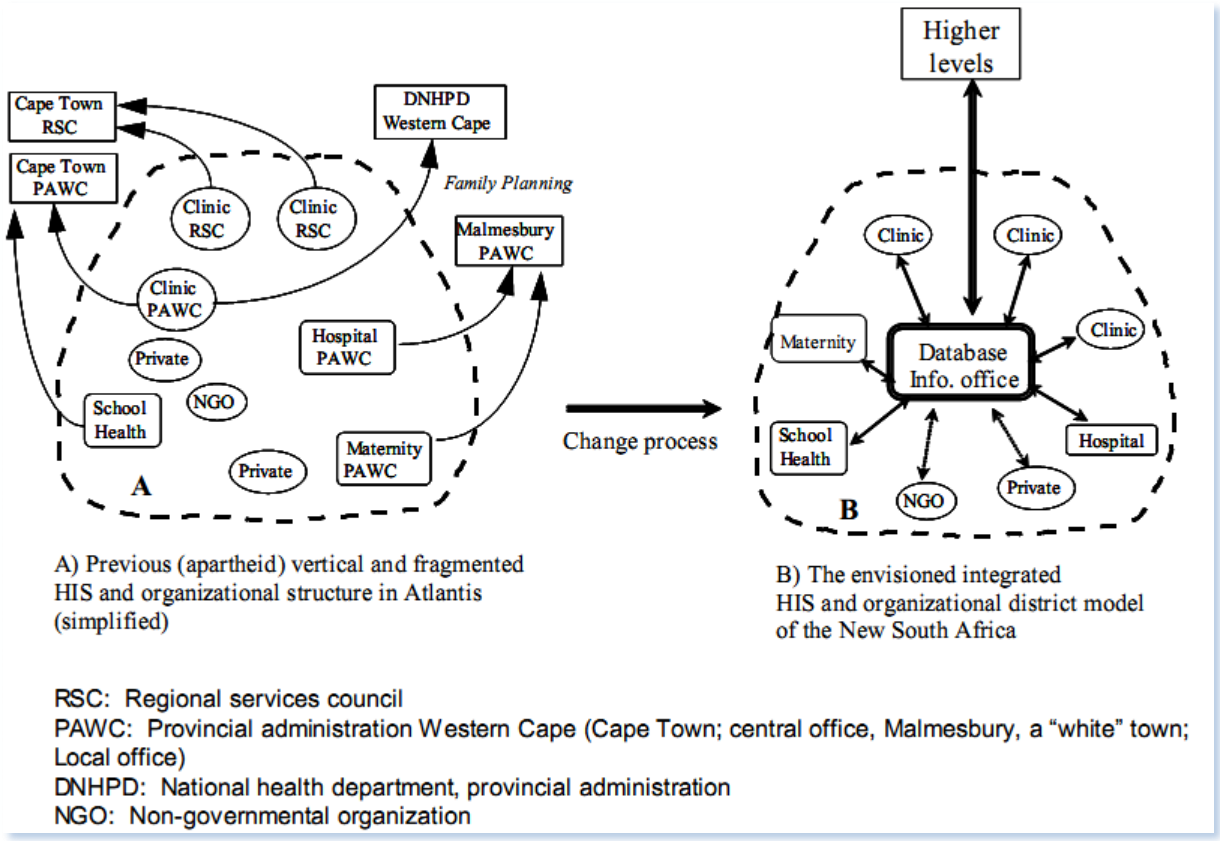


**Figure 2- 2** Drawing depicting the past and envisioned future information flows in the apartheid era "colored" town of Atlanits 1995 (Figure as presented by Braa et al (2004))

PD raises an issue when applied on software development in resource-constrained developing countries. Titlestad et al (2009) explore this issue by drawing on their experiences from their work within the HISP network. Both the lack of skilled people and the shortage of money in these settings make reliance on foreign actors necessary for developing good HIS'.

### South Africa

A good example of participatory design is the development of the first version of the DHIS software (in South Africa), where prototypes were released on a weekly – and sometimes even daily – basis, providing updates based on the users' suggestions for improvements (Braa et al 2004). The HISP network, who stands behind the development of DHIS, was initiated during the process of creating a unified HIS in South Africa after the apartheid. A professional software development team was later established to develop DHIS (ibid). The HISP team thus consisted of domain expert on both health care as well as computer programming.

### Sierra Leone (SL)

The Norwegian development team was not directly involved in DHIS 2 until 2008. At that time "[t]he customization for SL was organized as a collaborative effort between a software

company in Mali, and the team of coordinators and developers ion Norway (...)" (Staring & Titlestad 2008). Software issues, especially related to usability, were discovered and fixed, and through close cooperation with the users in Sierra Leone, "a Norwegian developer put in place a generic reporting framework" (ibid). As this framework was later presented on a workshop, it also quickly got popular amongst the other DHIS 2 development teams.

### 2.1.3 Top-down vs. bottom-up

Amonoo-Lartson et al (1984: 14) suggest a *bottom-up* instead of a *top-down* planning to meet the needs at the community level. Sæbø and Titlestad (2004) state that "an HIS that captures and uses data at local level is of the utmost importance". When choosing a bottom-up approach for the planning of the HIS, the local level's needs can be incorporated into the system.

***Case: Cuba***

In their field work in Cuba, Sæbø and Titlestad followed a bottom-up approach, identifying problems with *local* staff and having *local* trainings (Sæbø & Titlestad 2004). As the Cuban system is highly centralized, however, and things tend to be run in a top-down manner requiring control, it proved difficult to follow the chosen bottom-up approach. In fact they state that "the bottom-up approach followed will not succeed without political support at the highest level first" (ibid). Sæbø and Titlestad hence suggest that HISP adjust their approach to "a middle ground solution between the HISP bottom-up approach and the Cuban top-down approach". Furthermore they state that it is difficult to undertake a participatory approach in a culture where "people are used to agreeing with people in positions of power and are not used to opposing official views". Their conclusion is that in Cuba, with a highly centralized system, implementation must have a top-down approach, while the design process should use a bottom-up approach. They also stress that there often exista knowledge at local level that does not exist at the national level.

### 2.1.4 Prototyping

Titlestad et al (2009) claim that a key PD principle is to apply mutual learning processes to "bridge and blur the user-designer distinction from both directions". This requires that the designers understand the context in which the users live so that they can get a clearer opinion on the requirements of the system they are about to design. During the process towards a final product, prototyping and numerous face-to-face discussions are used as effective methods to reach the goal. But a threshold in this process is the significant lack in computer knowledge of the potential users for the system, hampering participation. Titlestad et al (ibid) suggest therefore interactive prototyping to deal with this threshold and claim that mutual learning processes often start with "exploration and struggle to make things work (...)." Furthermore they claim that a successful design team needs to include both software architects and domain experts. By sharing technological and contextual understandings (Kraut and Streeter 1995), knowledge gaps can be resolved in joint collaboration (Davis 1982; Oliver & Langford 1987). Correspondingly, Greenbaum and Kyng (1999: 143) state that

*"[u]sers, as well as professional designers, have knowledge and skills that are central to the design of useful computer applications; therefore, design needs to be organised as a cooperative activity between the users and the designers."*

Volkow (1998) concludes that it is important to take into account local conditions when developing information systems. According to Gumm (2006), however, mutual learning processes are difficult to accomplish, as "cultural and organizational differences often lead to misunderstandings".

### *Mozambique*

In Mozambique they used a participatory process when implementing DHIS 2, and that "process suggested that DHIS 2 was seen by all as a prototype rather than a ready-to-use software" (Puri et al 2004). The authors explain that reactions to the system were gathered through observations, interviews, workshops and training sessions and that those reactions were quite helpful: "These interactions helped to identify limitations in the prototype and implement suggestions for improvement" (ibid).

### *Boundary spanners*

*Boundary spanners* (Titlestad et al 2009) are described as mediators – persons traversing borders and thus make communication between designers and users easier. As the users of HIS' are far from software developers, the user-designer gap "can best be bridged by technically conversant people who are also adept at communicating with the core developer team." Referring to Finck et al (2004), who speak about using communication tools combined with a human mediator, Titlestad et al (2009) stress that such boundary spanners will understand the users' concerns, as they normally interacts closely with them, and at the same time they know some of the developers by name.

### 2.1.5 Cultivation of the installed base

According to Braa and Hedberg (2002), the design strategy followed in the South African HISP process can be denoted by the term *cultivation*, which they explain as "a slow, incremental, bottom-up process of aligning actors by enabling translation of their interests and gradually transforming social structures and information infrastructures where the resources already available form the base".

Braa and Hedberg (ibid) contrast the term *cultivation* to *construction*, the latter being explained by Hanseth and Monteiro (1998, ch 9), quoting Dahlbom and Janlert, as "selecting, putting together, and arranging, a number of objects to form a system". This is the opposite of cultivation, which they explain as interference with the natural process (ibid). Thus, while *construction* denotes the creation of a system more or less from scratch, *cultivation* is more about modifying the existing system/infrastructure. Quoting Braa and Hedberg (2002), cultivation of new standards "is then about transforming and changing the behaviour and routines of a social system" (ibid).

Hanseth and Monteiro (1998, ch 3) also stress that an infrastructure is never developed from scratch but rather "develops through extending and improving the *installed base*" – the already existing infrastructure. Furthermore they define an infrastructure as "an evolving shared, open, and heterogeneous installed base". It is *shared* by a community, *open*, meaning it has no limitations for the number of users, and it is consisting of *heterogeneous* elements. As an information infrastructure (II) is heterogeneous, "it becomes increasingly difficult to make changes when it expands, as the different elements of the II are so tightly interconnected" (ibid, ch 9). To change an II they claim that only very few components of the II can be changed at a time – "[t]he whole infrastructure cannot be change[d] instantly". Thus, the installed base will influence the design of the "new" infrastructure (ibid). Macias-Chapula et al (1998) also stress that "[s]ystems analysts/thinkers need to be aware of the interaction of all the elements that participate in the information system". If an information technology is to be "successfully" implemented, Westrup (1998) says, certain relationships, ranging from infrastructures to organisational characteristics, have to be put in place.

***Backwards compatibility***

When developing computer software, an issue to be aware of is backwards compatibility. "Backwards compatibility denotes the case when a new version of a product (…) functions also in conjunction with older versions of associated products" (Hanseth & Monteiro 1998, ch 9). Hanseth and Lyytinen (2010) state that whatever is added needs to be compatible with the installed base "and imposes constraints on what can be designed at any time" (ibid).

The concept of *black-boxing* should as well be mentioned when speaking of system development. Hanseth et al (1996) explain that "[t]he effect of black-boxing is that only the interface (the outside) of the box matters". As long as the interface looks the same, the inside does not matter. Latour (1999) also explains *black-boxing*: "When a machine runs effectively (...), one need focus only on its inputs and outputs and not on its internal complexity". Applied on ICT and system development this means that as long as the system offers the services it is supposed to, the complexity on the inside does not matter for the users.

## 2.2 ICT in developing countries

The third world has been and still is several steps behind the industrialized countries when speaking of industrial development. One can argue that the reason for this originates from the colonization of the third world and the great suppression the colonized countries were put under. Nevertheless, the developing countries are now far behind the industrialized countries in terms of knowledge, their economies and political governance and are thus dependent on cooperation with the industrialized countries to make significant progress within these fields. In fact, increased knowledge will also lay the foundation for a better economy and politics.

### 2.2.1 Research on ICT and IS in developing countries

Walsham et al (2007) state that there was at one time some debate on whether ICT was relevant to the developing countries. The answer, they say, is a clear "yes", and so the question is now *how* ICT can benefit development. ICTs have high potential value and can contribute to health delivery in rural villages as well as to software business in urban areas. Despite the importance of ICT in developing countries, Walsham et al points out that literature on the topic to date is relatively sparse. Sahay and Avgerou (2002) illustrate that, as they claim that there probably exist less than five articles that deal explicitly with developing countries in journals like *MIS Quarterly*, *Information Systems Research*, *Organization Science*, *The information Society*, *Journal of MIS*, and so on, for the past five years.

There are however signs that this is changing, Walsham et al (ibid) say, and mention that there are now special journals devoted to the topic (e.g. *IT for Development*) as well as special issues of mainstream journals (e.g. *The Information Society, 18*(2), 2002). Also the IFIP working group 9.4 (see below) on information systems in developing countries, established in 1988, has produced a number of volumes of conference proceedings, they say. Sahay and Avgerou (2002) explains that in May 2000 the IFIP working group 9.4 held a conference on "Information Flows, Work Practices and Local Improvisations" where they tried to shift the focus from "why are technology initiatives often failing in developing country contexts?" to "what can we do about it?". Furthermore, they state that

*"This shift in focus was also reflective of a larger trend in the field that acknowledged that no longer was it productive to debate 'are computers good or bad for developing countries?' but instead the need was to address the question of 'how can the potential of ICTs be harnessed to address locally relevant problems?'."*

Furthermore, Walsham et al (2007) say that in 2003 the IFIP working group 9.4 held a joint conference with IFIP working group 8.2 on "Organizational IS in the Context of Globalization". These activities, Walsham et al state, "provide further indication of a coming together of IS researchers whose interests span both developed and developing countries" (ibid).

Brown and Grant (2010) acknowledge the increased research on ICT and development. They have studied 184 journal articles and conference proceedings and propose a framework that suggests a partitioning of the existing literature on the topic into two distinct streams of research:

1. Those studies that focus on understanding technology "for development"
2. Those studies that focus on understanding technology "in developing" countries

They state that "[b]y explicitly separating the two research streams, each stream can focus on advancing the understanding of relationships specific to their individual agendas" (ibid).

### *IFIP working group 9.4*

The IFIP working group 9.4 is titled *Social Implications of Computers in Developing Countries* and has the following aims and scope (IFIP n.d.):

#### Aims

1. To collect, exchange and disseminate experiences of developing countries;
2. To develop a consciousness amongst professionals, policy makers and public on social implications of computers in developing nations;
3. To develop criteria, methods, and guidelines for design and implementation of culturally adapted information systems;
4. To create a greater interest in professionals from industrialized countries to focus on issues of special relevance to developing countries through joint activities with other Technical Committees.

#### Scope

1. National computerization policy issues;
2. Culturally adapted computer technology and information systems;
3. Role of transnational corporations, regional and international cooperation and self-sufficiency in informatics;
4. Social awareness of computers and computer literacy

### 2.2.2 ICT's influence on the third world

The One Laptop Per Child[1] founder Negroponte predicts the significant influence information and communication technologies (ICT) will have on developing countries as it brings knowledge to the people. For example for a school in a rural area where "there are no libraries and almost no books; the schoolhouse is sometimes a tree. To suddenly have access to the world's libraries – even at 4,800 bits per second – is a change of such magnitude that there is no way to understand it from the privileged position of the developed world" (Negroponte 1998).

Osterwalder (n.d) claims, referring to Negroponte, that many see ICT as an important tool for developing countries that can help them skip some stages of industrial development and jump right to the Information Economy, closing the gap on the developed world. Some sceptics will, however, have problems understanding how ICT can improve health and education for instance, as they cannot see how Internet connectivity can fight poverty. Sahay et al (2009) give an example on this matter from the health sector, quoting the Indian Commissioner's question to the HISP president: "How will your computers help to prevent mothers from dying in our health facilities?"

[1] http://laptop.org/en/

Osterwalder (n.d.) states that “the debate cannot be framed in these terms. (...) It is not a matter of choosing between ICT and health or ICT and education, but instead that of choosing the most effective way for ICT to help in the delivery of health, education, and small business development services.” POST (2006) supports this view, as it states that development and ICT are related, “since ICT can improve access to basic services, such as health and education”. It also points out that the introduction of ICT in developing countries is urgent, “since any delay puts developing countries at risk of being further marginalised”.

Technology in itself cannot solve social problems, Osterwalder (n.d.) concludes but is rather a “pre-requisite for economic and social development in our world”. Torero and von Braun (2005) stress that ICT is not a panacea ensuring development, but rather offers an opportunity for development. They mention three “Cs” when speaking of ICT – Connectivity, capability and content – and explain that “[a]ccess to information through ICTs is a question not only of *connectivity* but also of *capability* to use the new tools and relevant *content* provided in accessible and useful forms. Connectivity has been a priority, and it is a prerequisite for the other two ‘Cs’”. Considering the speed of the technology evolvement, however, they rather see the three “Cs” progress simultaneously.

### 2.2.3 The digital divide

The expression *digital divide* refers to the gap between people with access to ICT and people with very limited or no ICT access. Besides physical access POST (2006) lists six other factors that contribute to the disparities:

- **Lack of appropriate products**, as products are often not designed to meet the needs of the poor.
- The relatively high **cost**; 46 % of the sub-Saharan population lives on less than 1 US$ a day (Husby 2009).
- **Education** – a certain amount of technical skills are needed to benefit from ICT.
- **Language**, as ICT is dominated by English and many of those who can read only know a local language.
- **Human resources** – skilled ICT people migrate to the industrialized world and cause a lack of human resources to support ICT.
- **Lack of robust regulatory framework for ICT** – e.g. “[i]n Ethiopia 40% import tariffs on ICT equipment makes it too costly for all but the elite.“

#### *Bridging the digital divide*

POST (2006) proposes some ways to bridge the digital divide. Since open source software (OSS) is free of charge, OSS is “cheaper to acquire than proprietary software” and is thus more attractive than proprietary software for poor countries, as proprietary software often requires the users to pay licensing fees. In Kenya, LPAKenya (n.d.) asks: “Could software costs be cut, instead of government jobs, in order to reduce the deficit?” They want that

question to be investigated and further state that OSS counterparts to proprietary software obviously will eliminate licensing costs. POST (2006) refers to the One Laptop Per Child (OLPC) project to exemplify how the use of OSS can contribute to bridging the digital divide, as the OLPC computers are mainly open source based. The OLPC project's mission is "[t]o create educational opportunities for the world's poorest children (...)." Through the project they will also be connected "to the world and to a brighter future" (OLPC n.d.). Their vision corresponds to the United Nations' statement: "[T]he true meaning of what ICTs should be used for [is] to enable communities to find out more and to make choices and take decisions to improve their standard of living" (United Nations 2005:38).

POST (2006) emphasizes the responsibility of the national governments. By cutting taxes on ICT equipment and liberalising the markets, the ICT uptake might increase. Expensive taxes will make it hard for all but the elite to buy equipment, as exemplified with the Ethiopian example in the list above. To "raise awareness and generate demand" in the population, familiarising the people with ICT, is however necessary. Some say donor-funded telecentres have a role to play. Such telecentres offer "a range of telephone, computing, internet and information services" (ibid). The United Nations (2005) also conclude that telecentres "should be grafted onto existing infrastructure and existing customer bases to reduce start-up costs and to take advantage of existing infrastructure and connections".

### The UN and the MDGs

The international community must also be involved in bridging the digital divide. The United Nations (UN) launched the Millennium Development Goals (MDGs)[2] in 2000, aiming to reduce poverty and making lives better for the poor. ICT can be used in the work towards many of the goals and one sub-target of one of the goals explicitly says: "In cooperation with the private sector, make available the benefits of new technologies, especially information and communications" (United Nations 2010). As less than 5% of the people in the developing regions are fixed broadband subscribers, many of the "most effective development applications of ICT", which is requiring high-speed Internet connection, remain unavailable to far too many potential users (ibid).

### CNET's Bridge The Digital Divide

Other actors are also in the field trying to help bridging the digital divide. CNET Networks International Media has in cooperation with UK charity Computer Aid International launched the web site *Bridge The Digital Divide*[3] "to undertake the effort of bridging the digital divide between the developed world and the developing world" (CNET Networks n.d. a). They encourage both individuals and companies to donate money or computer accessories, as they see access to ICT as useful to "share information and raise awareness to combat poverty and injustice" (CNET Networks n.d. b).

[2] http://www.un.org/millenniumgoals/
[3] http://www.bridgethedigitaldivide.com/

### 2.2.4 Human capacity

Even though the technology exists in a country, someone needs to install and maintain it. The lack of skilled ICT people is one of the greatest constraints when it comes to ICT system development and maintenance in developing countries. Osterwalder (n.d.) stresses that "capitalizing on the opportunities of ICT depends (...) to a large degree on the existence of ICT related human capacity" and not only on the infrastructure and the access to the ICT. He divides the human capacities into three main groups, being related to infrastructure, sector application and users. According to these three groups he lists three requirements for the existence of ICT (also presented in Figure 2- 3):

- An infrastructure needs to be provided and maintained in a sustainable way, at a reasonable cost
- Local content needs to be available
- The applications provided through the ICT must be understood and used by the users

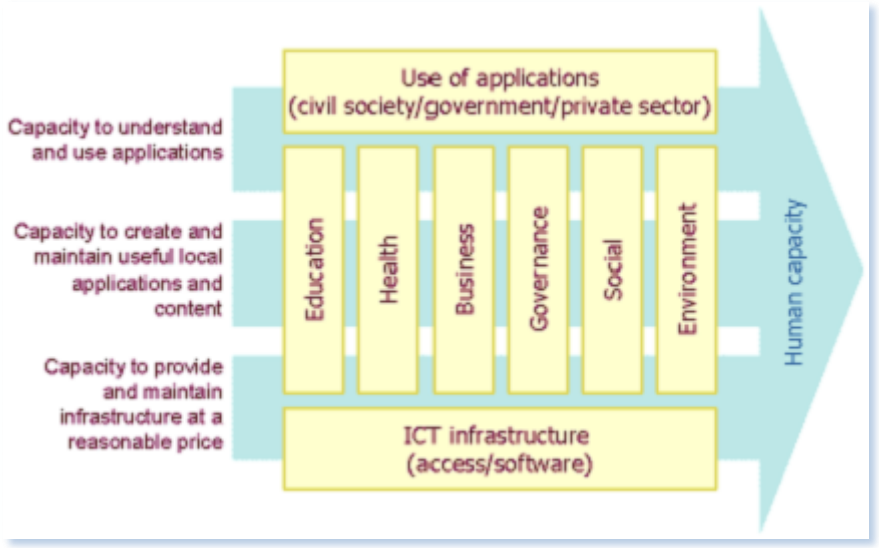


**Figure 2- 3** Cross-sectoral impact of ICT
(Image courtesy of Osterwalder (n.d.))

It is worth noticing that Osterwalder's requirements for the existence of ICT correspond to POST's (2006) factors contributing to the digital divide and the United Nations' (2005) reasons for why ICT penetration to a relatively high degree fails in developing countries. Osterwalder's requirements for existence are the cost of providing and maintaining infrastructure, usefulness and knowledge, and POST's corresponding factors are the high cost of ICT as well as human resources to support ICT, the lack of appropriate products, and language and education to understand the products. The UN mentions insufficient telecommunications infrastructure, expensive ICT access and shortage of requisite human capacity.

## 2.3 Health information systems in developing countries

Boerma (1991: 126) defines a health information system (HIS) as:

*"A combination of people, equipment and procedures organised to provide health information to health workers (and others) in a way that enables them to make informed decisions."*

According to Lippeveld and Sauerborn (2000), an HIS should support the following actions:

- Collection of data
- Transmission of data
- Processing of data
- Analysis of data
- Presentation of data
- Information use in planning and management

Correspondingly, the information cycle presented by Heywood and Rohde (2001: 21) contains the following phases for data/information management:

- Collect
- Process
- Analyse
- Present
- Interpret
- Use

There are many stories about implementation attempts of HIS' in the third world as well as in the developed world – some successful, many not. Heeks et al (1999) state that "the majority are likely to fail in some way" and claim that literature proves that most health care information systems (HCISs) fail. They list four main forms of HCIS failure:

- **Total failure**
  Immediately abandoned or never implemented
- **Partial failure**
  Unattained goals or "significant undesirable outcomes"
- **Sustainability failure**
  Initially success, but fails after a while
- **Replication failure**
  Succeeds in a pilot area, but cannot be repeated elsewhere.

### 2.3.1 The conception-reality gaps and the ITPOSMO model

To explain why so many HCIS implementations fail, Heeks et al (ibid) use the *ITPOSMO* model to look at the "gap between current realities and the design conceptions" (See Figure 2- 4). The greater the gap is, the greater the risk of failure. They state that "success and failure depend on the size of gap that exists between 'current realities' and 'design conceptions of the HCIS'". An example of a successful HCIS implementation is *ComputerLink* (Brennan & Ripich 1994), they say, "because of its limited conception-reality gaps".

The seven dimensions in Heeks et al's (1999) ITPOSMO model are

- Information
- Technology
- Processes
- Objectives and values
- Staffing and skills
- Management and structures
- Other resources, such as money and time

Their simple figure also demonstrates the model:

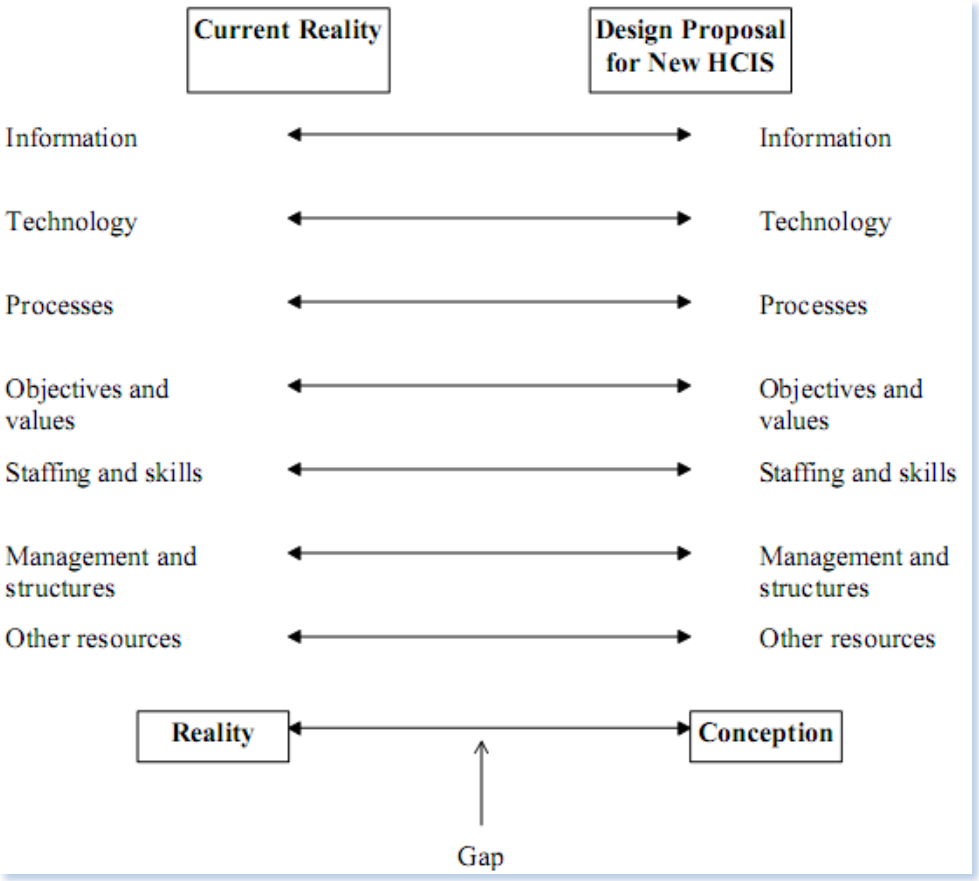


**Figure 2- 4** The ITPOSMO Dimensions of Change for Health Care Information System Proposals (Image courtesy of Heeks et al (1999))

By analyzing the conception-reality gaps of the implementation of an H(C)IS along these seven dimensions it should be possible to predict to a certain extent whether the implementation will fail or not. Or, if an H(C)IS implementation already has failed, the ITPOSMO model can be used to locate the possible reason(s) for the failure. Further, Heeks et al (1999) list "three archetypical conception-reality gaps (...) which make failure more likely to occur":

- The behavioural reality is different from the "hard rational models of organisation" which the HCIS is derived from
- A private sector HCIS is attempted implemented in public sector
- The cross-country transfer of a HCIS, especially from an industrialized country to a developing country

### 2.3.2 Several actors and fragmented information flow.

Fragmented information flow is very common in developing countries. That is often caused by the numerous actors involved in the health services in the countries. Unfortunately cooperation between different actors is relatively uncommon and the actors tend to introduce their own HIS' for reporting the data they are interested in. This leads to fragmentation of the information flow and thus poor data quality. The Health Metrics Network (HMN) proposes the integration of essential data in a shared repository (Titlestad et al 2009) to reduce this problem.

#### *Case: Malawi*

In Malawi, Chaulagai et al (2005) state that until 1999 there were too many uncoordinated systems used to gather information for the health services. The data reported were thus of bad quality and hence rarely acted upon (ibid; Kanjo et al 2008). Further, referring to publications from the Malawian Ministry of health and population (MOHP), Chaulagai et al (2005) state that "[v]arious national vertical programmes imposed their unilateral data requirements upon frontline staff, resulting in duplication and wastage of time and resources". The different programmes in Malawi operated vertically and there was very little coordination between the programmes. MOHP tried to harmonise the national HMIS so that all data from all actors would be reported through the new system, but in 2006 parallel reporting systems still existed, and the information flow was thus still fragmented (Kanjo et al 2009).

One of the reasons for the existence of parallel reporting systems in Malawi is, according Kanjo et al, that HMIS reports quarterly, while many actors are looking for monthly data, "resulting in the vertical programs establishing their own reporting systems" (ibid). Another reason is that the HMIS is not capturing all data elements that the different programmes are interested in, while a third reason is that some "line managers at district level are sometimes

required to make reports or provide data that is not part of the HMIS data as required by 'some bosses at the top' for record-keeping purposes" (ibid).

Further they state that weaknesses in the Malawian HMIS have "lead to high cost of reporting against multiple frameworks, more fragmentation, lack of standards and overburdening the data collectors among other things". In fact, Kanjo et al's findings show that the reporting requirements distract the primary providers of health care at facility level from their primary responsibility of patient care.

### 2.3.3 Implementation challenges

#### *Lack of skilled personnel*

When implementing computerized HIS', such as DHIS 2, there is no way around the fact that a certain degree of technical skills are needed to use and maintain the system. The problem, however, is that generally in developing countries the technical competence of the population is very poor. The implementation of the Family Health and Information Monitoring System (FHIMS) in India is an example of an HIS implementation that failed due to lack of skilled personnel: "The Health Department had limited technical competence and few dedicated resources for software support, and, thus, the application had limited value on the ground. (...) No data had been entered in this software in 78 of the district's 84 clinics during the previous 12 months" (Sahay et al 2009). Heeks et al (1999) also confirms that lack of technical competence can lead to implementation failure, and they give an example of an implementation of an HIS in the Philippines that failed, due to lack of technological infrastructure and skilled people.

#### Training. Case: Malawi

Training is an essential part of the implementation process of an HIS. Kanjo et al (2008) state that "[t]raining and retraining of health workers is critical for sustaining the system". When restructuring the HMIS in Malawi, including the implementation of DHIS 1.3, a cascade-training approach was used (Chaulagai et al 2005). The six month long orientation on information management and use was done by training groups from each district and the central hospitals, who in turn trained other health personnel within their jurisdiction. The results of the training proved that "people could perform much better with 2 half-day practice-based training sessions, than their colleagues with 5 days training in a classroom setting" (ibid).

### 2.3.4 Data quality

For data to be relevant so it can be acted upon in an appropriate way, data need to be of good quality. According to Shresta and Bodard (2000), data quality "refers to the degree to which the data or statistics measure what was intended to be measured when the data collection system was designed". They emphasize, however, that the higher data quality required, the higher the data collection cost will be, so even though the primary function of an HIS is to provide data, there must be "a trade-off between generating the highest-quality

data and the cost associated with collecting it" (ibid). They claim that there are not many decisions that require extremely precise data, but it should be considered which level of quality is desired to support unbiased decision-making.

In a manual developed by the EQUITY Project[4], Heywood and Rohde (2001: 42) list five requirements of good quality data:

- Available on time and at all levels
- Correct, complete and consistent
- Reliable and accurate enough to support decisions
- Represent all recorders of similar data
- Comparable, i.e. using the same definitions of data items

If data are not on time, it will lose its relevance to the decision makers, as "[o]ld data is of historical value only" (ibid). Heywood and Rohde also stress the importance of comparability: If the same data are not collected using the same tools, they are not comparable.

### *Poor data quality sources*

The quality of the data has improved enormously since the implementation of DHIS in South Africa, according to Heywood and Rohde (ibid: 43). Errors are still present, however, and some of the most common sources of errors are listed in Table 2- 1:

| Error | Example |
|---|---|
| Missing data | Data items for whole months are missing |
| Duplicate data | Multiple counting of a fully immunised child |
| Thumb suck | When data collection tools are not used routinely, staff just fills in a likely-looking number (often using preferential end digits!) |
| Unlikely values for a variable | A man being pregnant; low birth weight babies exceeding number of deliveries |
| Contradictions between variables | 100 births in a month where there are only 2,000 women in childbearing age |
| Calculation errors | Mistakes in adding |
| Typing error | Data is wrongly entered onto the computer |
| Capture in wrong box | Condoms distributed in the place of intra-uterine devices |

**Table 2- 1** Common sources of errors (Heywood & Rohde 2001: 43)

### Rearranged data

Shresta and Bodard (2000) point at rearranged data, such as graphs and figures, as a possible error source, as such presentations rely on information manually specified by a user. They give a hypothetical example where a programme manager wants to show the values of a data element for the rural *District X* in year *1996*, but by mistake presents the *1994* values

[4] http://www.msh.org/global-presence/equity.cfm

for the urban *District Y*. Shresta and Bodard claim that the district confusion might be discovered, but without reviewing the programming code it is unlikely that the confusion of years will be discovered.

### Inadequate staff skill

Furthermore Shresta and Bodard (ibid) mention inadequate staff skill as a reason for inaccurate data reporting, as the staffs' understanding of the definitions of the data elements play a vital role in data collection. These are "innocent" reasons and unintended, but still, they are contributing to poor data quality.

### Intended false-reporting

On the other hand they mention intended reporting of false/inaccurate data as a factor contributing to poor data quality, often due to the fear "that repercussions will occur if the employee does not attain a particular level on a performance indicator" (ibid). They show that such fear is not unwarranted by describing some reasons for intentional reporting of false data, followed by real life examples:

- The performance of health centres are being compared
    - Reporting false data on coverage for preventive care
- Avoid litigation
    - Underreporting number of visits because the fee paid by some patients was illegally kept by the health provider
- Impress supervisors
    - Exaggeration of the number of supervisions performed

## *Ensuring data quality*

Heywood and Rohde (2001: 43) suggest visual scanning as the most effective way to control reported data. They emphasize visually checking of *correctness*, *completeness* and *consistency*. Whether data is within normal ranges, all facilities have reported and whether the data is in the same range as a comparable time period or facility can easily be verified using visual scanning.

Furthermore they mention that the DHIS software can be used to validate data, as it can use validation rules and also check whether reported data values are within the accepted range.

### Routines when data are missing

Shresta and Bodard (2000) discuss the problems regarding poor recording and reporting of data and emphasize the importance of having consistent protocols for the treatment of missing data so that the quality of the final data can be determined. Further they stress that instructions on how to fill out forms, aggregate and handle missing data should, if possible, "be included in the forms since staff rarely refer to separate instructions".

### Double data entry

When it comes to data entry onto the computer, Shresta and Bodard claim that there are many institutions which require double data entry to reduce the errors. The computer program will then accept the data only if the data value are the same both places.

### Simple design of the information system

Shresta and Bodard (2000) suggest that the design of the information system is kept as simple as possible:

- Cards, forms and registers used for data collection are designed simply and have clear instructions
- Indicators are valid, sensitive and specific
- The number of levels in the information system (IS) are minimized to avoid errors during transfer and processing of data
    - The collector and the user of the data should be as close as possible
- Staff should use calculators when calculation is needed

### User involvement

If users are involved in the design of the system, it will increase ownership and promote general understanding of the system, ensuring relevant data are collected, leading to improved quality of the produced data.

### Design of data collection instruments

Sometimes it might even be useful to change the wording of a question or try different types or layouts of the data collection forms.

### Incentives

Shresta and Bodard (ibid) claim that "[t]he best incentive is to ensure that data collected are useful to the data collector". If data collectors cannot act upon the data they have collected, why should they care? Heywood and Rohde (2001: 43) also claim that "[t]he worldwide experience is that the more that information is used by people who collect it, the more accurate it will become". If data are required at a higher level, data collectors often need motivation to collect those data. Correspondingly, the Health Metrics Network's (2008) proposes a framework in which an HIS stimulates dissemination and use of data, and they state that an "essential step in strengthening health information systems is to link data production to data use".

Shresta and Bodard (2000) suggest positive feedback, acknowledging the work of the data collectors, as opposed to feedback aimed at punishing workers who do not meet the prescribed goals. If supervisors perform spot checks, monetary incentives may also improve the data quality. Shresta and Bodard points out, however, that history has shown that health personnel can falsify data in order to increase the reward.

### Checking procedures

Further, Shresta and Bodard (ibid) claim that checking procedures can improve data quality in a cost-effective way. They suggest that "[s]upervisors should systematically devote part of their time to verification of procedures and providing feedback to staff". Another routine that should be in place is cross-checking of data, "by collecting the same data through different means" (ibid).

### Training

Finally Shresta and Bodard highlight training as crucial to ensure data quality. They state that the "[d]ata collection instruments, data processing, analysis, and decision-making should be part of the national curriculum in schools of nursing and medicine". Also, as Kanjo et al (2008), they stress that refresher courses on the IS are important. As crucial training is, however, it is not sufficient for ensuring data quality in the long run. It "needs to be organized in an environment that promotes quality assurance through a system of accountability, positive and negative incentives, and control" (Shresta & Bodard 2000).

## 2.4 Summary

In this section I have reviewed literature on system HIS, ICT and system development in developing countries.

### *System development in developing countries*

Kanjo et al (2009) and Krutchen (2000) suggest an iterative design process for system design. Errors are likely to be revealed at an early stage and thus cheap to fix. Participatory design (PD) aims at involving all stakeholders so that the users' needs can be met (Braa et al 2004; Bødker 1996; Participatory design, n.d.). HISP seeks to follow a PD approach in their work (Braa et al 2004), but Titlestad et al (2009) claims that PD raises and issue when applied on software development in resource-constrained developing countries. HISP wants to do system implementation bottom-up, but experiences from Cuba suggest that a middle ground solution between a bottom-up approach and a top-down approach should be considered (Titlestad et al 2009). PD proved successful when developing DHIS in South Africa (Braa et al 2004). Braa and Hedberg (2002) state that the design strategy in South Africa can be denoted by the term *cultivation*. According to Hanseth and Monteiro (1998, ch 9), cultivation is interference with the natural process. When cultivating the installed base – the already installed system – only few components can be changed at a time (ibid). Backwards compatibility is important, so that updated systems are compatible with previous versions (ibid; Hanseth and Lyytinen 2010).

### *ICT in developing countries*

Torero and von Braun (2005) stress that ICT is not a panacea ensuring development, but rather offers an opportunity for development. Sahay et al (2009) show that not everybody

understands how ICT can improve health care. POST (2006) states that ICT can improve access to basic services, and Osterwalder (n.d) says that technology is a pre-requisite for economic and social development in our world. The expression *digital divide* denotes the gap between people with access to ICT and people with very limited or no ICT access. POST (2006) suggests that open source software can contribute to bridge the digital divide and refers to the One Laptop Per Child project as an example. The UN has launched the MDGs aiming at reducing poverty and making lives better for the poor (United Nations 2010), and CNET Networks has launched the web site *Bridge The Digital Divide* to undertake the effort of bridging the digital divide (CNET Networks n.d. a). Osterwalder (n.d.) points out that not only infrastructure and ICT access matter but also that ICT related human capacity is important. For ICT to exist he claims and infrastructure is needed, local content must be available, and the users must understand the applications provided through the ICT. His requirements correspond to POST's (2006) factors contributing to the digital divide and the United Nations' (2005) reasons for why ICT penetration to a relatively high degree fails in developing countries.

### *Health information systems in developing countries*

Heeks et al (1999) state that the majority of HCIS implementation attempts fail in some way and list four main forms of HCIS failure: total, partial, sustainability and replication failure. They present the ITPOSMO model as a tool to analyze at the gap between current realities and the design conceptions along seven dimensions.

Numerous actors involved in health services in a country tend to cause fragmented information flow and thus poor data quality. In Malawi there were too many uncoordinated systems used to gather information (Chaulagai et al 2005). Some results were duplication and wastage of time and resources. Kanjo et al (2009) found that reporting requirements in Malawi distracted the primary providers of health care at facility level from their primary responsibility of patient care.

Sahay et al (2009) and Heeks et al (1999) both give examples on HIS implementations that failed due to the lack of skilled personnel. Kanjo et al (2008) stress the importance of training and retraining of health workers to sustain the system. Chaulagai et al's (2005) findings show that practice-based training sessions give better outcome than training in a classroom setting.

## Data quality

Data quality refers to the degree to which the data or statistics measure what was intended to be measured (Shresta and Bodard 2000). Heywood and Rohde (2001) state that good quality data is available on time at all levels, correct, complete and consistent, reliable and accurate enough to support decisions, represent all recorders of similar data, and comparable. DHIS has significantly increased data quality in South Africa, they say. Errors are still present, however, and some common reasons are missing data, duplicate data, thumb suck, unlikely values, contradictions, calculation errors, typing errors and capturing in wrong

boxes (ibid). Shresta and Bodard (2000) mention rearranged data, inadequate staff skill and intended false-reporting as sources for bad quality data. To ensure data quality Heywood and Rohde (2001) suggest visual scanning and the use of the DHIS validation tool. Shresta and Bodard (2000) suggest double data entry, simple design of the IS, user involvement, redesign of data collection instruments, incentives, checking procedures and training as possible ways to ensure data quality. They also mention that routines should be in place when missing data are discovered. They emphasize, however, that the higher data quality required, the higher the data collection cost will be.

# 3 Methodology

In this section I explain what research methods I have used, how I did my research, and in the last section I will show that the research performed when implementing DHIS 2 in The Gambia truly is participatory action research.

## 3.1 Research methods

### 3.1.1 Participatory action research

Participatory action research (PAR) aims at involving all relevant parties in the research, blurring the line between the researchers and the researched until the researched become the researchers (Baum et al 2006). The researched go from being objects to participate in the research process. They will contribute to decide which topic to research, collect and analyze data and decide what action the research findings should lead to (ibid). Baum et al claim that "PAR seeks to understand and improve the world by changing it". The purpose of the research is thus to enable action, which is achieved through a reflective cycle. The resultant action leads to further research, which again leads to new findings and actions in an iterative reflective cycle (see Figure 3- 1). Wadsworth (1998) states that PAR "is action which is researched, changed and re-researched, *within* the research process by participants". Baum et al (2006) claim that understanding of history, culture and local context influences the reflective process. The process is directly linked to action and is embedded in social relationships.

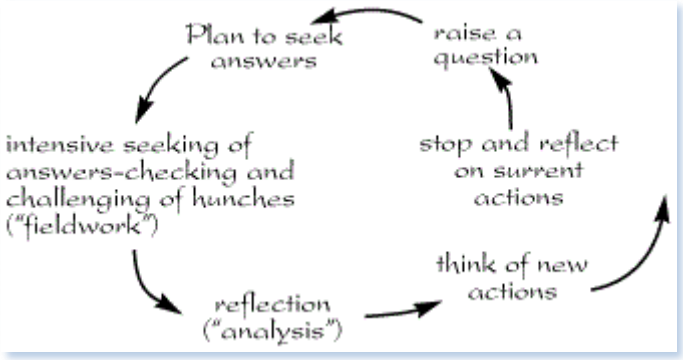


**Figure 3- 1** Simple research cycle (Image courtesy of Wadsworth 1998)

Wadsworth (1998) claims that PAR "most often arises from an unsatisfactory situation that those most affected wish to alter for the better (...)". PAR is however more possibility-oriented rather than predictive; the focus is closer to "what if we..., then maybe" than "if this, then that" (ibid). According to Wadsworth action research knows where it is coming from and that it is going somewhere, but the exact outcome of the research cannot,

however, be predicted in advance. The shape and focus of a participatory action research process can change shape and focus over time, as the participants' understanding of the reality and what is important to them changes through the process. This is a hallmark of a genuine PAR process, Wadsworth says. "Change does not happen at 'the end' – it happens throughout" (ibid).

Benbasat et al (1987) describe action research as a study in which the researcher "is a participant in the implementation of a system, but simultaneously wants to evaluate a certain intervention technique". Furthermore they state that "[t]he action researcher is not an independent observer, but becomes a participant, and the process of change becomes the subject of research". One of the objectives of the researcher is to take action to solve a problem (ibid).

### 3.1.2 Participatory action research in health research

In the 1980's and earlier there was reported little PAR in health journals. More PAR was reported through the 1990s, and in the 21st century PAR is increasingly used in health research (Baum et al 2006). The difference between PAR and other approaches to public health research is that PAR "is based on reflection, data collection and action that aims to improve health and reduce health inequities through involving the people who, in turn, take actions to improve their own health" (ibid).

HISP is an action research group, and according to Braa et al (2007) HISP "draw[s] on the Scandinavian action research tradition in IS development where user participation, evolutionary approaches, and prototyping are emphasized".

### 3.1.3 Case study

According to Benbasat et al (1987) there is no standard definition of a case study, but drawing on definitions from literature they state that "a case study examines a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities (people, groups, or organizations)".

## 3.2 Research approach

Prior to my first trip to the country some HISP members and British volunteers had installed DHIS 2 and prepared it for use from January 2010. During my stays there were no other HISP members in the country. My research was thus conducted by me in cooperation with local staff, with whom I worked closely every day.

### 3.2.1 Location and duration of studies

The location and duration of my studies can be divided into four, which I in turn will describe further:

1. Courses/preparations at the University of Oslo January – June and August – December 2009
2. First trip to The Gambia for ten weeks: January 14th– March 24th 2010
3. Support and further work on the Gambian database.
4. Second trip to The Gambia for three weeks: May 28th – June 18th 2010

### *Courses/preparations*

When the research groups at the Department of Informatics presented their fields of interest to the new master students January 2009, the research group *Global Infrastructure* was the only research group that did not speak of the oil industry and how you could make a fortune there. I therefore contacted the professor who held the presentation and he introduced me to a PhD-student within the research group. The PhD student recommended some courses that could be interesting to me, and especially three of them have proved useful:

- **Health management information systems**
  Amongst other things this course focused on data collection, data quality and analysis. Through this course I was also first introduced to HISP and DHIS 2.
- **Open source development**
  Through this course I learned about the framework used in the development of DHIS 2. The students were divided into groups, and each group developed a module for the software.
- **Information infrastructure**
  This course focused on large infrastructures and networks and presented cases demonstrating the difficulty of changing large-scaled infrastructures.

The PhD student explained that master students writing their thesis for the Global Infrastructure research group usually travel abroad to do field work and then write a thesis where the field work plays an essential role. Autumn 2009 I therefore contacted the head of the HISP network, an associate professor at the University of Oslo, and he introduced me to the situation in The Gambia; the DHIS database has been developed and reporting of data is supposed to happen through the software from January 2010. The 2009 data from the Excel returns also need to be imported into the database. I consulted some of the developers to find out how to do the import and got familiar with the recommended tools before I left.

### *First trip*

When I arrived in the middle of January I started to work on the 2009 Excel returns to prepare for the import process of the 2009 Excel returns that were to be collected on the trek late January/early February. The following month after the trek I spent most of my time importing the data.

A foreign actor presented a new mobile project that was to be enrolled in the country. DHIS Mobile could do much the same and I therefore suggested introducing DHIS Mobile instead. A DHIS Mobile test application was therefore developed by an Indian DHIS 2 developer. The other actor had however already agreed on contracts with the Gambian government and it was thus decided to pilot DHIS Mobile in addition.

#### *Support and further work in Norway*

When I was in Norway I communicated with the DHIS Mobile developer to prepare a mobile application for a DHIS Mobile pilot in one of the regions in The Gambia. Phones and a GSM USB modem were bought and I learned how to install and set up DHIS 2 with support for mobile reporting. I also consulted the core developers of the DHIS 2 software to figure out how to solve an error that was encountered when upgrading to the latest release of DHIS 2 in The Gambia.

#### *Second trip*

The mobile phones were confiscated by the airport customs in The Gambia. Although in the end I managed to teach the head of the IT office how to install the DHIS Mobile software on the mobile phones. The server database was updated to support mobile reporting. We went on a trek to have two training sessions on DHIS 2 for health workers. I also joined the trainings on the *SMS for health* project.

### 3.2.3 Data collection methods

#### *Interviews and conversations*

There are essentially three types of interviews: structured, semi-structured and unstructured interviews (Santiago 2009). In structured interviews the interviewer has a plan which needs to be followed without deviations. Semi-structured interviews are more relaxed, and the interviewer can be more friendly and sociable, allowing the researcher to explore the participant responses by asking for additional information. In unstructured interviews the researcher only needs to make sure he will cover the topics he has decided on beforehand.

During my stay in the country I only performed one interview, and that was unstructured. The reason for the absence of interviews was that I got my information needs covered during conversations and discussions with people on a daily basis. I worked in the same office as the Head of the IT office and we discussed DHIS 2 and implementation efforts every day. This was a really important source of information.

#### *Observation*

As we travelled around the country on trek I got to see how the head of the HMIS did his data collection. It was interesting to be just an observer and learn the Gambian way of working. When computer work needed to be done in the regional offices (collect Excel returns and update the DHIS 2 implementations) I tried not to interfere and just observed how the Gambians solved the tasks. That gave me a valuable experience of the level of

relevant IT knowledge among the staff, both on the regional offices as well as for the head of the IT office.

### *Field notes*

One of my primary data sources is my field "diary", where I have written down thoughts and reflections on my work. At the end of the day I tried to sum up the day's event and note some reflections as well.

### *Training*

Before the training sessions in June there were opening ceremonies, and both the head of the HMIS as well as local representatives held interesting speeches. On the training sessions I also got an insight in the general IT knowledge among the health workers in the country, both through their responses on the training and in conversations.

### *E-mails and instant messaging*

E-mailing and instant messaging were important communication channels through which I had contact with the developers in Norway. Using these tools, problems were solved and ideas were discussed.

## 3.3 The Gambia and PAR

The head of the Gambian HMIS wanted to see through an implementation of DHIS 2 in the country because he had learned through conversations and presentations that it was a powerful tool. He did not know quite what he was getting but was hoping that it would improve the current unsatisfactory data collection situation in the country (Wadsworth 1998). As the software was implemented, new ideas and requirements came forth, continuously changing my research process (ibid). Staff from the Ministry of health (MOH) took part in the work, deciding what action should be taken and plan what further work needed to be done, thus blurring the line between me, as a representative from the HISP research group, and the locals (the researched); they went from being research objects to participate in the research process (Baum et al 2006).

During my stays in the country I participated in the implementation of DHIS 2, took action to solve implementation problems and thus became a participant. The process of changing the system was the subject of my research (Benbasat et al 1987). Multiple data collection methods were used to gather information (from relatively few sources) in order to examine the previous Gambian data collection tools and the migration process to DHIS 2.

In the long term HISP hopes that DHIS 2 will contribute to improved health services in The Gambia, learn from what has been done in the country and so understand and improve the world by changing it (Baum et al 2006).

## 3.4 Summary

PAR aims at involving all relevant parties in the research, blurring the line between the researchers and the researched until the researched become the researchers (Baum et al 2006). "[A] case study examines a phenomenon in its natural setting, employing multiple methods of data collection to gather information from one or a few entities" (Benbasat et al 1987).

I had six courses at the University during 2009 focusing on computer development, HMIS' and information infrastructures. I had two field trips spring 2010 to The Gambia to help in the start-up process with DHIS 2. When I was in Norway between the trips I continued to work on the Gambian implementation. I collected my data mostly through conversations and observation, which I noted in my field diary.

The researched Gambians took part in the work and so became researchers themselves, blurring the line between the researcher(s) and the researched. The implementation and start-up process were examined in its natural setting, and data was collected from few sources.

# 4 Background

The Background section is divided in two. The first part presents general facts about the country and also gives a historical summary. Most facts are collected from online literature, as online encyclopaedias, while other facts are based on my own experience. In the second part I present the health care situation in the country and give example statistics showing that the health care situation is very poor.

## 4.1 The Gambia Country Profile


**Figure 4- 1** Map of The Gambia (Image courtesy of Central Intelligence Agency 2010)

### 4.1.1 Geography

The Republic of The Gambia is the smallest country on the African continent and is located on the western coast of the continent. Except for the 80 km long coast line, it is surrounded by Senegal, with which it shares 740 km of landline border (Gambia – republikk i Afrika, 2010; Central Intelligence Agency 2010). The length of the country, from west to east, is 338 km (Encyclopedia of the Nations n.d.). The capital, Banjul, is located by the Gambian river mouth North West in the country. The country is divided into six divisions (also referred to as regions) and one city. The divisions are subdivided into 35 districts and two councils; Banjul City Council and Kanifing Municipal Council.

As the highest point in The Gambia is only 53 metres above sea level (Central Intelligence Agency 2010), the country is very flat; one can barely notice which way the river flows. Close to the river lie dry grass lands and these are often flooded during rainy season, which lasts

from June to October. At the coast the annual rainfall is about 1,200 mm, while upcountry the annual rainfall is about 750 mm.

### 4.1.2 Historical summary

The information given in the historical summary presented here is all from BBC News (2010) and Leraand (n.d.).

In the 13th century Mande-speaking people gained control over parts of the area. They influenced the area until Islamic Fulani tribes after several religious wars settled in the 19th century. In 1455 the Portuguese came to the Gambia. British and French people came in the late 1500's and started comprehensive trading, where gold, ivory and slaves were most popular. The control over the country shifted between the French and the British, but in 1783 British control was established. Slave trading ceased in 1807.

In 1889 the present boundaries of the country was set, and in 1894 the Gambia became a British protectorate. The Gambia's first political parties were established in 1951. Before the Gambia's independence in 1965, Gambian politicians were involved in an indirect control from 1946-1963. Dawda Jawara's political party Progressive People's Party (PPP) gained popularity and won the elections in 1962. Jawara became the primary minister, and February 18th 1965 The Gambia became an independent country. In 1970 The Gambia became a republic, and Sir Dawda Jawara was the country's first president. He was also reelected 1972, 1977, 1982, 1987 and 1992. Several oppositional parties arose in the 1970's, but none of them could do anything with Jawara's popularity.

In 1980 the leader for the half military police corps was murdered, and president Jawara had to ask Senegal to send military forces to secure peace. In July 1981 a coup was attempted while president Jawara was out travelling. He had to ask Senegal to send military forces again, and it is estimated that around 1,000 people died during the uprising. In 1994 the military forces finally succeeded and deposed president Jawara. The coup was led by the young lieutenant Yaya Jammeh, who established a military council called Armed Forces Provisional Ruling Council (AFPRC). Jawara was exiled to Senegal and later United Kingdom. He was given amnesty in 2001 and returned to The Gambia, but without the possibility of participating in political activity.

Party political activity was prohibited until 1996, when Yammeh was elected president, and his party, Alliance for Patriotic Reorientation and Construction (AFPRC) got 33 of 45 seats in the parliament election.

Journalists have several times been arrested, and in 2004 the editor for the weekly newspaper The Point, Deyda Hydara, was executed. Media laws were introduced in 2002 to limit the critics of the president and the government, and they were further strengthened in 2004, despite international protests. August 2009 six journalists were jailed for associating the government with the murder of Mr. Hydara. They were later pardoned.

### 4.1.3 Population and language

The official language is English. This is the primary teaching language in school, but the first three years of primary school is often taught in a local language. The 9 year long primary school is free, and 70% of the children start here. However, only 29% goes to high school, while only 1.7% continues to higher education. Amongst the adults, the illiteracy was in 2000 estimated to be 63% (Gambia – samfunn og kultur, 2009). There are thus quite a lot of people only speaking local languages. Of the population of 1.8 million, approximately 40% represents the biggest tribe in the Gambia – the Mandinka tribe. Fula (18%) and Wolof (16%) are the second and third biggest tribes (Central Intelligence Agency 2010). As about half of the inhabitants in the capital, Banjul, are Wolofs (Banjul, n.d. a), however, Wolof culture and language has had quite an impact on the country. Where I lived during my stays, in Bakau, it is not unusual to speak three different local languages, in addition to English, as the inhabitants are a mixture of several tribes. This is not special for Bakau, but rather quite common in the towns and villages of some size all around the country. Worth noticing is that these languages are totally different and cannot be considered as various dialects of the same language.

### 4.1.4 The capital and its surroundings

With its approximately 50 000 inhabitants Banjul is one of the smallest capitals in Africa (Nations Online 2010). Many people who have their work here live in the bigger towns nearby, such as Bakau, Serrekunda and Brikama. Thus, Banjul serves in a way as an administrative centre. The biggest town in the Gambia is actually Serrekunda, which amongst other things is known for its large market.

### 4.1.5 Infrastructure

#### *Roads*

The roads in the country are overall in very bad condition. In Western Region, the most modern region, most of the main roads have asphalt and are thus in a relatively good shape. In the rest of the country all roads are dirt roads. An exception is the main road in the North Bank Division, going from the river mouth to Farafenni. On the south side of the river they are currently constructing a new and better road between Mansa Konko and Brikama, but still more than half of the distance consists of dirt roads. Also, president Yammeh has constructed a small asphalt road from his home village to the main road, even though all roads in the surroundings are dirt roads.

Due to these poor road conditions, the rain during the rainy seasons causes lots of damage to the roads, and in many places it becomes impossible to drive without a 4WD car with some distance from the undercarriage to the ground.

#### *Electricity*

National Water And Electricity Company Ltd. (NAWEC) has a generator serving the Greater Banjul Area in the Kanifing Municipality. The generator is a thermal power station and has a

capacity of 20 MW (National Water And Electricity Company 2008). To serve the more rural areas upcountry NAWEC has six small scale power systems operating on diesel generators, with capacities from 142 KW to 640 KW (Access Gambia n.d. b). To save fuel it is very common to stop the generators in the rural areas at night. The energy delivery is very unstable throughout the country, and a breakdown in the delivery happens relatively often, even in the ministry of health. "Backup batteries" are thus a widespread phenomenon, as the use of these allows the desktop computer user to save his data before the power disappears from the battery as well.

#### *Information infrastructure*

Internet access is quite a luxury in the country. The landlines are very slow; if one visits an Internet cafe, it is not unlikely that one will find that the cafe has only got a 256 kbps connection. Mobile Internet is taking over, and a Gambian telecom company, QCell, has developed a USB stick one can use to connect to the Internet. They have got coverage in almost all of the Gambia, but the 3G coverage is limited to the western part of the country, approximately from the coast and east to Farafenni (see Figure 4- 1). From Mansa Konko and eastwards the Internet connection is mostly through EDGE and in the most rural areas through GPRS.

None of the Gambian telecom companies individually can provide coverage in the whole country. Altogether they do however cover the whole country. As it is relatively expensive to call a recipient holding a SIM card from another provider it is quite common to have more than one SIM card. Phones holding two SIM cards are popular in The Gambia, and they are relatively cheap too, so there are many people who choose to have two such phones so that they can use SIM cards from four different providers at the same time.

### 4.1.6 ICT knowledge

The general knowledge on Information and communication technology (ICT) in The Gambia is quite poor. There are very few people who own their own computer, as technology is very expensive for the locals. Internet cafes start however to be common in the most populated areas, so most of the younger generation know what a computer is and can do simple operations, such as web browsing. Access Gambia (Access Gambia 2010) claims that as much as 98.4% of the Gambian pupils and 98.9% of the teachers use email.

Nevertheless, when going on a DHIS 2 training trek in June 2010, half the attendants at the training session did not know how to use a computer. After one of the teaching sessions in that place one of the attendants came forward to try DHIS 2, and she had never used a computer before, even though she was 20-30 years old. She remembered though from the presentation, which one of the mouse buttons to use, where to find the *Start button* in *Windows* and how to open *Firefox* and start DHIS 2.

## 4.2 Health care situation

### 4.2.1 Health service providers

In The Gambia the government is the major provider of health services, but there are also a lot of other actors involved in the health care, both in providing services as well as contributing with economical assistance. As seen from Table 4- 1, 24.3% of the total health expenditures are covered by external resources. Even though the government is the major provider of health services, people have to cover most of their health related expenditures themselves; 52.1% of the national expenditures on health are private expenditures (see Table 4- 1).

| 2007 data | The Gambia | Norway |
|---|---|---|
| Total expenditure on health of GDP | 5.5% | 8.9% |
| Private expenditure on health of total expenditure on health | 52.1% | 15.9% |
| General government expenditure on health of total government expenditure | 11.6% | 18.3% |
| External resources for health of total expenditure on health | 24.3% | 0 |
| Per capita total expenditure on health at average exchange rate | 22 US$ | 7,354 US$ |

**Table 4- 1** Health expenditures statistics (World Health Organization 2010)

#### *Vertical actors*

In an interview the head of the Gambian HMIS was asked whether or not there were many vertical actors in the Gambian health care. He answered rather briefly that there used to be more of them earlier but that there still exist some. The ones he pointed at were the tuberculosis control program and to some extent some HIV/AIDS programs. Some of the HIV/AIDS programs are integrated in the Gambian HMIS.

At a DHIS 2 training session in Lower River Region the director of regional health gave a speech in which he complemented the HMIS head's views and pointed to the fact that there exist many donor driven programs in The Gambia that want something in return. He mentioned malaria and tuberculosis programs as well as National Aids secretariat (NAS) and said that there are so many indicators to deal with that it is totally confusing. He claimed that about 40% of the Gambian health workers' time is spent on filling in forms and registers. The time would be better spent providing health services to the population, he stated.

### 4.2.2 Poor communication

During my stay in The Gambia I experienced that the communication within the ministry of health (MOH) could have been better. In autumn 2009, an employee in the MOH came in touch with International Health Partners (IHP) and was introduced to a project called *SMS for health*. IHP and their partners were given permission to roll out their project by people who did not bother either consulting the IT office at MOH or the HMIS head before signing

the contracts. At the presentation the representatives from IHP and their partners held February 23rd we could state that *SMS for health* and DHIS 2, with DHIS Mobile, have many similarities. By rolling out SMS for health a lot of duplicate work will thus be done in the future, as MOH is planning to roll out DHIS Mobile application as well.

### 4.2.3 High mortality rates

Compared to the industrialized country Norway, The Gambia has got some very high mortality rates. The World Health Organization (WHO) states for instance that the maternal mortality ratio (MMR) is unacceptably high, being 730 per 100,000 live births in 2001 (World Health Organization 2009). Table 4- 2 shows that the MMR is down to 690 per 100,000 live births in 2008, but that is still extremely high. The WHO writes that "[t]he main causes of maternal mortality are haemorrhages, eclampsia, anaemia, malaria in pregnancy and postpartum sepsis. Poor maternal nutrition contributes to complications during pregnancy and delivery, and shortage of skilled birth attendants further exacerbates the problem" (ibid). As seen from Table 4- 2 only 57% of the 2008 births were attended by skilled health personnel. Table 4- 3 throws more light on this topic as it shows that only 43% of the births in rural areas are attended by skilled health personnel while the same number for urban areas is 83%.

| **2008 data** | **The Gambia** | **Norway** |
|---|---|---|
| Children aged < 5 years underweight: | 15.8% | ... |
| Under-five mortality rate | 106/1,000 | 3/1,000 |
| Measles immunization coverage among 1-year-olds | 91% | 93% |
| Maternal mortality ratio (2005 data) | 690/100,000 | 7/100,000 |
| Births attended by skilled health personnel | 57% | … |
| Antenatal care coverage | 98% | ... |
| Prevalence of HIV among adults aged 15-49 years | 0.9% | 0.1% |
| Malaria mortality rate (2006 data) | 106/100,000 | ... |
| Tuberculosis mortality rate among HIV-neg. people | 44/100,000 | 0.4/100,000 |
| Population using improved drinking-water sources | 92% | 100% |

**Table 4- 2** Some health statistics for Gambia and Norway (World Health Organization 2010)

| **2006 data** | ***Place of residence*** | |
|---|---|---|
| | **Rural** | **Urban** |
| Births attended by skilled personnel | 43% | 83% |
| Measles immunization coverage among 1-year-olds | 93 | 91 |
| Under-five mortality rate | 150 | 96 |

**Table 4- 3** Gambian health inequities statistics (World Health Organization 2010)

### 4.2.4 Health workforce

The lack of health personnel at all levels is a big obstacle in the Gambian health care. Table 4- 4 shows that the Gambian health workforce is pretty weak; for instance: The relative number of physicians is more than 78 times lower than in Norway.

| Data from the 2000-2009 period | The Gambia | Norway |
|---|---|---|
| Physicians | < 0.5/10,000 | 39/10,000 |
| Nursing and midwifery personnel | 6/10,000 | 163/10,000 |
| Dentistry personnel | < 0.5/10,000 | 9/10,000 |
| Pharmaceutical personnel | < 0.5/10,000 | 7/10,000 |
| Environment and public health workers | < 0.5/10,000 | … |
| Community health workers | 1/10,000 | … |
| Hospital beds | 11/10,000 | 39/10,000 |

**Table 4- 4** Health workforce statistics (World Health Statistics 2010)

## 4.3 Summary

The Gambia is the smallest country on the Gambian continent. The Mandinka population of the country dates back to the 13$^{th}$ century. The country was subject for slave trading and was controlled by France and the United Kingdom before it became independent in 1965. Infrastructures are poor, and so are the ICT knowledge and the health care situation in the country.

# 5 Results and findings

In this section I will present the results and findings of my research. I start with presenting the data collection procedure before DHIS 2 was implemented. Further I go on to introduce how DHIS 2 was implemented and describe the first data collection trek after the DHIS 2 implementation. Section 5.3 presents DHIS 2 in detail, while I in section 5.4 present how I imported the data from the previously used Excel returns. Further I compare the Excel reporting tool to DHIS 2 before I go on to present some obstacles we ran into during my stays. In section 5.7 I go into detail on the work I had to do to get the GIS and Mobiles modules to work properly after upgrading DHIS 2 to version 2.0.4. I go on to compare the data quality for the 2009 and 2010 data, and in section 5.9 I explain how the *SMS for health* project contributes to fragmentation. Finally, in section 5.10 I present some of the recent activities in The Gambia.

## 5.1 Data collection before DHIS 2

In 2000 Excel sheets were introduced at the regional level as a reporting tool. Through the project *Participatory health, population and nutrition project* the regions had access to the Internet, and the Excel sheets could therefore be sent by e-mail to the national level. When this project reached its end in 2005 the regions also lost their Internet connection. From that time on data had to be collected on *treks* (see section 5.1.1).

At that time there were several vertical actors in the Gambia, and as these actors paid the workers on the clinics enrolled in their programs for collecting and reporting data, this data was prioritized by the workers, as MOH could not afford to pay for "HMIS data collection". In 2005 the financial situation of the MOH was so bad that they could not afford even one trek this year.

In August 2007 a harmonisation and integration process was started in order to develop tools for data collection. A new Excel database was created and registers and returns were also made. Each facility uses tally sheets to register data when patients visit the clinic, and when the month is due they sum up the numbers on returns and send these to the regional level. At the regional level the data are typed into the distributed Excel sheets. (More about the Excel sheets in section 5.1.2.)

### 5.1.1 Treks

Four times a year a group of people from the ministry of health (MOH) go on a trek, and during this trek the Excel sheets are copied to a USB memory stick. In this way the reported data are brought back to the national level and the data can be compiled and bulletins prepared. All facilities are visited; public and private facilities and Non-Governmental Organizations' (NGOs) facilities, as well as community health facilities.

### *January treks*

In January the fourth quarterly data from the previous year will be collected. In addition data on human resources, bed capacity, updates on the health facilities and the RHT trekking sites are collected through oral questioning.

### *April, June and October treks*

In April, June and October data from the previous quarter will be collected. In addition the MOH representatives control the registers and the returns in use. As the latter task is quite time consuming they do not do this at the January treks when resource data are collected.

### *The trek tasks*

I joined the MOH representatives on the 2010 January trek. The MOH representatives were the head of the HMIS, the head of the IT office and a statistician, as well as a driver. On this trek more than 35 facilities were visited, of which six were regional offices. On the regional offices the head of the IT office and I could do some computer work. The main task was to copy the 2009 data, but as we had a downloaded version 2.0.3 of DHIS we installed this on four of the six regional office computers. Later during the trek it was reported a bug in the new release of the software, so we did not install it in the remaining two regional offices. The bug is described in more detail in section 5.6.2.

#### Time wastage

At the approximately 30 other facilities we had no job at all and were just waiting for the head of the HMIS to finish his questioning of the person in charge at the facility. The only thing that was done at these facilities was that the head of the HMIS sat down with the person in charge at the facility and asked him/her questions about human resources, bed capacity, health facility updates and catchment area for the facility. As far as I noticed the statistician that also joined the trek did not do anything at any health facility during the whole trek.

#### *Why treks?*

When questioned why these treks are necessary to collect data from the facilities (other than the regional offices) instead of rather doing telephone interviews, the head of HMIS answered that phone calls are expensive – even more than the cost of fuel. Further he argued that some facilities are so rurally located that he is guaranteed to run into network/connection problems when calling the facilities. Also the workers may feel they are appreciated when a “boss” from the MOH visits their local facility.

## 5.1.2 The Excel data collection files

The HMIS head had in cooperation with another person designed the three main Excel files used for reporting from 2005. In each region there were one file for reporting PHC Village data and two files for reporting health facility data – one for monthly data and one for quarterly data.

### *Health facility monthly*

The Excel file for the health facility monthly returns has one sheet for each health facility in the region, each having about 300 rows and 65 columns used to report data. In addition, there are two sheets showing accumulated data – one sheet for monthly and one for quarterly. The last sheet in the file is a sheet showing 36 different charts of quarterly and annual data – all for *data elements* values, i.e. no *indicator* charts (DHIS 2 terminology are presented in section 5.3.3). Figure A- 1 shows the Excel file layout.

### *Health facility quarterly*

The Excel file for the health facility quarterly returns has quite a similar layout as the file for the monthly returns, with one sheet for each health facilities. The sheets for the reported data do however only have 6 columns and about 200 rows. This file also has a sheet showing accumulated data both for each quarter and annual. Finally, the last sheet here shows 18 charts of quarterly and annual data – also here it is only for *data element* values.

### *PHC village monthly*

The Excel file for the PHC village monthly returns is somewhat similar to the ones for the health facility returns, but still it differs as there is one sheet for each PHC circuit in a region holding data for all PHC villages in the PHC circuit. The sheets have about 250 rows and 40 columns. Also here there are two sheets for monthly and quarterly accumulated data. As in the two other files there's also here a sheet showing charts; 23 *data elements* charts show monthly, quarterly and annual data.

## 5.1.3 Application of data

The Gambian HMIS head said in an interview that collected data was compiled before bulletins were prepared. A bar chart presented in a Gambian HMIS quarterly bulletin can be seen in Figure 5- 1:

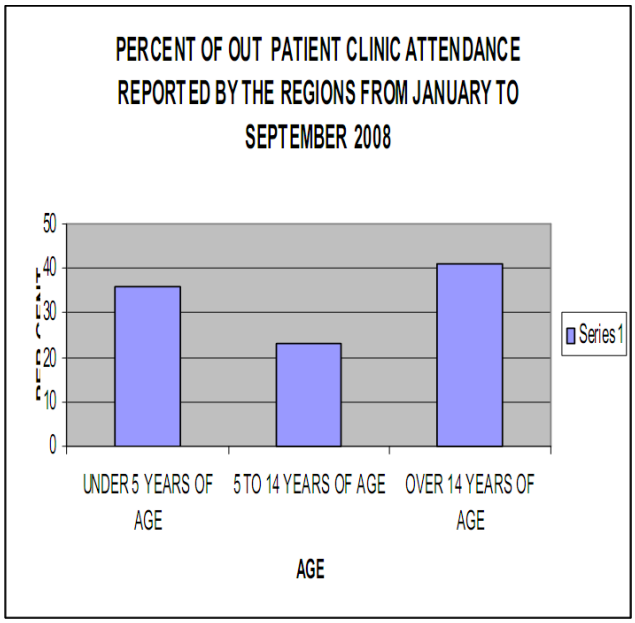


**Figure 5- 1** An example bar chart from a Gambian HMIS quarterly bulletin

Figure 5- 2 shows an example table from the same bulletin.

| TABLE. 19 TOTAL NUMBER OF OUT PATIENT CLINIC ATTENDANCE REPORTED BY THE URR (BHF) FROM JANUARY TO SEPTEMBER 2008 | | | | | |
|---|---|---|---|---|---|
| | FIRST QUARTER | SECOND QUARTER | THIRD QUARTER | TOTAL | TOTAL % |
| UNDER 5 YEARS OF AGE | 6345 | 7142 | 12171 | 25658 | 36.6 |
| 5 TO 14 YEARS OF AGE | 7213 | 3218 | 5881 | 16312 | 23.3 |
| OVER 14 YEARS OF AGE | 8751 | 6793 | 12644 | 28188 | 40.2 |
| TOTAL OUTPATIENT ATTENDANCE | 22309 | 17153 | 30696 | 70158 | 100 |

**Figure 5- 2** An example table from a Gambian HMIS quarterly bulletin

At the end of a training session in October/November 2008 the participants requested training of health workers so that they could be able to do simple analysis and make use of generated data. They wanted to be able to share information with their communities and thus requested computers and printers at the facilities. Their requests have however not yet been met. Only the regional offices do have computers and printers.

## 5.2 The introduction of DHIS 2

### 5.2.1 Implementation

Around March 2009 the Head of the Gambian HMIS heard about DHIS 2 for the first time through a Norwegian lady. He checked the web page to learn more about DHIS 2, and when he attended a conference in Ouagadougou in Burkina Faso, he got in touch with an IT specialist working with HIS in Sierra Leone, and this man told him more about DHIS 2. On this conference he also met a representative from Norway who taught him even more about DHIS 2. Later these three also discussed DHIS 2 on a Skype conference.

The Gambian HMIS head then decided to pilot DHIS 2. In August 2009 a female British volunteer in the Gambia sat down to learn DHIS 2, and she taught two employees at MOH how to use the software. When she left, another British volunteer came to The Gambia to work further with DHIS 2. In October the University of Oslo sent an associate professor and a PhD student to assist the Gambia in building the database, design data entry forms and set up the system. They spent three weeks in the Gambia doing this.

The volunteer was later accompanied by yet another British volunteer, and together these two young men amongst other things created installation guides and training material, and in November 2009 they held a Data Entry Clerk (DEC) training. Together with the HMIS head and the head of the MOH IT office they travelled around the country to install DHIS 2 on the regional health offices' computers so that the software was ready to be used from January 2010.

The hope for the future is that the regional offices will be provided with Internet access so that they can access the national implementation through the Internet. The power supply in MOH is however relatively unstable, so a national implementation of DHIS 2 should therefore be installed on a server with reliable power supply to ensure that the regions can access DHIS 2 whenever desired. Pristine Consulting has offered to host an implementation of DHIS 2 for free, so the two volunteers also installed DHIS 2 on one of Pristine Consulting's servers in The Gambia.

### 5.2.2 The first trek

Late January I joined the HMIS head, the head of the MOH IT office and an MOH statistician on a data collection trek. This was the first trek after DHIS 2 was started to be used. Before leaving for trek we downloaded version 2.0.3 of DHIS. After a brief testing of the latest release we decided to bring it along to update the computers at the regional offices, as they were using version 2.0.1 of the software. My task on the trek was, together with the head of the IT office, to collect the last 2009 data and update the DHIS 2 installations. Our trek lasted for five full days, and even though it is only 338 km from west to east in the country, the total length of our trip closed in on 1,000 km, due to all the detours to visit the health facilities. Figure 5- 3 shows where the regional offices are located, as well as the approximate travel route of our trek:

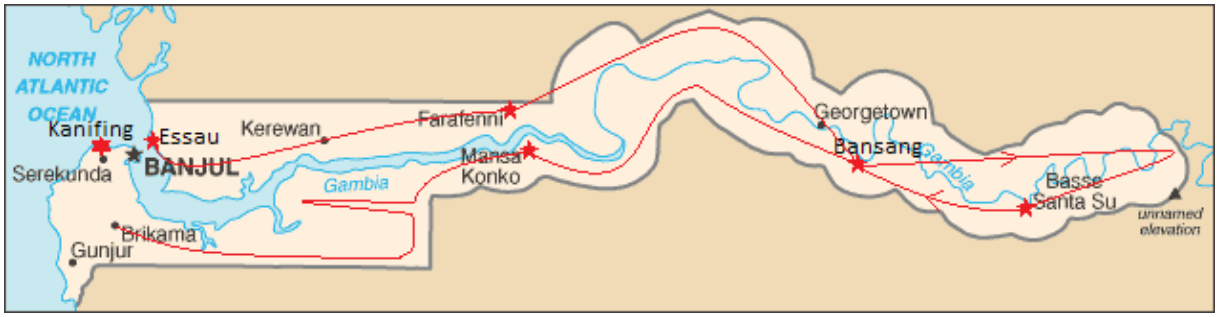


**Figure 5- 3** The location of the regional offices and the approximate travel route of our trek

#### *Essau, NBWR – day 1*

After taking the first ferry in the morning from Banjul, the first stop on the trek was in Essau, where the regional office for North Bank West Region (NBWR) is. The town is situated at the coast of The Gambia (see Figure 5- 3). In the office there was one computer and one data entry clerk (DEC), and they did not have Internet connection. The Excel returns were collected and version 2.0.3 was installed. A brief testing of the system did not show any errors. We then headed towards Farafenni, but at the way we stopped at several health facilities so the HMIS head could update his data on the human and equipment resources at the facilities.

### *Farafenni, NBER – day 1-2*

Farafenni is located in the north of the country, just on the border to Senegal, and is the regional office of North Bank East Region (NBER). Between Essau and Farafenni the road conditions are quite good, but as we visited many facilities on the way, we did not use the highway that much. DHIS 2 was upgraded in Farafenni as well, and the Excel sheets were also successfully copied. There is one DEC in the office. We spent our first night in Farafenni, and the morning thereafter we tried to install DHIS 2 on the AFPRC hospital, located next to the regional office. We encountered virus related problems, however, and so we were not able to complete the installation. After several hours spent trying to complete the installation we gave up and travelled further towards Bansang.

### *Bansang, CRR – day 2*

In Bansang lies the regional office for Central River Region (CRR). The one DEC that was working there patiently showed us to the office even though it was late in the evening. We upgraded DHIS 2 and tried to copy the Excel returns. When accessing the returns on our own computers, however, they had been corrupted by viruses. After some trying we figured out how to solve the problem. We zipped the Excel files and renamed the zip-file to a filename with an "unknown" file extension, copied the file, renamed it back to .zip and unzipped the files to our computers. Then we were able to open the Excel files.

### *Basse, URR – day 3*

The day thereafter we headed for Basse, where the regional office for Upper River Region (URR) is. We visited many facilities on the way and did not arrive in Basse until late in the evening. In the morning we went to the regional office. The DEC working there showed us to the computer room, where there were two computers. DHIS 2 was installed on one of them, and the other computer could access DHIS 2 through a local area network (LAN) connection. Having a dial-up Internet connection, this was the only regional office with Internet access. After we had upgraded DHIS 2 to version 2.0.3, the DEC told us he had spoken with the DEC in Bansang who said that he had discovered an error in the new version. He showed this to us and hoped that we could fix the error. We tried to fix it, but the error was relatively complex, so we ended up with exporting the data from the system, installing a snapshot of the 2.0.2.-version of the system and then we imported the data into this version again (see section 5.6.2).

As we were working on the problem, the DEC joined the rest of the team on a short trip to visit a facility nearby. During our work we needed the administration password, but the DEC refused to share it with us by phone (or at all, really), as he had been told that he should never share his password with anybody. We thus had to wait until he was back before we could continue our work. When the system was working, we headed travelled eastwards towards Soma/Mansa Konko

### *Bansang again – day 4*

We passed Bansang on our way to Soma/Mansa Konko and stopped there to see if we could fix the problem the DEC had encountered. We tried to downgrade DHIS 2 from version 2.0.3 back to version 2.0.1. It proved successful, and we could travel further to Soma/Mansa Konko.

### *Soma/Mansa Konko, LRR – day 4*

In Lower River Region's (LRR) regional office in Soma/Mansa Konko DHIS 2 is installed on one of the computers there. As we had experienced trouble with the upgrading in Basse and Bansang, we did not upgrade to 2.0.3 in Soma/Mansa Konko. The Excel returns were copied successfully.

### *Day 5*

After spending the night in Soma/Mansa Konko we headed back home. On our way back we visited many health facilities, and late in the evening we finally arrived Bakau, were my guesthouse was.

### *Kanifing, WR – day 6*

As the Western Region's (WR) regional office is located close to Bakau, where both the head of the IT office and I lived, we went there and copied the Excel returns. We did not do the upgrading, as we had still not figured out what caused the errors. There are two DECs in the office, but only one computer with DHIS 2.

### *Summing up the findings*

I have summed up the properties for the regional offices in Table 5- 1:

| Region | # of DECs | # of PCs w/ DHIS 2 | LAN | Internet access | Upgraded to 2.0.3 | Additional comments |
|---|---|---|---|---|---|---|
| **NBWR** | 1 | 1 | No | No | Yes | |
| **NBER** | 1 | 1 | No | No | Yes | |
| **CRR** | 1 | 1 | No | No | Yes → No | • Downgraded to 2.0.1 again<br>• Virus trouble |
| **URR** | 1 | 1 | Yes | Yes | Yes → 2.0.2 | • Downgraded to a snapshot of 2.0.2 |
| **LRR** | 1 | 1 | No | No | No | |
| **WR** | 2 | 1 | No | No | No | |

**Table 5- 1** The properties of the regional offices

Each region has one DEC but WR, which has two. DHIS 2 is installed on one computer in all the regional offices. No regional office has access to the Internet except from URR, which is provided with a dial-up connection. URR's regional office is also the only one with a LAN. DHIS 2 was upgraded to version 2.0.3 in NBWR, NBER, CRR and URR. In CRR it was later

downgraded to 2.0.1 again, while we downgraded to a snapshot of version 2.0.2 in URR. In LRR and WR we did not upgrade DHIS 2.

## 5.3 DHIS 2

*”DHIS 2 is my baby! I will breastfeed it to the maximum!”*
– The Gambian HMIS head

DHIS 2 (District Health Information Software, version 2) is a web-based computer software for “collection, validation, analysis, and presentation of aggregate statistical data [...]” (HISP 2010 a). The first version of DHIS was however developed on the Microsoft Access platform and thus required Microsoft Windows as operating system to run (DHIS, n.d.). It was piloted in four pilot sites in South Africa 1997-1998 (HISP 2010 b). The first web version of DHIS, version 2.0, was first released in 2008, after three years of development releases (DHIS, n.d.). DHIS 2 is used in many countries in the third world, such as India, South Africa, Sierra Leone and Malawi. DHIS 2 is released under the BSD license[5] and can thus be used for free.

### 5.3.1 Installation

To install DHIS 2 (using a .war file) on a computer, a relational database and a Java servlet container are required. PostgreSQL[6] and Apache Tomcat[7] is a popular combination and are also used in The Gambia. DHIS 2 uses Hibernate[8] to communicate with the database and requires the user to create a configuration file called *hibernate.properties* and an environment variable called *DHIS2_HOME* which points to the folder holding the *hibernate.properties* file. The *hibernate.properties* file contains the database name and username and password needed to connect to the database.

### 5.3.2 Generic

DHIS 2 is claimed to be a generic tool that lets the users customize the software to suit their needs “without the need for programming” (HISP 2010 a). Examples of this are adding and organizing data elements into groups, creating category options, categories and category combinations and creating data sets for reporting fairly simple and straight forward procedures. On the other hand, to create a customized data entry form is somewhat more complicated – a WYSIWYG editor can be used, but HTML programming knowledge will be very helpful.

[5] http://www.linfo.org/bsdlicense.html
[6] http://www.postgresql.org/
[7] http://tomcat.apache.org/
[8] http://www.hibernate.org/

The software can generate reports, but if one wants to customize the report design, BIRT viewer needs to be installed and programming skills are required, as the design file (.rptdesign suffix) needs to follow xml syntax.

### 5.3.3 Terminology

The DHIS 2 namespace contains many words that are not very common in everyday language, and even if some are, they might have a special meaning in DHIS 2. I therefore find it important for clarification to list some of the words from the DHIS 2 namespace that are used in this thesis, in Table 5- 2:

| Word/concept | Explanation | Example |
|---|---|---|
| Data element | Collected data | Malaria cases |
| Data value | Value reported for a data element | 5 |
| Data set | Holds a set of data elements, e.g. all data elements related to malaria | Malaria |
| Indicator | Composed of multiple data elements, usually a numerator and denominator. Used to calculate coverage rates. | BCG coverage < 1 yr: $\frac{\textit{Number of BCG immunized children < 1 yr}}{\textit{Number of children < 1 yr}}$ |
| Indicator group | Used to group similar indicators | All indicators on vaccination coverage |
| Category option | Instead of creating a lot of similar data elements, category options can be created for further distinguishing | Creation of category options *Male* and *Female* gives the reporting opportunities *Male malaria cases* and *Female malaria cases* |
| Category | Combines category options into a category. Can be assigned to a data element. | Category options *Male* and *Female* can be put in the category *Sexes*. Category options *RCH cases* and *OPD cases* can be put in the category *RCH/OPD*. |
| Category combination | Combines categories | Combining categories *Sexes* and *RCH/OPD* gives the reporting opportunities *Male RCH malaria cases*, *Male OPD malaria cases*, *Female RCH malaria cases* and *Female OPD malaria cases* |
| Organization unit | A unit data is reported for. Can be a health facility, PHC village, PHC circuit, a district, a region and a country. | RVTH Polyclinic, AFPRC Hospital, Jajari PHC Village, Upper Badibu District, Lower River Region, The Gambia |

**Table 5- 2** Explanation of some words from the DHIS2 namespace

#### *The organization unit tree*

The organization unit tree (Figure 5- 4) is a hierarchy tree that appears on many of the pages in DHIS 2. It lets the user choose which organizational unit he wants to perform his action on. For instance, the tree appears on the Data Entry page, on the pages for dataset and completeness reporting, as well as in the section for organization unit hierarchy operations.

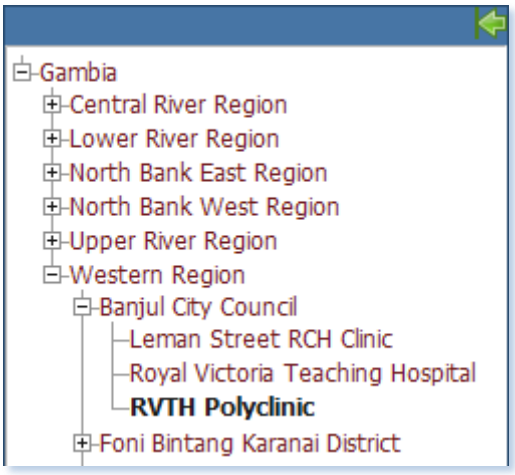


**Figure 5- 4** The Gambian organisation unit tree

### 5.3.4 DHIS 2 modules

***Data Entry***

The data entry module is the very essential module of DHIS 2. Everything in DHIS 2 is based upon what is entered in this module, using the data entry forms. A data entry form has to be assigned to a dataset, and when a user enters data here, the data will automatically be saved as soon as a value is entered (no need to press a *Save* button). This module corresponds to the Gambian Excel sheets in which the data was entered before the introduction of DHIS 2. When entering data the user can validate the data using the validation feature in DHIS 2. When pressing the *Run validation* button, the software checks whether the entered data conflicts with the user created validation rules or the specified minimum and maximum values for a data element. A popup window will show the result of the validation (see Figure 5- 5).


**Figure 5- 5** A popup window stating that the data validation was successful

### *Data Elements and Indicators*

In this module the user can create data elements and indicators as well as category options, categories and category combinations (see Table 5- 2). Data Elements represent the collected data, such as the number of malaria cases in a region. To avoid creating too many data elements the user can create categories with category options. For example, instead of having two data elements *Malaria cases, male* and *Malaria cases, female*, the user can create a category *Sexes* in which the category options *Male* and *Female* can be created. When a category is applied on a data element it gives more reporting opportunities. When the category *Sexes* is applied on the data element *Malaria cases*, the user can report *Malaria cases, Male* and *Malaria cases, Female*. This is especially helpful when a lot of data elements are to be collected and distinguishing between different target groups are desired. To see how category combination works, refer to Table 5- 2.

#### Indicators

Indicators are composed of multiple data elements and do usually have a numerator and a denominator. Indicators are for instance used to calculate coverage rates, such as BCG coverage (see Table 5- 2). Indicators are especially useful for comparison reasons, as it does not make sense to compare the number of e.g. malaria cases in a rural area to the number of malaria cases in a more populated area. The indicators will, however, give a correct picture of the malaria situations in those two different areas, as a percentage value is applicable for comparison; the total number of malaria cases divided by the population in the area will show how big a part of the population in the area is infected with malaria.

### *Data Quality*

This module allows the user in a simple way to check the quality of the registered data in the system. An effective way of doing that is to create validation rules.

#### Validation Rules

A validation rule is a rule that compares several data values to see if they are conflicting, according to requirements specified in the validation rule. A validation rule has a left side and a right side and an operator specifying how the left side should relate to the right side. For instance, a validation rule in DHIS 2 for The Gambia specifies that the number of cases of *Malaria in Pregnancy Lab Confirmed (OPD Cases)* has to be lower than or equal to (<=) the number of cases of *Malaria In Pregnancy Uncomplicated (OPD Cases)*. The validation rules are a useful tool, but running the validation from the data entry module (when entering data) the popup window shows a clumsy message, as illustrated in Figure 5- 6:

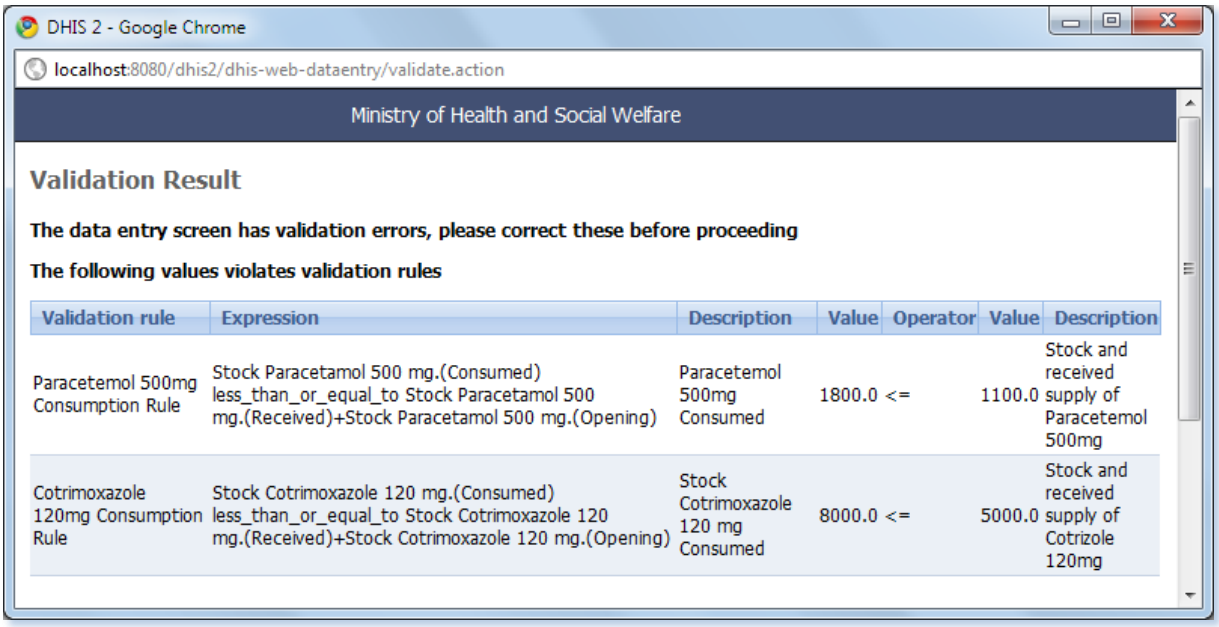


**Figure 5- 6** A popup window shows the validation result

The way the validation results are presented when applying the validation rules from the Data Quality module, is much more understandable, as illustrated in Figure 5- 7:

| Organisation unit | Period | Left side description | Value | Operator | Value | Right side description | Details |
|---|---|---|---|---|---|---|---|
| (Removed) | February 2010 | Paracetemol 500mg Consumed | 1800.0 | <= | 1100.0 | Stock and received supply of Paracetemol 500mg | |
| (Removed) | February 2010 | Stock Cotrimoxazole 120 mg Consumed | 8000.0 | <= | 5000.0 | Stock and received supply of Cotrizole 120mg | |

**Figure 5- 7** Validation result as showed in the Data Quality module

### Min and max values

The user can also specify a minimum and a maximum value for a data element, or the system can be asked to generate min and max values based on the reported values for the past six months. When asked to, the system will check whether reported data is outside the accepted range of the data values. The min and max validation result will show in a popup window together with the validation violations:

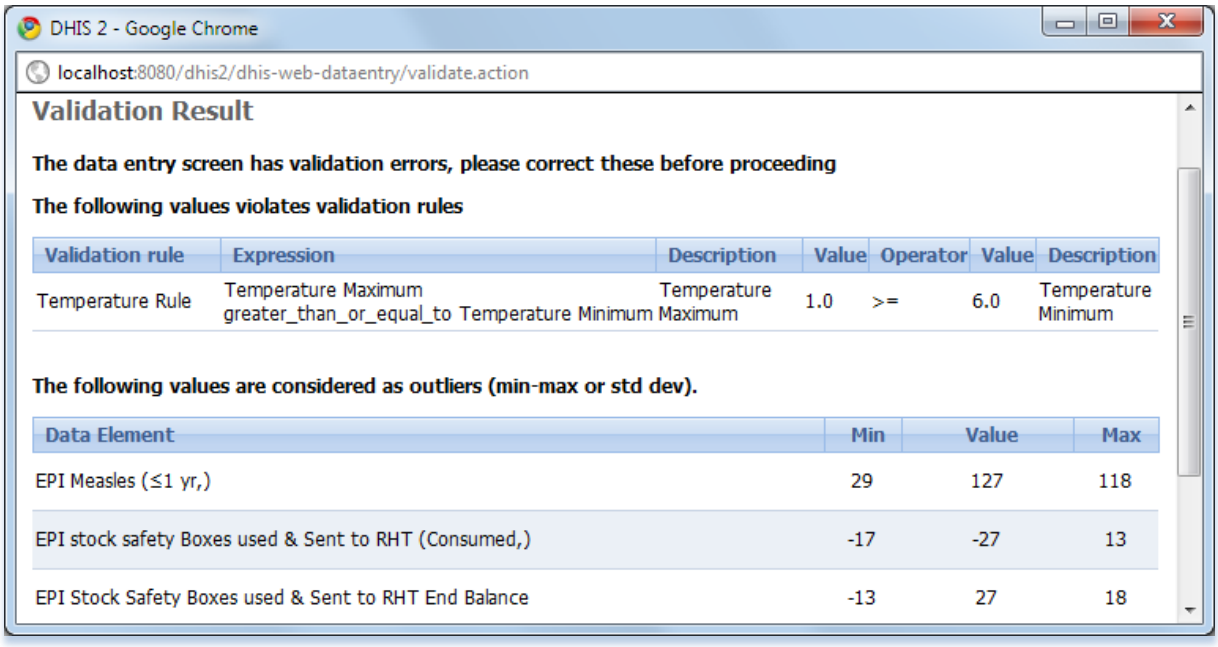


**Figure 5- 8** Min and max violations as well as a validation rule violation

### *GIS*

The GIS module is a very useful module to show and compare indicators. The map shows coverage in terms of predefined colours for good and poor coverage (see Figure 5- 9). The map can be set to show all kinds of organizational units. In The Gambia one can choose among regions, districts, health facilities, PHC circuits and PHC villages, and the map can be generated to show calculated indicators for a month, a quarter, a year etc, depending on the reporting frequency of the data the indicator relies on. When viewing health facilities and PHC circuits and villages, they will appear as dots on the map, while districts and regions will show the whole areas. Figure 5- 9 shows the districts' coverage for the indicator *BCG Coverage < 1 year* for a 2009 month:

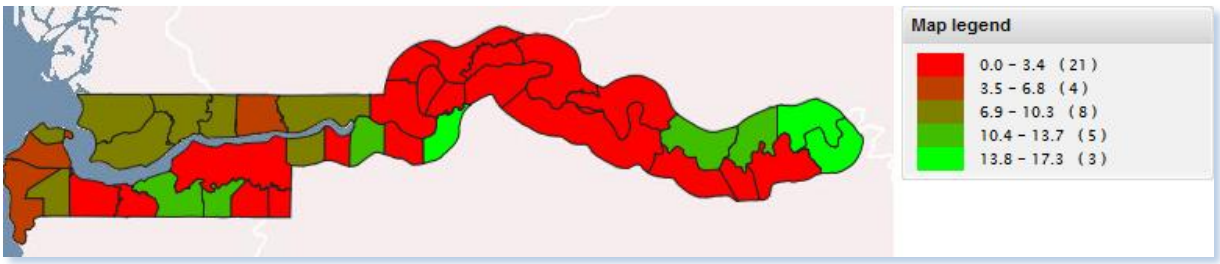


**Figure 5- 9** Map showing the indicator *BCG coverage < 1 year* for a 2009 month. The map is generated by the GIS module in DHIS 2. Lack of reporting causes the low coverage values. The meaning of the figure is only to demonstrate the GIS module.

As the GIS module does not calculate the indicator values itself but rather extracts the aggregated data from the database, the indicator values have to be calculated before

entering the GIS module. This can be done by using the Data Mart module or by generating an indicator report for the same period, organization unit and indicator which one wants to study in the GIS module.

*Note: From the 2.0.5 release of DHIS the indicator values will be calculated automatically when using GIS.*

### *Reports*

The Reports module allows the user to create a lot of different reports. I will briefly explain some of them here.

#### Dataset Report

The simplest report in DHIS2 is the dataset report. The user chooses which dataset the report shall contain, a period and an organization unit with or without children. If an organization unit with children is selected, the system will accumulate data. For example, if a district is selected and the dataset selected only applies to health facilities, the data will be accumulated so that the report will show the sum of the reported data values within the whole district.

#### Report Table

When reporting, it is common to report the same thing as in the previous report. It is therefore useful to have quick access to the data that is going to be reported. Report tables let the user select only the data elements/indicators/dataset the user is interested in. For example, if a malaria report is to be handed in every month, a malaria report table can be created, holding the necessary data elements/indicators/datasets so that the user will not have to select them every month. The report table can be used by standard reports designed in BIRT or Jasper.

#### Data Completeness Report

A Data completeness report shows how many forms in an area (a district, region or the country) are complete for the selected reporting period. The user can choose whether the report should be based on (subjective) complete data set registrations or (objective) compulsory data elements. If it is based on complete data set registrations, the report will show how many forms are marked as complete by the users. On the other hand, if the report is based on compulsory data elements, the report will show how many forms have all their compulsory data elements filled in. The latter will thus be a more objective way to measure completeness.

#### Chart

When creating a chart, the user can choose between a bar chart or a line chart, and a period chart and an organization unit chart. The difference between a bar and a line chart is obvious, but the difference between a period chart and an organization unit chart needs to be clarified. A period chart shows the indicator coverage for *one organization* unit for selected indicators and selected periods. An organization unit chart shows the indicator

coverage for *one period* for selected indicators and organization units. The period charts thus compare one organization unit for different periods, while the organization unit charts compare different organization units for one period. Figure 5- 10 shows an example of a period line chart:

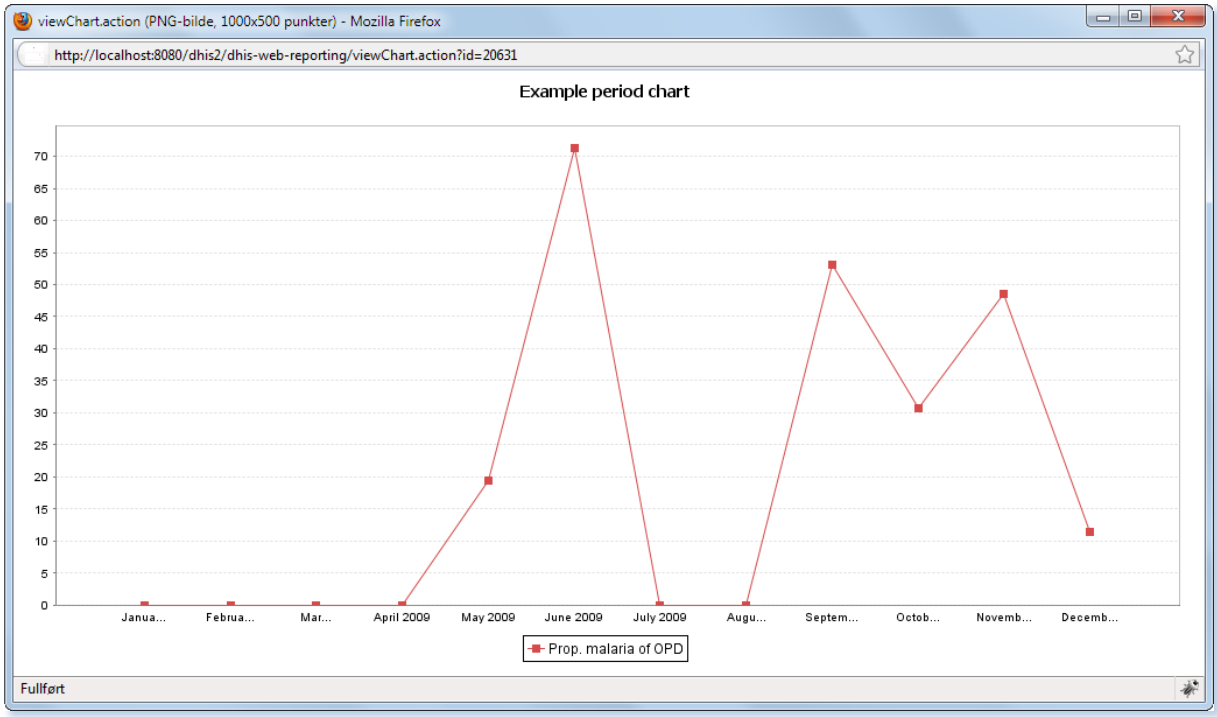


**Figure 5- 10** Example period line chart showing the indicator *Proportion malaria cases of all OPD cases* for a Gambian organization unit through 2009. Note that six months show 0. The data source shows that the reason is that OPD attendances are not registered for those months. Such deviations were difficult to reveal in the Excel returns.

### Pivot Table

A pivot table shows the indicator values for a selected indicator group, all organization units in the selected organization unit level and the specified periods in a table layout. The table is clickable, and when clicking a cell in the table the user can ask the system to automatically create a period or an organization unit chart for one or all of the indicators presented in the pivot table.

### *Import-Export*

The import and export module lets the users easily export data from an instance of the system and import the data into another instance. This requires that the database structure is the same; it will it not be possible in The Gambia to import an exported file from Sierra Leone or any other country using DHIS 2.

The users can also export data to other formats, e.g. the old DHIS 1.4 format and the Indicator Exchange Format (IXF) developed by UNAIDS, which is supported by several other

information systems, such as DevInfo[9], KIDS[10] and HealthMapper[11] (DHIS 2 Documentation Team 2010).

### *Mobiles*

The Mobiles module makes it possible to receive reports sent using the DHIS Mobile application. To use this module, a GSM modem must be installed on the server so that text messages can be received. In addition some configuration files also have to be created on the server. The application used on the mobile phones needs to be redesigned for every update, as it is a standalone java application and needs to hold all essential data, like the names of the data elements to be reported. The users can also use the module to send text messages. (More about DHIS Mobile in section 5.7.2)

### *Name-Based Data Records*

The name-based data records module lets the users create programs which patients can be enrolled in. The patient's names will be stored, and relations to family members can also be specified. This module is for following patients through a medical program and does not track regular health care visits.

## 5.4 Transferring 2009 data to DHIS 2

### 5.4.1 Huge amount of data

In the Gambian HIS there are three main returns used for data reporting: *Health Facility Monthly Returns*, *Health Facility Quarterly Returns* and *Village Health Services Returns*. The latter is for reporting data for PHC villages, and the other two for health facilities. Each Excel sheet consists of 200-300 rows, and one sheet only reports data for one health facility. As there are many health facilities in the country, a more or less automatic import process was desired. Figure A- 1 shows an example of one of the Excel sheets used for reporting.

### 5.4.2 Normalizing the Excel sheets

It was decided to use Kettle to convert the Excel files containing the data to XML files, as DHIS 2 has an Import tool that can import zipped XML files as long as these files follow a certain layout. However, for Kettle to "understand" the Excel sheets, the sheets had to be altered so that they presented one data value on each line. When an Excel sheet is on this form, each line in the XML output file from Kettle will correspond to a line in the Excel sheet. In order to present one data value per line in an Excel sheet, all data values in an existing sheet had to be mapped to a new Excel sheet. As the Kettle template we used only read one sheet per Excel file, we had to save each sheet in each Excel file as a single Excel file. We then created a new sheet in these new files and mapped one data value from the other sheet to each line, until all data values had been mapped to the new sheet. Now each new

[9] http://www.devinfo.info/
[10] http://kids.fao.org/
[11] http://www.who.int/health_mapping/tools/healthmapper/en/

Excel file contained a sheet with data values presented in a normalized way; seven columns called *orgunitId*, *dataelementId*, *categorycomboId*, *periodId*, *value*, *de name* and *category*, as Figure 5- 11 shows:

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | orgunitId | dataelementId | categorycomboId | periodId | value | de name | category |

**Figure 5- 11** Normalized Excel sheet layout

The five first column titles correspond to five of the columns in the database (see Figure 5- 12). The latter two columns in the normalized Excel sheet did not serve a specific purpose for the import process apart from being useful for manual controls.

| dataelementid [PK] integer | periodid [PK] integer | sourceid [PK] integer | categoryoptioncomboid [PK] integer | value character varying(255) | storedby character varying(31) | lastupdated date | comment character varying(360) |
|---|---|---|---|---|---|---|---|

**Figure 5- 12** Column names of the *datavalue* table in the database

When the Excel to XML conversion was performed, Kettle's XML output file layout corresponded to the layout in the normalized sheet; each line was on the form presented in Figure 5- 13 (Note that *de name* and *category* are left out, as they did not hold any useful information for the import process.):

```
<dataValue><orgunitId>1234</orgunitId>                    <dataelementId>
12</dataelementId>  <categorycomboId>  10</categorycomboId>  <period>
1000</period> <value> 12,3</value> </dataValue>
```

**Figure 5- 13** A row from a Kettle generated XML file (example values are used)

All Excel sheets that were used for reporting had the same layout (or at least they were supposed to – see section 5.4.3 for import challenges), so once we had created the new sheet with mapped data values, we could copy this sheet into the other Excel files, as the cell references we used in the new sheet would match the cells in the other Excel files as well.

### 5.4.3 Import challenges

#### *Unsupported XML layout*

It turned out that the Kettle-generated XML output files had an unsupported layout, so DHIS 2 was unable to import the data from the XML files. After some time spent trying to figure out what caused the import error, it was instead decided to create SQL queries from the XML files which could be executed in pgAdmin. This new conversion process would be less time consuming than locating the XML layout error, as this process could be done by relatively simple "search and replace" operations.

### *Template errors*

As there existed three different returns, three different Excel templates for the Kettle conversion process were needed. A lot of testing was done to verify that all data values were converted correctly. It is a time consuming job to create those templates as every single one of the data values had to be manually mapped to a new cell in the new sheet. Some errors were discovered, and it took some time to verify that all cell references were correct.

### *Incomplete database*

During the import process it was discovered that the data elements in the database did not fully match the data elements reported in the Excel sheets. This was caused by two things: 1) Some of the data that were reported are not supposed to be collected anymore, so these data elements are therefore not in the database, and 2) during the creation of the database and the data entry forms in DHIS 2, some data elements were simply forgotten. Thus the database and the data entry forms had to be updated before the import process could start.

The database was also missing some health facilities, so these needed to be created in the database before the data could be imported.

### *Inconsistency in the returns*

As the template for the normalized Excel sheet that maps all data values one by one had fixed cell references to the original sheet, it was very vulnerable for inconsistencies in the original sheet. If data values for some reason occurred in another cell than it was supposed to be, the template would not be able to map this value to the normalized sheet.

#### Changes in medicines

During 2009 a new drug was introduced in the Gambian health service, while another drug was substituted by another. Thus the reporting of one drug ceased, while two new drugs had to be added to the returns. The template for the normalized Excel sheet was designed to map data from the “old” returns – returns that were not updated to report the new drugs. Some facilities had however modified the returns themselves. As one drug was supposed to replace an old drug, some facilities just changed the name of this drug in the Excel sheet, while other facilities added a new row for this drug. Some facilities decided to keep the old row, while other ones deleted it. Some facilities also created a new row for the new drug that was introduced. These manual modifications led to frustration while trying to find a way to automate the import process. The mapping template for this return had to be modified, so in the end it was used four or five different templates for one return, each and one of them specially designed to suit different versions of the return.

#### Double reporting

For some reason some facilities also managed to edit the return so that two rows reported the same data element. This seemed to cause confusion for the Data Entry Clerk, as it seemed quite arbitrary which row the data was typed into, while the other row was left empty (i.e. with the prefilled 0-value). To map the right value (not the 0-value), a test that

compared the values in the two possible cells was created, and then the greater value was mapped to the normalized sheet. The Excel code snippet used for this was the following:

```
=STØRST('Input Data'!B$127;'Input Data'!B$129)
```

**Figure 5- 14** Example of Excel code snippet used to compare two data values and map the greater ("Størst" means "greatest")

### Displacements of data

In two of the Excel sheets there was discovered some weird displacements of some of the data. It looked like a row had been inserted and that someone had tried to move the data to the correct place. No matter how much time spent on it, it was impossible to decide which data values belonged to which data elements. The data values from these two sheets were thus not imported.

### *Empty cells vs.* 0

When reporting data, there's a difference between reporting the value *0* and not reporting a data value. *0* means that the actual number to be reported is *0*, while when a data value is not reported, it means that there has not been collected any data for this one. The Excel returns, however, seemed quite inconsistent in this matter. Some sheets were designed to automatically present the value *0* if no other data was typed in these cells (see for instance Figure A- 1). In other sheets these cells were empty. What was decided for the import process was that when *0* was reported, *0* should be imported to the database, and when a cell was empty no data should be imported.

When a cell reference is created in Excel and the referenced cell is empty, the new cell still gets the value *0*. Thus *0* would be reported even if the cells were empty. To avoid this, a "search and replace" process was performed on each original Excel sheet so that empty cells were substituted with the letter *a*. Later, before creating the SQL queries, rows containing the data value *a* were deleted to prevent them from being imported to DHIS 2.

### *Already existing data in the database*

Some 2009 data already existed in the database. To go through the database to see which data was imported would take too long. One possibility was to create a query that for each data value checked if the data value already existed in the database, but as some random tests on the already registered data showed that some of them did not match the data in the returns, it was decided that all registered data should be overwritten. As the *insert into* command throws a *unique_violation* exception when trying to insert something already existing, an SQL function was created to update the current row with the new value when a *unique_violation* exception is thrown.

## 5.5 Excel vs. DHIS2

In this section I will go through the comparable topics of the old and the new reporting system.

### 5.5.1 Excel in general

Excel is a very useful tool, but even though, unless precautions are taken, it is also a vulnerable tool. In the Gambian spreadsheets used for reporting there are lots of cells referring to other cells, and a small change can thus make the whole spreadsheet collapse. Especially as no cells have been locked; all cells are open for modifications. All Excel files contain a few sheets summing up the reported data values from the facilities, and in one of the regional files a reference error has occurred so that data values are not summed up, but instead "#REF!" annotations are shown in the cells, as illustrated in Figure 5- 15:

| OTHER DISEASE OF SPECIAL FOCUS AMONG CHILDREN <5 YEARS (IMNCI) | OTHER DISEASE OF SPECIAL FOCUS AMONG CHILDREN <5 YEARS (IMNCI) | | | | | OTHER DISEASE OF SPECIAL FOCUS AMONG CHILDREN <5 YEARS (IMNCI) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MALNUTRITION | 132 | #REF! | #REF! | #REF! | #REF! | #REF! | #REF! | #REF! | #REF! | #REF! |
| SEVERE MALNUTRITION | | | | #REF! | #REF! | | | | #REF! | #REF! |
| SEVERE MALNUTRITION WITH ANAEMIA | | | | #REF! | #REF! | | | | #REF! | #REF! |
| LOW WEIGHT WITH ANAEMIA | 63 | #REF! | #REF! | | | #REF! | #REF! | #REF! | | |
| ANAEMIA | 212 | #REF! | #REF! | #REF! | #REF! | #REF! | #REF! | #REF! | #REF! | #REF! |
| PNEUMONIA | 392 | #REF! | #REF! | | | #REF! | #REF! | #REF! | | |
| SEVERE PNEUMONIA | | | | #REF! | #REF! | | | | #REF! | #REF! |

**Figure 5- 15** Reference errors in one of the Excel returns

As the charts depend on the accumulated values the charts were thus empty, as Figure 5- 16 shows.

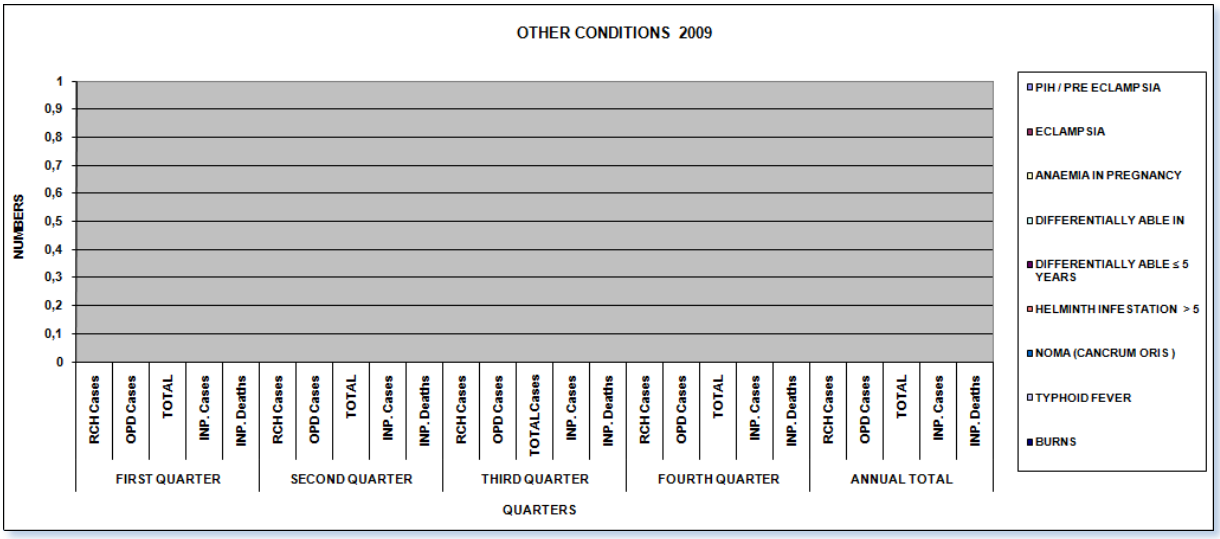


**Figure 5- 16** Reference errors caused empty charts in one of the Excel returns

### 5.5.2 Data entry

When using the Excel sheet there is one sheet for each year, and in this sheet all data elements are reported. Colours are not used to distinguish a data element row/column from another, and the possibility for typing a value in the wrong cell is thus relatively high. In addition, having almost 300 rows of data elements to report in a single sheet makes it quite big and confusing. When an Excel file contains one such sheet for each health facility in a region, the Excel file grows relatively big – the biggest files exceed 10 MB.

The DHIS 2 data entry forms are designed using the same layout as the data collection forms used in the facilities. The rows have different colours, making it easier for the user to type the data in the correct field. In addition the biggest Excel data entry form is now divided into three different data entry forms in DHIS 2.

### 5.5.3 Data validation

In the Excel sheets used for reporting there were no automatic validation of the entered data. The only way to validate the data is through manual procedures, such as e.g. eyeballing (Heywood & Rohde, 2001: 43).

In DHIS 2, when a data element is created, the type of value it is supposed to hold must be specified, e.g. a number or text. If a data element is supposed to hold a number and the user enters letters in the form, it will automatically pop up a message telling the user that the value entered is invalid. In addition the user can choose to validate the data entry forms using user created validation rules and user or system generated minimum and maximum values. If validation violations are found, a popup window will show which violations are found (See Figure 5- 6). Else the popup window will tell the user that the data passed validation.

### 5.5.4 Data elements and indicators

Indicators are calculated from multiple data element values. The Excel files used for reporting did not show any indicators. The charts in the Excel files were based on the values of the data elements. In fact all data and information in the Excel files were collected and accumulated data values.

In DHIS 2 the user can easily create indicators by specifying a numerator and a denominator. The indicator values are then automatically calculated when needed, for instance when creating charts or viewing indicator coverage in GIS (*Note: the latter was not possible until in the 2.0.5 release of DHIS 2*). Indicator values are better suited for comparison than data element values, as data element values will depend on the population in an area; a district with large population will obviously report more data than a less populated district.

### 5.5.5 Chart

The main difference between the charts in the Excel files and in DHIS 2 is that the charts in the Excel files are based on reported data element values, while the charts in DHIS 2 are based on calculated indicator values. To create a chart in DHIS 2 that shows data element

values, a new indicator must be created with the data element value as numerator and the value *1* as denominator. In addition DHIS 2 gives the users opportunities to modify the charts to meet their interests. Modification and creation of new charts in the Excel files requires more effort than the same process in DHIS 2.

Furthermore, the charts presented in the Excel files tend to contain a lot of data, instead of just a few, and are thus hard to read, as Figure 5- 17 illustrates:

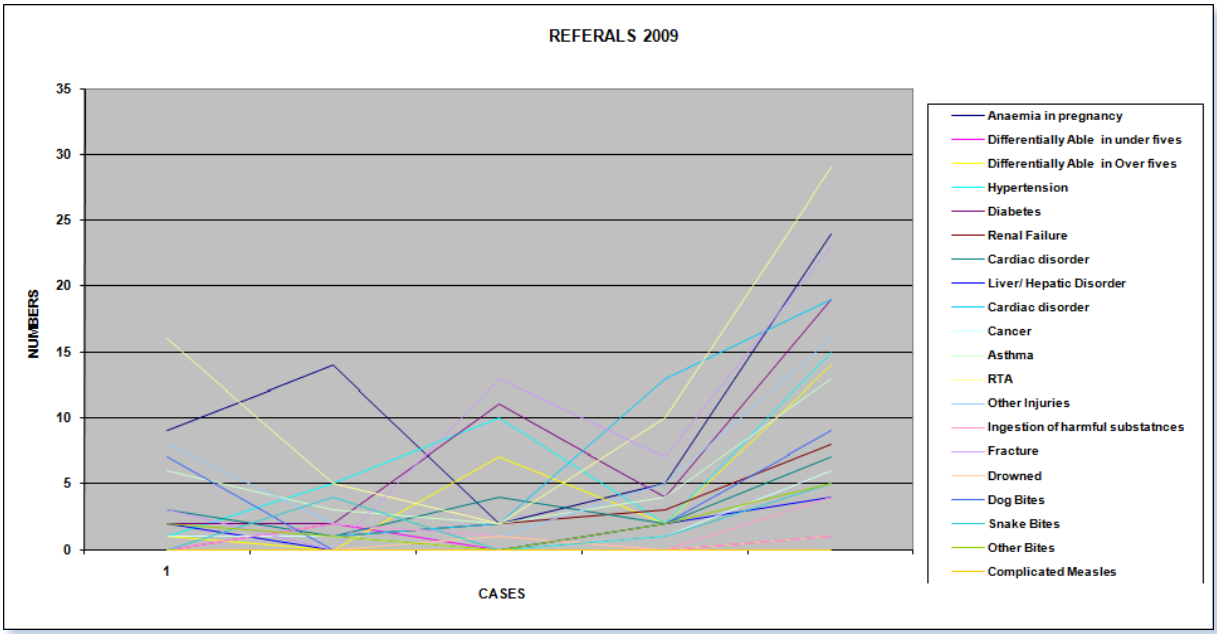


**Figure 5- 17** A lot of data presented in an Excel chart makes the chart hard to read

### 5.5.6 Data completeness

The Excel sheets offer no way to check whether all data are reported for a health facility, as all cells hold the value *0* even before data is entered. DHIS 2, on the other hand, offers two ways to check whether data entry forms are complete: the *subjective* complete dataset registrations report and the *objective* reports based on whether the compulsory data elements are given a value or not. If the *subjective* method is chosen to see if a form is complete, it requires that the data entry clerk has been honest when he has marked the data entry form as complete.

### 5.5.7 Dataset report and Report Table

The Dataset Report functionality in DHIS 2 reminds one of the Excel sheets containing the accumulated data in the Excel file used for reporting. One of the differences, however, is that the dataset report is adjustable so that the user can select which period to report. The Excel sheets present monthly, quarterly and annually accumulated data for a region, while the DHIS 2 dataset report is constrained to show a dataset for only one period, but can accumulate data upwards in the organization unit hierarchy to the selected level for the report. To accumulate data for a quarter or a year a report table can be made.

### 5.5.8 Import and export

As of now, the MOH sends representatives on trek four times a year to collect data from the previous quarter. In the Excel file era they copied the Excel files to the USB stick – now they are copying the exported DHIS 2 files. The exported DHIS 2 files can then be imported on the server. It would obviously be more efficient if the regional offices had Internet connection and could send the exported files via email. An exported DHIS 2 file is also much smaller than the corresponding Excel file and would thus require less of the Internet connection; an exported DHIS 2 file containing all 2009 data for one of the regions is 0.5-1 MB, while the sizes of the Excel files for a region add up to about 13 MB.

### 5.5.9 Mobile reporting

In The Gambia they planned to pilot DHIS Mobile for six months, but on my second trip to The Gambia, bringing 27 phones with me, the phones were confiscated at the airport customs. At the same time *SMS for health* was just about to start their six month long pilot project, so during my relatively short three weeks stay we did not get to start the pilot. Nevertheless we got to test DHIS Mobile, and the experience was good. The HMIS head expressed that he was very impressed and stated: “Weow! This is fantastic!”

By deploying mobile phones with the DHIS Mobile application installed on it, the users can report on the phones rather than filling out the paper forms. But as long as there is no Internet connection at the regional offices, the mobile users will have to report both on paper and by phone, since the regions will not be able to access the mobile-reported data, as it gets directly stored on the MOH server.

## 5.6 Obstacles

### 5.6.1 Virus

One of the most annoying obstacles we ran into during the work with DHIS 2 was all the computer viruses. USB sticks are frequently used in The Gambia, and when many computers are not connected to the Internet, the antivirus softwares’ antivirus definitions on these computers tend to be out of date. New viruses affect the computers and in some cases the viruses can do significant damage.

#### *Bansang, CRR*

When we went on trek in January 2009 we travelled around the country to collect data from the regional health offices. As in many other places there was no Internet connection in Bansang. Copying the Excel spreadsheet files which contained the last 2009 data to a USB stick was no problem, but when we tried to open them on another computer, they were all corrupted. We checked if the files were corrupted on the regional office computer, but they worked fine there. A virus on the regional office computer damaged the files we copied to the USB stick. We tried to compress the files to a .zip-file, but this file was also corrupted by the virus. The solution that worked was to compress the files to a .zip-file and then rename

the file so it had an “unknown” file ending. Then we could copy the file to the USB stick, clean the stick for viruses using another computer, and then rename the file back to .zip and unzip the files.

### 5.6.2 Upgrading DHIS 2

#### *New features*

When I first arrived in The Gambia, they were using DHIS v. 2.0.1 – the oldest version of DHIS 2. The latest release of DHIS 2 at that time (January 2010) was v. 2.0.3. Version 2.0.3 has some features that 2.0.1 does not have. A map client is integrated (Geographic information system [GIS]), data completeness reporting are extended to be objective, and a patient record system is developed (see section 5.3.4 for a presentation of the modules).

#### *Upgrading difficulties*

Before leaving for trek late January, v. 2.0.3 was downloaded and installed on the MOH’s server for testing purposes. Some small tests were performed and it seemed to run smoothly. It was thus decided to install v. 2.0.3 on the regional offices’ computers where they currently were using 2.0.1. Version 2.0.3 was hence installed in the regional offices in Essau (NBWR), Farafenni (NBER), Bansang (CRR) and Basse (URR). The installations went fine and the quick testing on each place did not show any signs of weaknesses. When we were in Basse, the Data Entry Clerk (DEC) in Basse told us that the DEC in Bansang had called him and told him about a problem in the 2.0.3-version. He demonstrated in the system what he was told; one of the data entry forms did not show but instead an error message appeared on the screen.

None of us understood what caused the error message and therefore we spent a lot of time trying to fix the problem. We tried to run v. 2.0.1 again, but then neither the form nor an error message appeared but a white screen. We installed yet another version of DHIS 2 – a “snapshot” of v. 2.0.2, but still the form would not appear. We ended up exporting the data when using the 2.0.2-snapshot, and then we restarted the software using an older database. Now the form appeared, and we imported the exported data.

On our way back to Banjul we passed Bansang, and after removing v. 2.0.3 and installing v. 2.0.1 again it worked. In one way or another we must have done something differently from what we did in Basse. Farafenni and Essau had still not reported the problem, but there is no reason to think that they should not have the same problem.

##### The problem

When explaining to one of the main developers of DHIS 2, he responded that the problem was caused by a bug that was about to be fixed for the 2.0.4 version. When the 2.0.4 beta version was released it was downloaded and installed on MOH’s server, but the error was still there. After some mailing with the same developer, he recognized the problem and explained what caused it: In v. 2.0.1 different *categories* can hold the same *category option*. In the later releases a *category option* cannot be used by more than one *category*.

In the Gambian database there was a *category option* called *Other* that was used in two *categories*. The solution was thus to create another *category option* called *Other* so that the two different *categories* did not contain the same *category option*.

## 5.7 Upgrading efforts

### 5.7.1 GIS

#### *Shapefiles*

The GIS module lets the user compare indicator coverage across organizational units in the country. In order for GIS to work maps must be created. A PhD student at the University of Oslo, currently working for the WHO, in Geneva, could supply me with the needed shapefiles (files with a geospatial vector data format). It turned however out that the way the country was divided into regions and districts within DHIS 2 didn't correspond to the way it was done in the shapefiles. For instance, *Banjul City Council* is a *region* in the shapefile, while it is a *district* under *Western Region* in DHIS 2. Also, *North Bank Region* is one region in the shapefile, while it is divided into *North Bank East Region* and *North Bank West Region* in DHIS 2. In addition three more districts needed to be split to represent the corresponding seven districts in DHIS 2.

A region/district in a shapefile is represented by a polygon which consists of numerous coordinates defining the border. When the districts were to be divided into smaller districts, new borders had to be drawn. I did not know exactly where to draw those borders, and also it is quite time consuming to find the correct coordinates. I solved the problem by finding which facilities/PHC villages where located in which districts in DHIS 2 and drew a straight border so that the facilities/PHC villages fell on the correct side of the border. The borders will thus not reflect the detailed reality but will nevertheless do their mission (see Figure 5-18)

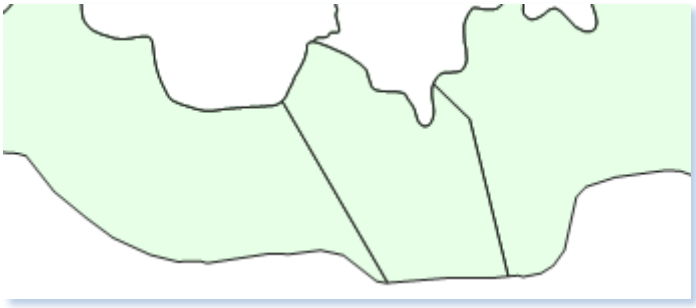

**Figure 5- 18** Simple borders manually created to divide a district into three sub districts

When dividing *North Bank Region* into two smaller regions I did not have to draw new borders but could use the coordinates from the existing border between the districts *Jokadu District* and *Lower Badibu District*.

### *GeoJSON*

The GIS module in DHIS 2 relies on files with the GeoJSON file format. Such files can be generated from shapefiles and are in reality plain text files with the file name extension .geojson. When the shapefiles corresponded correctly to the DHIS 2 organisational hierarchy, the necessary GeoJSON files was generated. One file is needed for each organisational level, and thus seven GeoJSON files had to be created; for regions, districts, health facilities, PHC circuits, PHC key villages, PHC villages and all PHC villages (both the key villages and the "regular" villages).

As I got the shapefiles for the districts and regions it was relatively easy to create the corresponding GeoJSON files. The creation of the GeoJSON files for the other five organisational levels required however extensive work. These had to be created manually, and each organisation unit needed to be assigned a coordinate. Geographical data is presented in an understandable way in GeoJSON files and it is thus relatively easy to modify or create such files without the need for third party software. An example line, representing a health facility, can be seen in Figure 5- 19:

```
{ "type": "Feature", "properties": { "NAME3": "AFPRC Hospital"},
"geometry": { "type": "Point", "coordinates": [ -15.59688, 13.57336
] } }
```

**Figure 5- 19** Example line from a .geojson file, representing the health facility *AFPRC Hospital*

#### Finding coordinates

In DHIS 2 there are 761 organisation units, of which 39 are districts, 6 are regions and one is the national level. Of the 715 remaining organisational units 50 had already been assigned coordinates, leaving 665 without. The head of the HMIS had given me an Excel file containing the 1,857 villages in The Gambia and their coordinates. Many of the health facilities, PHC circuits and PHC villages in DHIS 2 have the same name as an actual village in the country, so by aligning the content from the *organisationunit* table in pgAdmin with the content from the Excel file I could find many of the coordinates needed.

When we travelled around the country late January/early February I used the GPS on my phone to register the location of most of the facilities we visited. These coordinates were used when creating the GeoJSON files.

To manually write line by line on the form shown in Figure 5- 19 would be pretty time consuming. I figured out, however, that if I copied the content of the *organisationunit* table from pgAdmin and pasted it in a text editing software, the columns were separated by semi colons. The file could thus be saved as a .csv file and reopened in Excel, making it easier to copy the coordinates from the Excel file from the HMIS head.

When the DHIS 2 organisation units with names corresponding to Gambian village names had been assigned coordinates, 146 PHC villages were still missing coordinates. As each PHC village belongs to a PHC circuit I found the coordinates for the PHC circuit and registered a coordinate for the PHC village that only differed a little bit from the one for the PHC circuit. This was obviously not the best solution but nevertheless it indicates more or less the area where the PHC village resides.

#### Creating the GeoJSON files

When all organisational units had been assigned coordinates (still in Excel) I saved the file as a .csv file and reopened it in a text editing software. Using search and replace the content was transformed into the layout presented in Figure 5- 19.

#### *Generating indicator values*

The GIS module does not automatically generate the indicator values but uses the already calculated indicator values stored in the database. To have GIS show the correct indicator coverage the indicator values thus need to be calculated before entering the GIS module. The indicator values can be calculated either by creating charts or running data mart. The preferred and easiest solution is the latter. When creating a data mart the user can select for which organisation units and periods the specified indicator values should be calculated for. When the process is finished the user can enter the GIS module and view the indicator coverage for the indicators, organisation units and periods the indicator values have been calculated for.

If new data are entered, the indicator values need to be calculated all over again. If no new data are entered there is however no need to calculate the indicator values more than once.

*Note: From the 2.0.5 release of DHIS the indicator values will be calculated automatically when using GIS.*

### 5.7.2 Mobile reporting

#### *Preparation*

When I was in Norway between my two field trips to The Gambia I communicated with the Gambian HMIS head about piloting DHIS Mobile. It was decided that it should be piloted in Western Region. One of the datasets chosen for the pilot is reported quarterly in DHIS while the mobile reporting is planned to be monthly. A new dataset thus needs to be created to support mobile reporting.

#### *Hardware*

DHIS Mobile requires a GSM modem on the computer where the data are to be stored. In the GSM modem a SIM card is installed, and when this SIM card receives an SMS from the DHIS Mobile application, the content of the SMS gets “translated” and stored in the database.

Before I left Norway a GSM USB modem and 27 mobile phones were bought. The intention was to use these in the DHIS Mobile training, but at the airport in The Gambia the phones were confiscated by the customs.

### *Software*

To get DHIS Mobile to work an installation of DHIS 2 with the Mobiles module activated is required. The SMS service in the Mobiles module in DHIS 2 needs to be started manually every time DHIS 2 is started. SMS' that have been sent while the SMS service has been inactive, however, will be received when the SMS service is started.

The DHIS Mobile application is hard-coded and needs to be redeployed every time changes in the database are made, even if they are small. An example of a mobile reporting form can be seen in Figure 5- 20:

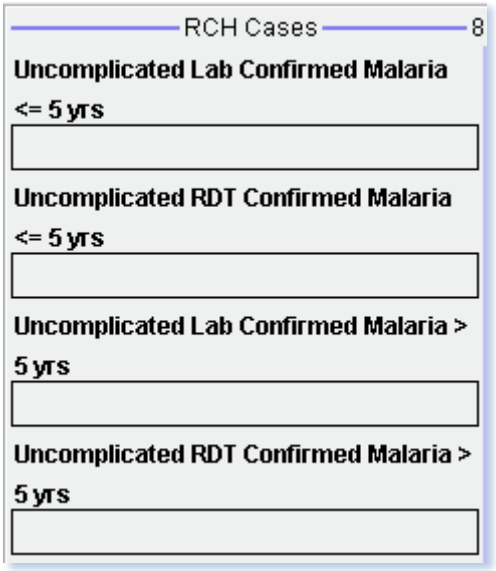


**Figure 5- 20** Example reporting form from the DHIS Mobile application

#### Registration of users

When an instance of the DHIS Mobile application is installed on a phone, a new user must be registered in DHIS 2. The user's mobile number must be registered and the user can be assigned to one, and only one, organisational unit. When the GSM modem receives an SMS generated by the DHIS Mobile application, DHIS 2 will see if the number of the sender is registered in the database. If the number is registered and the user holding that number is assigned to an organisation unit, then the reported data will be registered for this unit.

#### Mapping data values to the database

When the user is finished entering data on the phone the mobile application can generate and send an SMS holding the reported data values to the SIM card installed in the GSM modem on the server. The generated SMS does not contain any information on the reported

data elements other than the reported values. I.e. if the SMS is sent to an incorrect number, the receiver will not understand anything. Figure 5- 21 shows an example SMS where the period type is *monthly* (indicated by the '3' between the '*' and the '?') and the reporting month is April (2010-04-01). The values are separated by pipes. The first value is 1 and the last one is 10. When two pipes are adjacent it means that no data value is reported.

```
2#1*3?2010-04-01$1|2|3|4|5|6|7|||||8|9|||||||||10
```

**Figure 5- 21** The layout of the SMS generated by the DHIS Mobile application

A configuration file is needed to map the received values to the correct data value in the database. The configuration file is simply a file listing which data elements and category option combinations the received values should be mapped to. The layout of the configuration file is <data element id>.<category option combination id>, <data element id>.<category option combination id>, etc, as illustrated in Figure 5- 22:

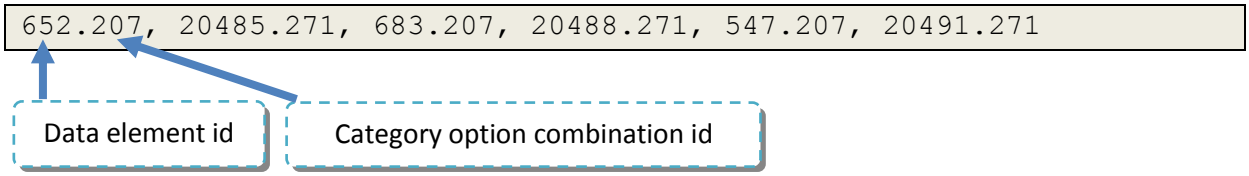


**Figure 5- 22** The configuration file shows where the received values shall be mapped

The first value in the SMS will be mapped to the first element listed in the configuration file, i.e. will the value 1 (from Figure 5- 22) be mapped to the data value in the database with *dataelementid* 652 and *categoryoptioncomboid* 207 for April for the organisation unit which the user sending the SMS is assigned to. Figure 5- 23 illustrates how the data value would have been stored in the data base table *datavalue*.

| | dataelementid integer | periodid integer | sourceid integer | categoryoptioncomboid integer | value charac |
|---|---|---|---|---|---|
| 1 | 652 | 18896 | 925 | 207 | 1 |

**Figure 5- 23** An example row from the database table *datavalue*

### *New datasets*

A new dataset was created to support monthly mobile reporting of the data that is currently reported on quarterly basis. When testing the new mobile application everything worked perfectly. The HMIS head had, however, attended a workshop where they discussed which data to collect in the country and he thus wanted to change some of the data elements reported. I therefore modified one of the data entry forms in DHIS 2 to meet his wishes. It

turned out, however, that we had misunderstood each other, so a brand new data set had to be created instead. Thus two new data sets were created in DHIS 2 to support mobile reporting. The DHIS Mobile application was also redesigned to meet the new requirements.

### *Training*

The head of the IT office was taught how to install the DHIS Mobile application on the mobile phones as well as how to start the SMS service in DHIS 2. The confiscated phones were not collected from the airport during my stay, so the plan was therefore that the head of the IT office will install the DHIS Mobile application on the phones after they are collected. Further MOH will organize training on DHIS Mobile for the health workers in Western Region so that the pilot can be started.

## 5.8 Data Quality

As the 2009 data were imported into DHIS 2, I could run the DHIS 2 validation rules on the 2009 data to see if there were some errors. I also applied the validation rules on the January, February and March data for 2010 so I could compare these data (which is reported using DHIS 2) to the 2009 data. First I will present some 2009 examples of poor quality data.

### 5.8.1 2009 data

### *Missing data*

First of all, without using the validation rules, the most notable thing is when data is missing (see e.g Figure 5- 10). On the first 2010 trek (late January/early February) the data from the last 2009 quarter was gathered. Data were collected from all but one region. That region did not report data for November and December 2009, neither for the last quarter.

### *Stock*

Violations in stock reporting is the biggest contributor to the validation violations for the 2009 data. Of the 1,179 validation violations found are namely 332 of them related to the validation rule group *Drug and Other Medical Supplies Management* and 391 to the *Vaccine Management* validation rule group. In total are thus more than 60% (723 out of 1,179) of the violations related to stock monitoring. The violations were spread throughout the year in following way:

| **Month** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Med.* | 24 | 128 | 14 | 12 | 18 | 19 | 12 | 22 | 9 | 26 | 31 | 17 |
| *Vacc.* | 16 | 195 | 21 | 25 | 15 | 19 | 20 | 16 | 9 | 18 | 21 | 16 |
| **Total** | **40** | **323** | **35** | **37** | **33** | **38** | **32** | **38** | **18** | **44** | **52** | **33** |

**Table 5- 3** The distribution of validation violations of the 2009 data

Except from the deviation in February the errors are spread relatively evenly. The February deviation turns out to be caused by an error in the Excel sheets used for reporting. The users are supposed to report *Opening stock*, *Stock received* and *Stock out* (See Figure 5- 24). The template is designed to automatically calculate the *Total* and *Consumed* values. For instance, in the figure the formula in cell *E236* is "=D236-F236", i.e. *Stock out* subtracted from *Total*. The designer of the template has however typed "+" instead of "-" for the February calculation of consumed stock, thus adding together the values of *Total* and *Stock out*.

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | JANUARY | | | | | FEBRUARY | | | | |
| 234 | DRUG & OTHER MEDICAL SUPPLIES | OPENING STOCK | STOCK RECEIVED | TOTAL | CONSUMED | STOCK OUT | OPENING STOCK | STOCK RECEIVE | TOTAL | CONSUMED | STOCK OUT |
| 235 | MANAGEMENT | | | | | | | | | | |
| 236 | ARTEMETHER-LUMMEFANTRINE 20/120 mg (6Tabs) | 3278 | 0 | 3278 | 238 | 3040 | 340 | 0 | 340 | 3145 | 2805 |
| 237 | ARTEMETHER-LUMMEFANTRINE 20/120 mg (12Tabs) | 1019 | 0 | 1019 | 150 | 869 | 869 | 0 | 869 | 1637 | 768 |
| 238 | ARTEMETHER-LUMMEFANTRINE 20/120 mg (18Tabs) | 1092 | 0 | 1092 | 91 | 1001 | 1001 | 0 | 1001 | 1875 | 874 |
| 239 | ARTEMETHER-LUMMEFANTRINE 20/120 mg (24Tabs) | 1807 | 0 | 1807 | 552 | 1255 | 1257 | 0 | 1257 | 1953 | 696 |

**Figure 5- 24** Miscalculations for the *Consumed* values for February

Figure 5- 24 also shows that there is a typing error; the value in cell *G236* should be *3,040* and not *340*.

It is not only the mistake of the spreadsheet designer, however, that causes stock reporting errors. Also it seems that not all data collectors (or data entry clerks) quite understand the meanings of *Opening stock*, *Stock receive*, *Consumed* and *Stock out*. See Figure 5- 25 for an example stock reporting. *Opening stock* and *Stock receive* are automatically summed up in the *Total* column. But for some reason it is consequently reported an over-use (consumed more than available) of the medications, and the *Consume* values have also been copied to the *Stock out* column (except from in row 244, maybe due to typing error?).

| | A | Q | R | S | T | U |
|---|---|---|---|---|---|---|
| 1 | | APRIL | | | | |
| 234 | DRUG & OTHER MEDICAL SUPPLIES | OPENING STOCK | STOCK RECEIVE | TOTAL | CONSUMED | STOCK OUT |
| 235 | MANAGEMENT | | | | | |
| 241 | COTRIMOXAZOLE 480 mg | 1000 | 1000 | 2000 | 9000 | 9000 |
| 242 | COTROMOXAZOLE 120 mg | 1000 | 1000 | 2000 | 5000 | 5000 |
| 243 | AMOXICILLIN 250 mg | 1000 | 500 | 1500 | 3000 | 3000 |
| 244 | AMOXICILLIN 125 mg | 100 | 100 | 200 | 500 | 50 |
| 245 | SULPHADOXINE PYRETHAMINE. | 0 | 1000 | 1000 | 3000 | 3000 |

**Figure 5- 25** The reported consumption is more than what is actually available

Another stock reporting example can be seen in Figure 5- 26. Only one of the October data values are reported incorrectly (Cell AY241), while for November it is reported an over-use of all medications listed in the figure. Also, only one of the November *Opening stock* values corresponds correctly to the October *Stock out* values.

| | A | AU | AV | AW | AX | AY | AZ | BA | BB | BC | BD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | OCTOBER | | | | | NOVEMBER | | | | |
| 234 | DRUG & OTHER MEDICAL SUPPLIES | OPENING | STOCK | | | STOCK | OPENING | STOCK | | | STOCK |
| 235 | MANAGEMENT | STOCK | RECEIVE | TOTAL | CONSUMED | OUT | STOCK | RECEIVE | TOTAL | CONSUMED | OUT |
| 236 | ARTEMETHER-LUMMEFANTRINE 20/120 mg (6Tabs) | 160 | 0 | 160 | 80 | 80 | 0 | 0 | 0 | 300 | 0 |
| 237 | ARTEMETHER-LUMMEFANTRINE 20/120 mg (12Tabs) | 160 | 0 | 160 | 60 | 100 | 0 | 0 | 0 | 300 | 0 |
| 238 | ARTEMETHER-LUMMEFANTRINE 20/120 mg (18Tabs) | 160 | 0 | 160 | 60 | 100 | 0 | 0 | 0 | 300 | 0 |
| 239 | ARTEMETHER-LUMMEFANTRINE 20/120 mg (24Tabs) | 160 | 0 | 160 | 100 | 60 | 0 | 0 | 0 | 300 | 0 |
| 240 | ORS | 60 | 0 | 60 | 30 | 30 | 20 | 0 | 20 | 80 | 0 |
| 241 | COTRIMOXAZOLE 480 mg | 3000 | 0 | 3000 | 2000 | 2000 | 1000 | 0 | 1000 | 5000 | 1000 |
| 242 | COTROMOXAZOLE 120 mg | 50 | 0 | 50 | 20 | 30 | 20 | 0 | 20 | 30 | 20 |
| 243 | AMOXICILLIN 250 mg | 3000 | 0 | 3000 | 1000 | 2000 | 1000 | 0 | 1000 | 4000 | 1000 |
| 244 | AMOXICILLIN 125 mg | 25 | 0 | 25 | 15 | 10 | 10 | 0 | 10 | 40 | 10 |

**Figure 5- 26** Good October-reporting but poor for November

### *Unlikely values*

Another frequent violation in the 2009 data is unlikely values. For instance, one facility reported that there were 17 AFB positive patients while the total number of the AFB patients only was 13 (Figure 5- 27).

| | A | L | M | N | O | P |
|---|---|---|---|---|---|---|
| 1 | | MARCH | | | | |
| 2 | | RCH | OPD | TOTAL | INPATIENTS | |
| 3 | | | | | | |
| 4 | | CASES | CASES | CASES | CASES | DEATHS |
| 178 | NO OF AFB PATIENTS | 0 | 0 | 13 | | |
| 179 | NO OF AFB POSITVES | 0 | 0 | 17 | | |

**Figure 5- 27** The reported number of AFB positives exceeds the reported number of AFB patients

## Malaria

One of the most common violations, however, regards malaria. The validation rule says that the number of lab confirmed malaria cases must be less than or equal to the number of malaria cases. Running the validation rules on the 2009 data revealed however 269 (i.e. 59% of the non-stock related) validation violations, all of them reporting that the number of lab confirmed malaria cases are greater than the number of malaria cases. Figure 5- 28 and Figure 5- 29 show examples from two of the clinics that reported data violating the DHIS 2 validation rules. The errors in the figures are for September and August, respectively. The values reported in the adjacent months may indicate that the data entry clerk has mistyped some of the data.

| | A | AK | AL | AP | AQ | AU | AV |
|---|---|---|---|---|---|---|---|
| 1 | | AUGUST | | SEPTEMBER | | OCTOBER | |
| 2 | | RCH | OPD | RCH | OPD | RCH | OPD |
| 3 | | | | | | | |
| 4 | | CASES | CASES | CASES | CASES | CASES | CASES |
| 8 | UNCOMPLICATED MALARIA > 5 YEARS | 0 | 970 | 0 | 353 | 106 | 720 |
| 9 | LAB CONFIRMED MALARIA > 5 YEARS | 0 | 3 | 0 | 697 | 0 | 0 |

**Figure 5- 28** It is reported more cases of *Lab confirmed malaria* than cases of *Uncomplicated malaria*

| | A | AF | AG | AK | AL | AP | AQ |
|---|---|---|---|---|---|---|---|
| 1 | | JULY | | AUGUST | | SEPTEMBER | |
| 2 | | RCH | OPD | RCH | OPD | RCH | OPD |
| 3 | | | | | | | |
| 4 | | CASES | CASES | CASES | CASES | CASES | CASES |
| 11 | UNCOMPLICATED MALARIA IN PREGNANCY | 1 | 14 | 7 | 6 | 15 | 18 |
| 12 | LAB CONFIRMED MALARIA IN PREGNANCY | 0 | 0 | 3 | 167 | 0 | 0 |

**Figure 5- 29** It is reported more cases of *Lab confirmed malaria* than cases of *Uncomplicated malaria*

## Misunderstandings

Analysis of the validation rules results show that it is quite common not to involve stillbirths when calculating the total number of deliveries at facility. Figure 5- 30 and Figure 5- 31 show incorrect and correct reporting of deliveries, respectively. In Figure 5- 30 it can be seen that the number of stillbirths is left out when calculating the number of total deliveries; the value should be 115, not 112. Figure 5- 31 show correct reporting, including stillbirths in the calculation of *Total Deliveries*.

| | A | D |
|---|---|---|
| 1 | | |
| 2 | BIRTHS AT HEALTH FACILITY | THIRD QUARTER |
| 3 | Total Deliveries | 112 |
| 4 | Deliveries Attended by Midwife | 39 |
| 5 | Live Births < 2.5 Kg. | 23 |
| 6 | Live Births > 2.5 Kg. | 89 |
| 7 | Fresh Stillbirths | 1 |
| 8 | Macerated Stillbirths | 2 |

**Figure 5- 30** Stillbirths are left out when calculating *Total Deliveries*

| | A | B | C |
|---|---|---|---|
| 1 | | | |
| 2 | **BIRTHS AT HEALTH FACILITY** | FIRST QUARTER | SECOND QUARTER |
| 3 | **Total Deliveries** | 47 | 40 |
| 4 | **Deliveries Attended by Midwife** | 27 | 30 |
| 5 | **Live Births < 2.5 Kg.** | 3 | 2 |
| 6 | **Live Births > 2.5 Kg.** | 40 | 36 |
| 7 | **Fresh Stillbirths** | 3 | 2 |
| 8 | **Macerated Stillbirths** | 1 | 0 |

**Figure 5- 31** Correct calculation of *Total Deliveries*

### *Capture in the wrong cells*

A surprising result of the analysis is that there are 60 occurrences of reported cold chain maximum temperature which is lower than the reported minimum temperature. The facility with the most violations reported the maximum temperature lower than the minimum temperature five times, while the minimum temperature were reported lower than the maximum temperature only four times. It seems thus quite randomly where the values are entered. Either that or the people treating the data are mixing the meanings of *minimum* and *maximum*.

### Calculation error or typing error?

To distinguish typing errors from calculation errors can be difficult. The reported data in Figure 5- 32 is an example of either sloppiness or inadequate mathematical skills. The validation rule applied on these data says that the number of total deliveries must equal the number of all live births and stillbirths, i.e. the values in row 3 must equal the sum of the values in rows 5, 6, 7 and 8 in the Figure 5- 32. From the figure we can see that the data entry clerk (or the data collector) has either forgotten to include the number of *Live Births < 2.5 Kg* for the first quarter when calculating the number of *Total Deliveries*, or he might have mistyped the value for *Live Births > 2.5 Kg*; 9 and 0 are adjacent keys and it is thus not unlikely that the data entry clerk has mistyped 59 instead of 50. If the live births values are correct the value should however have been 68 and not 59.

*Total Deliveries* in second quarter is correctly reported, but the calculation of the *Total Deliveries* value for the third quarter looks odd. Either the data entry clerk (or the data collector) must have summed 52+3+1=56, or he has miscalculated 52+5=56, or he might have calculated 52+5=57 but due to sloppiness typed 56 instead of 57. Nevertheless, neither 56 nor 57 is the right value but 61.

| | A | B | C | D |
|---|---|---|---|---|
| 1 | | | | |
| 2 | **BIRTHS AT HEALTH FACILITY** | FIRST QUARTER | SECOND QUARTER | THIRD QUARTER |
| 3 | **Total Deliveries** | 59 | 50 | 56 |
| 4 | **Deliveries Attended by Midwife** | 46 | 49 | 52 |
| 5 | **Live Births < 2.5 Kg.** | 9 | 2 | 5 |
| 6 | **Live Births > 2.5 Kg.** | 59 | 48 | 52 |
| 7 | **Fresh Stillbirths** | 0 | 0 | 3 |
| 8 | **Macerated Stillbirths** | 0 | 0 | 1 |

**Figure 5- 32** Miscalculation for first and third quarters

### 5.8.2 2010 data

When applying the validation rules on the available 2010 data (January, February and March) only 93 errors were revealed. The corresponding number for the 2009 data is 499. The distribution of errors through the first quarter can be seen from Table 5- 4:

| | **January** | **February** | **March** | **1st quarterly** |
|---|---|---|---|---|
| **2009** | 61 | 341 (24)* | 62 | 35 |
| **2010** | 39 | 31 (21)* | 14 | 9 |

**Table 5- 4** The distribution of validation violations for the first quarter for 2009 and 2010
*) The numbers in parenthesis are when the stock related violations are left out.

The numbers in Table 5- 4 do however not reflect the reality the way they should. Performing some sql-queries on the database shows that it is reported more than twice as many (non-zero) data values for the first quarter in 2009, compared to 2010. The number of non-zero values reported the first quarter in 2009 and 2010, together with the number of violations per 1,000 reported data values, can be seen from Table 5- 5:

| | **January** | **February** | **March** | **1st quarterly** | **1st quarter total** |
|---|---|---|---|---|---|
| **2009** | 28,844 | 26,657 | 28,651 | 2,304 | 86,456 |
| *Violations per 1,000* | *2.46* | *12.79 (0.90)** | *2.16* | *15.19* | *5.77 (2.11)** |
| **2010** | 16,373 | 12,405 | 11,767 | 910 | 41,455 |
| *Violations per 1,000* | *2.38* | *2.50 (1.69)** | *1.19* | *9.89* | *2.24 (2.00)** |

| | |
|---|---|
| *Violations per 1,000* ***2009 total*** | *1.39* |

**Table 5- 5** Non-zero values reported and validation violations per 1,000 reported values for the first quarter for 2009 and 2010
*) The numbers in parenthesis are when the stock related violations are left out.

From Table 5- 4 it seems like the 2010 data are of much better quality than the 2009 data. Table 5- 5 reveals however that the differences are not that big, though there is a notable

difference. Looking away from the February violations regarding stock monitoring, the 2009 February data has in fact less violations than the 2010 February data. Figure 5- 33 visualizes the differences in validation violations for the first quarter in 2009 and 2010:

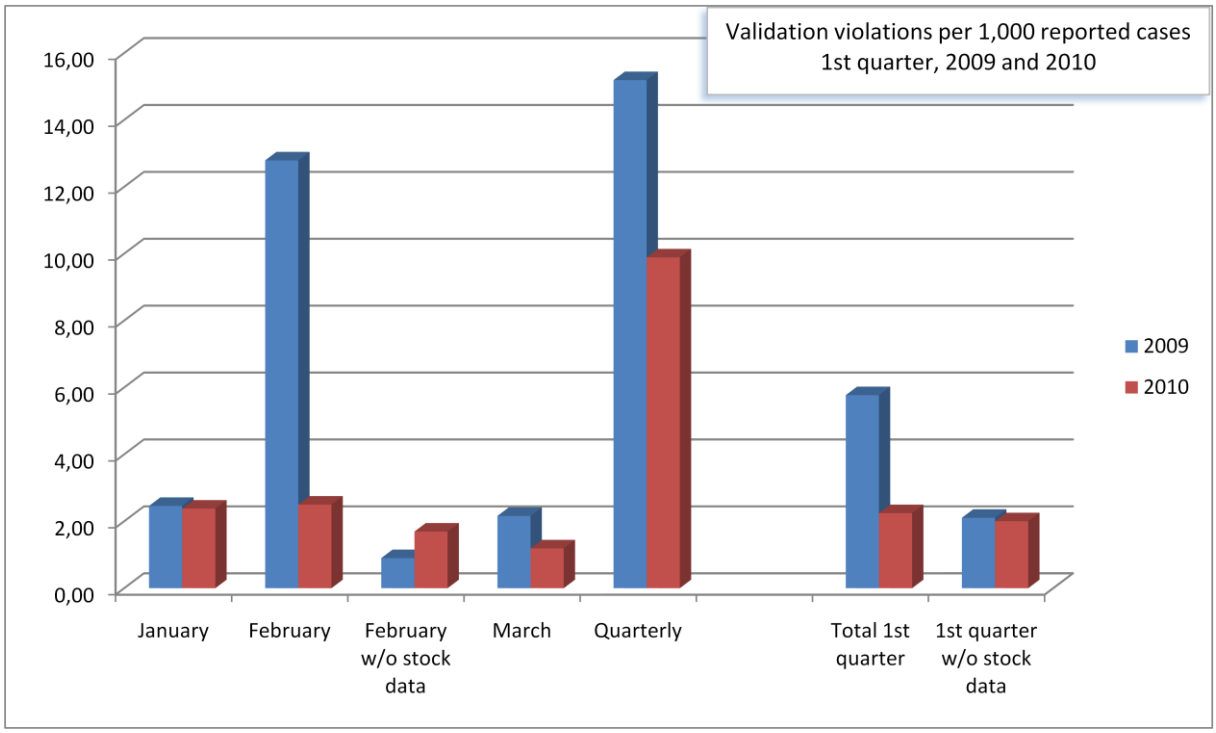


**Figure 5- 33** The differences in validation violations for the first quarter of 2009 and 2010

I will now analyze the validation violations for 2010 to show what causes the 2010 violations.

### *Missing data*

From Table 5- 5 above it is obvious that a lot of 2010 data is missing, since it is reported less than half the amount of data values as for the same period in 2009. Spot checks in DHIS also confirm this suspicion.

### *Stock*

The data presented in Figure 5- 34 below is from the same facility as the data in Figure 5- 25 above. The amount of consumed medications in two of the five cases in Figure 5- 34 is reported to be more than the amount of available medications. Also after the introduction of DHIS 2 the *Consumed* value are still copied to the *Stock out* value on this facility (except from for *Cotrimoxazole 120 mg*, which most likely is due to a typing error).

| DRUG AND OTHER MEDICAL SSPPLIES MANAGEMENT | | | | |
|---|---|---|---|---|
| | STOCK IN TINS / DOSES DURING THE MONTH | | | |
| | OPENING STOCK | STOCK RECEIVED | CONSUMED | STOCK OUT |
| COTRIMOXAZOLE 480 mg | 1000 | 5000 | 1100 | 1100 |
| COTRIMOXAZOLE 120 mg | 1000 | 5000 | 9000 | 900 |
| AMOXICILLIN 250 mg | 8400 | 500 | 11000 | 1100 |
| AMOXICILLIN 125 mg | 1506 | 1000 | 50 | 50 |
| SULPHADOXINE PYRETHAMINE. | 17000 | 1000 | 1000 | 100 |

**Figure 5- 34** The reported consumption values seem to be copied to the stock out column. Also some over-use are reported (consumed more than available).

Another example of a stock related validation violation can be seen in Figure 5- 35 below. The reported consumption value for *Polio* exceeds the amount of stock available. Interestingly the reported *Consumed* value equals the sum of the *Opening*, *Received* and *Balance* values. Maybe a calculation error when typing the data has caused the validation? 420 + 1,000 + 360 = 1,780, while 420 + 1,000 - 360 = 1,060; the correct *Consumed* value (given that the three other values are correct) should thus be 1,060.

The *Pneumococcal* values in Figure 5- 35 are also worth to notice. 234 + 739 – 777 = 196, and not 191, as is reported as the *Balance* value. This error was not revealed by the validation rules but was discovered quite by chance. The reason for the error is unknown – it might just be a typing error.

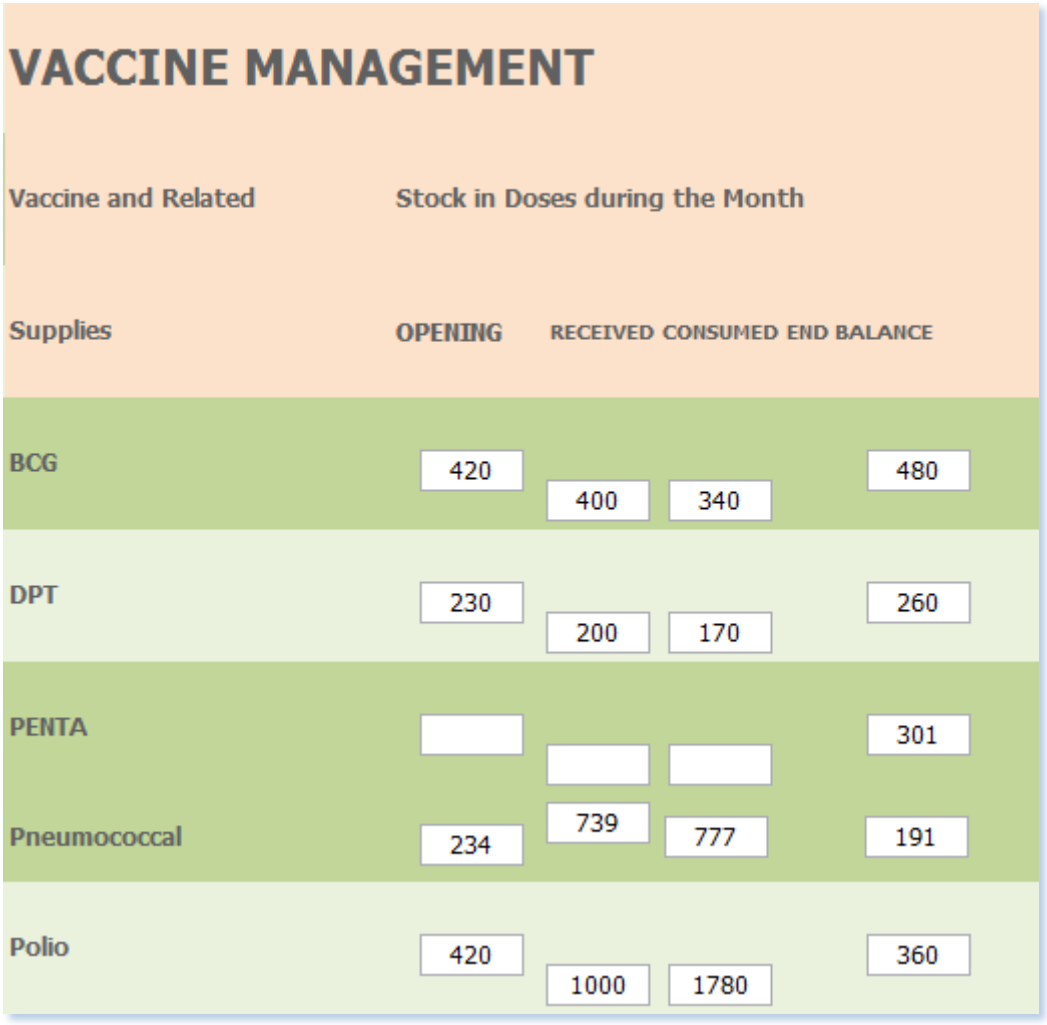


**Figure 5- 35** Possible miscalculations for the *Pneumococcal* and *Polio* values

### *Unlikely values*

Also after taking DHIS 2 into use unlikely values are reported. The stock examples above are good examples of that. Figure 5- 36 also shows an example of an unlikely value. The facility reports that the number of patients post test counselled exceeds the number of patients that were actually tested.

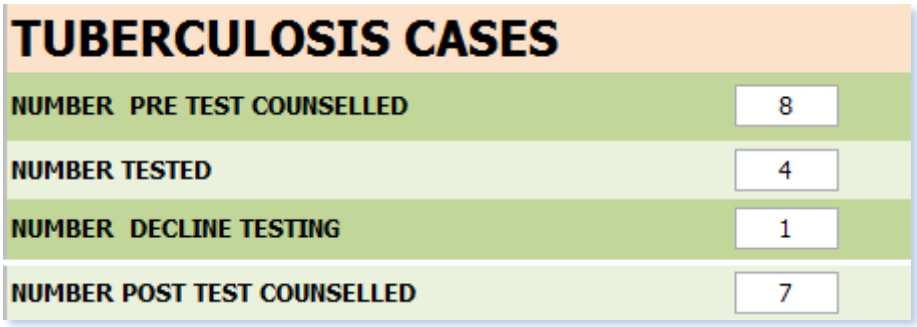


**Figure 5- 36** The number of post test counselled patients exceeds the number of tested patients

### Malaria

The malaria violations were also present for the 2010 data. Figure 5- 37 shows that a facility has reported 264 lab confirmed malaria cases for patients above the age of 5 years, while the number of uncomplicated malaria cases for the same group of people was reported to be 200.

| | RCH CASES | OPD CASES |
|---|---|---|
| UNCOMPLICATED MALARIA > 5 YEARS | | 200 |
| LAB CONFIRMED MALARIA > 5 YEARS | | 264 |

**Figure 5- 37** It is reported more cases of *Lab confirmed malaria* than cases of *Uncomplicated malaria*

### Misunderstandings

The stock examples above show very clearly that someone has misunderstood the data elements definitions. Other 2010 examples are the misunderstandings regarded births at facility, as were also mentioned for the 2009 data. Figure 5- 38 below shows an example from a facility where the stillbirths are omitted from the calculation. The *Total Deliveries* value should thus be 425 and not 397.

| BIRTHS AT FACILITY | |
|---|---|
| Total Deliveries | 397 |
| Deliveries Attended by Midwife | 360 |
| Live Births ≤ 2.5 Kg. | 30 |
| Live Births > 2.5 Kg. | 367 |
| Fresh Stillbirths | 9 |
| Macerated Stillbirths | 19 |

**Figure 5- 38** Stillbirths are left out when calculating *Total Deliveries*

### *Capture in the wrong boxes*

Also the validation violations for the first three months of 2010 show several occurrences where the maximum cold chain temperature is reported lower than the minimum temperature. In fact one of the facilities reported lower maximum temperature both for

January and February (no data for March). Two of the other facilities that reported the same self-contradiction reported correctly in the other months. One of these facilities reported a maximum temperature of 5 degrees, while minimum temperature was reported 12 degrees; the reported value might indicate that the minimum temperature should be either 1 or 2 degrees. The other facility seems to have mixed minimum and maximum temperature, as the reported temperatures were similar to the (correctly) reported values for another month, namely 2 and 5 degrees.

The rest of the facilities listed on the validation violations list reported only for one month, indicating that they have mixed the meanings of *minimum* and *maximum*.

## 5.9 Fragmentation

### 5.9.1 SMS for health

In autumn 2009 an employee at the MOH got in touch with International Health Partners (IHP). In cooperation with Matssoft, Vodafone and Pfizer they have rolled out the *SMS for health* project in Tanzania. The main focus of the project is on the reporting of malaria medications stock details. The health workers report stock details by SMS', and when a reporting date is closing in they will receive an SMS reminding them to report. If data are correctly reported on time, the health workers will automatically receive credit on their SIM card. The reported data can be viewed on a web page, and a map can be generated to show how the stock level is in each district.

IHP claims that the project has proved successful in Tanzania as it has improved the stock monitoring, preventing the facilities to run out of medications in the malaria season. They therefore wanted to roll out the project in The Gambia as well.

Without consulting neither the Gambian HMIS nor the head of the IT office people higher up in the MOH hierarchy authorized the project. Contracts were thus signed in February 2010 and it was decided to start a six month long pilot June 2010.

#### *Commercial interests*

HISP contacted the *SMS for health* project partners and suggested a cooperation to avoid time-consuming reporting, resulting in duplicate work and further fragmentation of the information flow. Vodafone is however a commercial company, and a Global Commercial Manager of Vodafone Health Solutions involved in the *SMS for health* project explained that they had contracted for the services in The Gambia as for now. It was however stated in the email that there "may be an evolution of the service that could use your [HISP's] capabilities if there is a place for them in the value chain".

A HISP member attended a meeting with IHP and Vodafone to discuss cooperation. The model that Vodafone uses in this project cannot, however, be combined with the idealistic

mindset within HISP. Basically Vodafone offers a reporting infrastructure, a place to store data, and a website where data can be accessed. The service does however cost, but donors pay these bills on behalf of The Gambia. Thus, as for now, *SMS for health* is free for The Gambia.

## 5.10 Recent activities

### 5.10.1 International workshop

September 2010 there was held a workshop in Accra, Ghana[12] that aimed at strengthening HIS capacity throughout West Africa. The head of the MOH IT office and the HMIS head from The Gambia attended the workshop, which was organized by the West African Health Organization (WAHO), WHO, the University of Oslo, Health Metrics Network (HMN) and the Capacity *Plus* project. The workshop was participant driven, and one of the open sources software solutions it was put focus on, was DHIS 2. The participants discussed experiences and problems and thus learned from each others. Some of the software developers also attended the workshop and could contribute to helping the participants with their issues.

### 5.10.2 UN requirements

From 2011 the UN requires that all data elements will have a gender dimension. That means that the entire Gambian data base will have to be redesigned to satisfy the UN, as only a few data elements at the present time have a gender dimension. The Gambia has however not received any money to cover the cost of the redesign process.

### 5.10.3 Attracting actors

#### *NAS*

Although DHIS 2 has been functional for less than a year it has already started to attract other actors. The National Aids Secretariat now shows interest in DHIS 2 and might want to use the system for their reporting. Currently the NAS reporting happens through the Global Fund to fight AIDS, Tuberculosis and Malaria (GFATM) monthly monitoring report form.

#### *mSupply*

One of the professors working for Global Fund on the pharmaceutical supply chain software mSupply was also impressed of DHIS 2. mSupply is currently being piloted in The Gambia, and he wants it to be linked to DHIS 2 and wants to secure that no data is collected both in DHIS 2 and mSupply.

[12] http://www.intrahealth.org/page/open-source-and-global-health-unconference-focuses-on-health-information-systems-in-west-africa-september-20ndash24-accra-ghana

### 5.10.4 Internet access at regional level

November 2010 the head of the IT office could report that all regional offices now have Internet connection. The connection is provided through satellite and the speed is 1 Mbps. Global Fund has sponsored the connection and will continue to pay the connection bills.

## 5.11 Summary

In this section I have presented the results and findings of my research. DHIS 2 was implemented the autumn 2009. Four times a year MOH staff has travelled around to collect data from the regional offices. They will continue with this until the regional offices will get Internet access. In the regional offices there is one DEC (two in WR) who types data that are collected from the health facilities on a monthly basis. Timeliness is poor, and the validation rules revealed many validation violations on both the 2009 and 2010 data.

DHIS 2 are a relatively complex tool compared to the previous used Excel returns, but learning the basic functionalities is easy. Extensive training can nevertheless be held to increase capacity to use useful tools provided by the system, such as the GIS and charts functionalities. Importing the 2009 data that was reported through the Excel returns was a time-consuming task, and virus and version incompatibilities of DHIS 2 also contributed to frustration. Preparing GIS and DHIS Mobile required a lot of work, but in the end it seemed to work smoothly.

The project *SMS for health* was introduced the spring 2010. It aims to monitor the malaria medications stock at health facilities and has introduced their own HIS, thus fragmenting the health care sector even more. The project overlaps some of the work done through DHIS 2, especially if also considering DHIS Mobile.

Recently MOH staff attended an international workshop on HISs in Ghana. The UN requires more detailed data reporting, and DHIS 2 is already starting to attract other actors from the health care sector in the country. The regional offices have also quite recently been provided with Internet access.

# 6 Discussion

In this section I will discuss my results and findings from my research in the light of the reviewed literature. I start out with system development in developing countries and move on to ICT in developing countries and HIS' in developing countries. In section 6.4 I discuss the Gambian data quality, and in the final section 6.5 I briefly discuss further plans and possibilities for The Gambia. Through this section I will approach my research questions on human capacity, data quality and how DHIS 2 can ease data collection and reporting.

## 6.1 System development in developing countries

Osterwalder (n.d.) stresses the importance of human capacity when it comes to capitalizing on the opportunities ICTs offer. As noted above the ICT knowledge in The Gambia is quite poor, so The Gambia's ICT future might look relatively bleak, considering Osterwalder's views. People can however be trained in ICT, so by training people when introducing new systems the capacity can be increased. Osterwalder (ibid) lists three requirements for the existence of ICT. Table 6- 1 shows these requirements applied to the Gambian implementation of DHIS 2:

| **Capacity to...** | **DHIS 2...** |
|---|---|
| ... provide and maintain IS at a reasonable price | ... is totally free |
| ... create and maintain useful local applications and content | ... contains health data for regions, districts and facilities; provides tools as charts, reports and GIS |
| ... understand and use applications | ... is relatively advanced for health workers not used to computers |

**Table 6- 1** Osterwalder's (n.d.) requirements for ICT existence applied on the Gambian DHIS 2 implementation

According to Osterwalder (n.d.), will DHIS 2 have a chance to survive in The Gambia? The system was provided for free and it does not require much to maintain it once it is installed and is working. The content within the system is highly relevant for health care, and the tools and opportunities the system offers will ideally make the work easier for the health workers. The biggest constraint is however the users' capacity to use the system. Nevertheless, even if the users do not use all the opportunities provided by DHIS 2, they still gain more by using the system than they did using the Excel tool earlier. It is crucial though to follow up the users and train them so that they can take even more advantage of the system. The answer on whether DHIS 2 will survive and continue to exist, according to Osterwalder's requirements, is thus *yes*!

Osterwalder's requirements corresponds to POST's (2006) factors contributing to the digital divide as well as the UN's (2005) reasons for why ICT penetration to a relatively high degree fails in developing countries. It should thus be put significant emphasis on these perspectives when introducing (new) ICT in developing countries. I've argued that HISP has succeeded, according to these perspectives, when implementing DHIS 2 in The Gambia.

### 6.1.1 The design process in The Gambia

When designing and implementing a system an iterative approach is recommended (Kanjo et al 2009). The early and continuous evaluation and feedback gained by using an iterative approach helps reveal errors at an early stage and so reduces the cost of fixing them. When a more linear approach is used, such as the waterfall model as presented by Krutchen (2000), errors are not likely to be discovered early and it will be costly to fix them. When DHIS first was developed (in South Africa) an iterative design process was chosen. Continuous feedback and suggestions for improvements resulted in frequent releases of the software.

In The Gambia, on the other hand, a more linear approach was chosen. The HISP people sat down with the head of the HMIS and the head of the MOH IT office to design the software. When it was designed it was deployed in the regional offices as well as in the MOH. Later, when I arrived in the country, I found that there were several errors in the database, and due to the lack of Internet connectivity in the regional offices the regional implementations could not be updated unless some competent people physically went there and updated the system for them. Even though The Gambia is a small country, it takes several days travelling around the country, due to poor infrastructure. The cost of fixing the errors that were revealed relatively late was thus greater than it would have been if it was decided to pilot the software in one region instead of in the whole country. Even now, not all problems have been fixed, due to the lack of skilled people in the country.

### 6.1.2 Participatory design in The Gambia

HISP wants to follow a participatory approach in their work with HIS', and history shows that they have succeeded quite well (e.g. Braa et al 2004). The development of the first version of DHIS (ibid) serves as a good example of their success using a participatory design (PD) approach. The participatory prototyping led to rapid cycles with new builds on a weekly and even daily basis (ibid). Also the DHIS 2 implementation in Sierra Leone stands as a great example on user participation in design and implementation, as new functionalities were put in place in close collaboration with the locals (Staring & Titlestad 2008). Even though DHIS 2 was first piloted in India 2006, it was not on par with the functionality of DHIS version 1 until the software had undergone further development in Sierra Leone 2008-2009.

The participation in South Africa/Sierra Leone and in The Gambia can be compared to the invention and the use of the LEGO bricks. User participation contributed to the design of two types of LEGO bricks in South Africa and Sierra Leone, while the user participation in The Gambia (and all other countries where DHIS are implemented) is more about how to put

together the LEGO bricks to develop a well functioning information system, following a PD approach.

The work that was done in The Gambia was twofold. The empty DHIS 2 database was populated, and installations, routines and trainings were also necessary to accomplish before DHIS 2 could started to be used. Since the system was going to be designed and implemented according to the locals' needs, user participation was thus crucial in the implementation process.

By sending the HISP head and a PhD student to help the Gambians in the implementation process HISP confirms that they act according to their primary goal, "following a participatory approach to support local management of health care delivery and information flows (...)" (ibid). MOH staff contributed by telling the HISP persons what data elements and indicators to create and how to design the data entry forms and the reports, and in that way they participated in the software development.

During the autumn 2009 there were three British volunteers in the Gambia spending a lot of time on developing training material and teaching Gambians how to use DHIS 2. They also travelled around the country and helped MOH staff install DHIS 2 at the regional health offices. When I first came to The Gambia in January 2010 the software was operational but needed modifications; for example some data elements were wrong, some were no longer to be reported and some new had been added. Also a new version of DHIS 2 had been released, which required relatively advanced database modification before upgrading to it. Maintaining and synchronizing six different instances of a database without Internet connectivity requires careful planning to keep the databases compatible with each other. To ensure stability and sustainability through such processes, reliance on experienced persons from similar work would be preferable. As I had close to no previous experience with the use of DHIS 2 and hence was not aware of the implications regarding the updating and modification of the software and the database, there still exists some incompatibility between the different instances of the databases.

Titlestad et al (2009) mention the lack of skilled personnel and shortage of money as an issue regarding software development in resource-constrained settings, making reliance on foreign actors necessary for developing good HIS'. As the implementation of DHIS 2 does not involve creating a brand new HIS but rather adopting already existing software, skilled programmers are not that important to perform a successful implementation. The implementation and modification of DHIS 2 does however still require some computer skills. As the number of relatively experienced computer technicians in The Gambia, let alone within the MOH, is low, the presence of foreign actors has been vital to design, implement and sustain DHIS 2.

As DHIS 2 is free and open source software (FOSS) it costs absolutely nothing to use it. The infrastructure needed to make use of the system is however expensive, seen from a

Gambian point of view. Without monetary support from foreign actors, equipment needed for the HIS might not have been (prioritized, and thus) purchased. Even the three week long stay of a Norwegian associate professor and his companion to help them in the implementation process would have cost them a fortune if they had to pay for it themselves[13]. Titlestad et al's (2009) statement – that the reliance on foreign actors is a necessity for the development of a good HIS – fits thus well with the financial and educational situation within, as well as with experiences from, The Gambia.

### 6.1.3 Gambian prototyping

Titlestad et al's (2009) emphasis on mutual learning process must be seen as an important tool in the development of new software, as with the DHIS development in South Africa (bid), where the developers listened to the users' suggestions for improvements. When adopting DHIS to a new country, the mutual learning process will naturally be shorter and cannot be given the same importance as when developing software from scratch. Nevertheless, to finalize the software, prototyping and face-to-face discussions will be invaluable, and local knowledge is essential to maximize the usability of the software. Although both The Gambia and South Africa are developing countries, local knowledge and needs will be different, and hence DHIS needs to be modified to meet local requirements. The modification will however not be related to the system itself but its contents (data elements, indicators, forms, reports, etc).

The design team in The Gambia consisted of an associate professor and a PhD student from the University of Oslo – both enrolled in the HISP network; the Gambian HMIS head and the head of the MOH IT office. They all represented knowledge from different fields, although some overlapped. The associate professor has a lot of experience from DHIS 2 implementations in other countries, and the PhD student is actually a medical doctor with programming skills and much experience with DHIS 2 implementations. The Gambian HMIS head presented the Gambian requirements for what the system needed to cover, and the head of the IT office is in charge of maintaining the system once it is operational. A software architect and domain experts were thus represented in the design team, as recommended by Titlestad et al (2009). With the IT head's presence in the design team the HISP persons could also get an impression of the level of IT knowledge within the MOH. Through the three weeks spent on adapting DHIS 2 to the Gambian context HISP thus learned about local requirements and IT knowledge, and the Gambians learned a lot about the possibilities of DHIS 2.

The experience from Mozambique suggests that, when implemented, DHIS should be seen as a prototype and not as a ready-to-use software (Puri et al 2004). From my own experience from my work in The Gambia I totally agree with that statement. Based on observations, discussions and training sessions, the Gambian health workers seem quite impressed with

[13] Including travel expenses, salary and grants for food and housing, the cost for bringing a (Norwegian) person to The Gambia for three weeks would approach four times the yearly salary of an employee at the Gambian MOH.

the software. There has nevertheless been frustration with some functionality, mainly caused by lack of basic computer knowledge. It is a huge step migrating from Excel spreadsheets to an advanced database system for people with limited computer skills. The users thus need time to get familiar with the system and given the opportunity to provide feedback.

Experience has shown that the implementation of a complex HIS in a developing country is hard to plan. It is not always easy to quite understand the level of knowledge amongst the locals. During my stays in The Gambia I noticed that people spoke very much, almost bragged, about things they knew. And when other people spoke of things they did not know much about, they nodded along and pretended that they understood. One could thus get the impression that they knew a lot more than they actually did. So when I thought I had explained a computer issue well, as the recipient said he understood it, he failed trying to accomplish the task it himself. Later when explaining things to the locals, I tried to ask questions to verify that they had understood what I just said. It is obvious that it is not easy to implement an advanced HIS in such a context. I guess one just has to be patient and learn the local culture as one walks.

### *Top-down vs. bottom-up*

The design approach chosen in The Gambia can be described as a top-down approach, as only a few people from the ministry were involved in the process. Nevertheless, as The Gambia is such a small country, all the regions are collecting the same data, so there would be no point in gathering people from all regions to discuss which data should be collected in the different regions. Hence a bottom-up approach when designing the system is likely to have resulted in the same final result.

In Cuba Sæbø and Titlestad (2004) suggest a bottom-up approach on design and a top-down approach on implementation, due to the centralized system in the country, requiring them to have full support at highest level before implementing anything. In The Gambia the decisions are also made at national level, and history shows that people get sacked quite fast if they act on their own. Sometimes the reasons for demoting are also unknown. People are therefore very careful and afraid of doing something that can cause them to lose their jobs. So even if HISP wanted to try a bottom-up approach when implementing DHIS 2 it would not have been feasible, and because of the small size of the country there would be no point in choosing a bottom-up approach for the design process. The chosen top-down approach for both design and implementation was thus obviously the best choice in The Gambia.

### *Boundary spanner*

The way Titlestad et al (2009) describe *boundary spanners* corresponds with how I experienced my role in The Gambia. According to them, boundary spanners are mediators – persons traversing borders and thus make communication between designers and users easier. As my stays in The Gambia in total lasted for 13 weeks and I was working closely with the locals every day, I understood many of their concerns and could bring their requirements

and thoughts further to the developers in Norway. Titlestad et al state that the user-designer gap "can best be bridged by technically conversant people who are also adept at communicating with the core developer team" (ibid). As I got to know the Gambians quite well and also, compared to the level of IT knowledge within the MOH, am very skilled in computing, I am sure I contributed to bridging the gap between the users and the developers. This became especially visible during the import process of 2009 data, as well as through the work with the modification of the database and the upgrading of the software.

### 6.1.4 Installed base cultivation

An infrastructure is defined as "an evolving shared, open, and heterogeneous installed base" (Hanseth and Monteiro 1998, ch 3). According to Hanseth and Monteiro's explanations of the words *shared*, *open* and *heterogeneous*, the Gambian HMIS can be considered an infrastructure, as it

- is shared by the health workers as well as the patients,
- has no limitations for patients (users) and
- consists of heterogeneous elements, such as technical equipment as well as staff.

Hanseth and Monteiro (ibid) stress that an infrastructure cannot be developed from scratch but will always be developed through extending the installed base. The implementation of DHIS 2 in The Gambia visualizes this in a good way. Although DHIS 2 was a new system introduced in the country, the already existing infrastructure and routines were/are used in the implementation and use of the system. The facilities are still using the same paper forms to register data, and the work routines are still the same. DHIS 2 was also installed on the same computers which data entry clerks earlier used to type data into the Excel spreadsheets. Earlier MOH staff travelled around the country copying the spreadsheets to a usb stick they brought along. They still travel around, but now they copy exported files from DHIS 2 to their usb stick. HISP has thus contributed to transform and change the behaviour and routines (Braa & Hedberg 2002) of the Gambian HMIS through the implementation of DHIS 2. Hanseth and Monteiro (1998, ch 9) claim that only few components of an II can be changed at a time, and in the Gambian case it is only the reporting tool that has been changed. The installed base has thus influenced the design of the "new" infrastructure (ibid).

### 6.1.5 Backwards compatibility

When releasing software updates it is important to the users that the new release of the software is backwards compatible (Hanseth & Monteiro 1998, ch 9) with the previous version. For DHIS 2 this means that after upgrading the software there should be no problem using the new release. The experience in The Gambia, however, was the opposite. When I arrived in The Gambia they were using version 2.0.1 of DHIS. At that time version 2.0.3 was released, so we wanted to update the software. The Gambian implementation had however been designed in a way which was incompatible with the 2.0.3 release, so after upgrading,

the software crashed at certain points. After returning to Norway I spoke with some of the experienced developers, and they explained what caused the error. The solution was relatively advanced, and with the current ICT knowledge in the MOH they would never have managed to solve the problem. Backwards compatibility is thus important when releasing DHIS updates.

The problem can also be linked to the *black-boxing* concept. The effect of black-boxing is that only the outside matters – there is no reason to focus on the complexity within as long as the outside is the same (Hanseth et al 1996; Latour 1999). DHIS 2 is continuously under development, and the complexity within (the code) thus increases. The outside (functionality) of the software also changes. Nevertheless, as new releases of DHIS 2 are made so users can upgrade the software, the new releases must be designed in a way that is (backwards) compatible with the design of the previous version, especially in the way they relate to the database. Thus we can speak of a desired black-boxing effect for the communication between the software and the database. If new releases required manual work on the database, then DHIS 2 would not have been upgraded in many countries due to the lack of sufficient computer skill.

## 6.2 ICT in developing countries

### 6.2.1 ICT's influence on the third world

Developing countries are far behind the industrialized world in many fields. One of them is the ICT field. The current time we are living in is often (at least in Norway) referred to as the *I(C)T age*, indicating that ICTs play a significant role in our lives. Nevertheless, the ICTs have not reached the third world to the same extent as the industrialized world and thus we speak of the digital divide, indicating the gap between people with and without access to ICT. Looking at ICT's role in the industrialized countries, it has become important in many fields, e.g. health and education. POST (2006) stresses that the introduction of ICT in developing countries is urgent to prevent the digital divide from growing. The OLPC project contributes to bridge the digital divide as it facilitates computer knowledge and also contributes to bring general knowledge to people through connecting them "to the world" (OLPC n.d.).

Although ICT facilitates education and health services one needs to be aware that ICT is not a panacea ensuring development (Torero & von Braun 2005). Torero and von Braun's three C's says something important: ICT needs to offer relevant *content*, the users must be *capable* to use it, and *connectivity* is required to gain access. The OLPC project aims at *connecting* the children to the world, and Negroponte (1998), before his launch of the project, spoke of bringing the world's libraries (*content*) to the poor. Through the project they will also learn how to handle computers (*capability*). Thus, it seems like Negroponte has succeeded in not seeing ICT as a panacea, but rather has used ICTs to facilitate development.

Capability challenges in developing countries also affect the implementation of DHIS 2. DHIS 2 easily *connects* the users to relevant health related *content*, but the *capability* of the users is however the biggest bottleneck in implementation and use of the software. On one of the training sessions I held on DHIS 2, I had to explain how to use a computer mouse. When the computer knowledge is that poor the way towards mastering DHIS 2 and getting the most out of it seems extremely long. Also, at one of the regional offices the data entry clerk (DEC) could not understand why his completeness registrations would not register. The problem was that Firefox was set to block popup windows, and the DEC did not notice the information bar telling him this. When activated, the popup window appeared telling him that there were errors in his form, preventing it from being marked as complete.

POST (2006) presents some reasons contributing to the digital divide. One of them is language, as English is the primary language in the field of ICT. In The Gambia, English is the official language, but it is only taught at school, so people who have not attended school will speak very poor English, if any at all. And even though people have been to school, I learned from my interaction with locals that the knowledge of the English language is terribly poor in the country. Even people high up in the ministries speak badly (and are also having trouble understanding) English. When overlooking an installation of some software on a computer in the MOH IT office, the employee who installed the software could not understand why he could not finalize the installation. The simple reason was that when he was asked to create and retype a password, he for some reason inserted a username and a password. I never understood whether the misunderstanding was caused by his lack of English skills or because he simply did not read all the text on the screen. Nevertheless, these examples show that the *capability* of the Gambians can be questioned, and not only at the grass-roots level, but in the Ministries as well. Thus, without further extensive and thorough training and retraining of users, I fear that the Gambians will not be able to maximize their use of DHIS 2 for a long time, if ever.

I see the OLPC project and DHIS 2 as effective tools facilitating education and health services. Osterwalder (n.d.) states that the real question in the debate on ICT versus charity is how ICT in the most effective way can help in education, health and small business development services. From the arguments presented here I find it obvious that the OLPC project and DHIS 2 effectively contribute to improving education and health. OLPC facilitates computer knowledge, and DHIS 2 enhances the collection and processing of data. Comparing the situation in the third world to the industrialized world, I agree in POST's (2006) emphasis on the urge of bringing ICT to the developing countries, though with the important awareness that ICT should not be considered a panacea ensuring development.

### 6.2.2 FOSS

LPAKenya (n.d.) raises a question on software costs versus government jobs. As OSS is free and does not require licensing fees there might be a lot of money to save on shifting from proprietary software to OSS. DHIS 2 is FOSS and is thus free to implement and use. Also, the

users are free to modify the software if they wish to do so. During my stays in The Gambia I learned that if something is free (or claimed to be free), then it is considered good. One of the mobile operators has a campaign called *Free Bonanza*, claiming they give away free minutes, free SMS' and free data traffic if the user calls or texts a given number. But in reality the user ends up paying a one-time fee for the call/SMS to the number, so the user ends up paying to get free minutes, SMS' or data traffic. Nevertheless, it is marketed as free, so the users are very happy about it. The reason for the positive feeling on free things is however the poverty. If they can get something for free it means they can save more of the little money that they have. On a training session on a mobile reporting system, free t-shirts were handed out to the participants – one per participant. It was a one day training for two groups, and when the second group arrived the second day, there were no t-shirts left – the participants from the first day had taken them all.

When introducing free software that has proved successful in many other countries, the Gambians are easily persuaded of its benefits. It is namely the F in FOSS that really matters in The Gambia. When overhearing presentations on DHIS 2 I noted that they presented DHIS 2 as an "open source software, meaning it is absolutely free to use. We have not even paid a single butut[14]!" The fact that a computer program is open source does not seem to mean much to them; during my stays in the country I did not meet a single person with Java programming skills, so it will be some time before Gambians can contribute to the development of DHIS 2.

### 6.2.3 Gambian ICT uptake

POST (2006) suggests that donor-funded telecentres have a role to play in familiarising the population with ICT, offering "a range of telephone, computing, internet and information services". The head of the Gambian MOH IT office runs two small Internet cafes in his home town, in which the accessories mainly are charity gifts. The people living in the area are poor, but the Internet cafes have increased the ICT knowledge in the population in the area. In addition to providing computer access to customers, the staff in the cafes also helps the customers, teaching them how to operate a computer. One of the sub targets of the UN's MDGs (United Nations 2010) aims at making ICTs available, in cooperation with the private sector. The head of the IT office runs his Internet cafes in his spare time, but they are not a result of cooperation with the UN, but rather of donated computer accessories, as encouraged by CNET Networks (n.d. a). There are a relatively large number of Internet cafes in such a small area as that town is which is not representative of the rest of the country. Many people are living rurally and in mud huts, and ICTs are far from their reality. There is thus still a lot of work to be done to reach the UN's goal on making ICTs available.

The national government also has responsibility when it comes to ICT uptake. They can cut import tariffs and liberalise the markets to increase the ICT uptake (POST 2006). When going to The Gambia for the second time I brought 27 cell phones that were supposed to be used

[14] 1 dalasi (GMD) = 100 butut. 1 NOK ≈ 4.5 GMD.

in the DHIS Mobile pilot. The head of the MOH IT office met me at the airport and we told the customs what the intended use of the phones was. We were told to leave them there until we could prove it with a letter from MOH's permanent secretary. When bringing the letter the phones were collected without paying a lot of import tax. The Gambian government thus facilitates ICT uptake in the public sector.

## 6.3 HIS' in developing countries

Heeks et al (1999) list four main forms of HCIS failures: total, partial, sustainability and replication failure. Seeing the Gambian implementation of DHIS 2 in the light of their explanations of the failure forms, sustainability failure is the most likely to cause concerns, since DHIS 2 has been neither abandoned, and nor have any undesirable outcomes been discovered. In addition it makes no sense to speak of a possible replication failure in The Gambia, as DHIS 2 was piloted in the whole country. Considering the current situation in The Gambia the sustainability failure might however occur. MOH staff have all the way been impressed by the possibilities that DHIS 2 offers, and the head of the HMIS even said: "DHIS 2 is my baby. I will breastfeed it to the maximum!" They are, however, now experiencing trouble importing data from the regions to the national implementation at the MOH. There are two main reasons causing the implications. First, for a period there were different versions of DHIS 2 running across the country. Version 2.0.3 was installed on some of the regional offices before the error was discovered, resulting in the fact that they cannot report the quarterly data using DHIS 2. Secondly, changes have been made to the organisation unit structure on the national DHIS 2 implementation, so when one tries to import data, the file to be imported is incompatible with the DHIS 2 version running at the national level. There has thus been an initial success, but my fear is that if the errors are not fixed soon, DHIS 2 might be abandoned, and we will have an example of sustainability failure.

### 6.3.1 ITPOSMO and DHIS 2

The ITPOSMO model is a tool presented in (Heeks et al 1999) to analyze the gap between conception and reality of an HCIS implementation. The model can be used to estimate the risk of failure of such an implementation. I will therefore analyze the Gambian DHIS 2 implementation using this model.

- **Information**
  DHIS 2 holds lots of health-related data and can be used to create charts and reports. Charts were also in use before, and reports had to be created manually. Users can easily access the information they are interested in.
- **Technology**
  DHIS 2 is a more advanced tool than Excel, but basic functionalities are easily learned. DHIS 2 is platform independent and does not require high-performance computers. It could thus be installed on the same computers that were used for Excel reporting.

- **Process**
  DHIS 2 is installed on the same computers that were used for Excel reporting and did not require changes in infrastructure or routines.
- **Objectives and values**
  The DHIS 2 users are impressed of the software; it offers so much more than earlier tools and makes their tasks easier to perform. The users' needs are truly met.
- **Staffing and skills**
  DHIS 2 is quite an advanced tool for a health worker who is not used to computers. Extensive training needs to be held. There is a relatively large gap between reality and conception along this dimension.
- **Management and structures**
  DHIS 2 replaced existing tools and did not require more staff. As mentioned no routine or infrastructural changes were necessary.
- **Other resources**
  DHIS 2 is totally free, but training is relatively expensive. Everything was however financed by foreign actors. Using the system does not require more time from the users then previously used tools.

The analysis shows that the largest conception-reality gap is found along the *staffing and skills* dimension. In general, as with Heeks et al's ComputerLink example, the "design [and implementation of DHIS 2] were either matched to existing realities or required only very limited change along seven possible dimensions" (ibid). That might explain why the implementation of DHIS 2 has proved successful in The Gambia.

According to Heeks et al's archetypical conception-reality gaps (ibid), the only one DHIS 2 can relate to is the one regarding cross-country transfer of an HCIS. DHIS was developed and first used in South Africa. Later it has become increasingly more famous and is now in use in many countries. History shows that most implementations succeed, but there are however examples of failures. The centralized system in Cuba prevented the HISP team from following a bottom-up approach in their implementation, in the end resulting in implementation failure and abandonment of the project. Nevertheless, so far the implementation in The Gambia has proved more or less successful. The problems that have occurred are not related to contextual differences but to technical implications. Fixing the problems requires however skilled computer technicians and the lack of computer knowledge within the MOH is hampering participation (Titlestad et al 2009) on this matter.

### 6.3.2 Fragmentation in the Gambian health care sector

Numerous actors in the health sector often cause fragmented information flow in developing countries. The Gambian HMIS head could tell that the numbers of actors has decreased, but still there are some, such as malaria, tuberculosis and HIV/AIDS. Health Metric Networks proposes that essential data gets integrated in a shared repository

(Titlestad et al 2009), and some of the HIV/AIDS programmes in The Gambia are integrated in the Gambian HMIS. The information flow is, however, still fragmented. The last contribution to even more fragmentation is the *SMS for health* project. The introduction is basically a result of poor communication within the ministry, as the person who authorized the project consulted neither the head of the HMIS nor the head of the MOH IT office. The project pilot was thus rolled out, and some of the data reported through *SMS for health* are also reported using DHIS 2, hence resulting in duplicate work.

Although *SMS for health* is yet another actor in the Gambian health care, their use of reminder SMS' and incentives to make health workers report is however admirable and something to learn from. When the deadline for reporting is approaching, health workers get an SMS reminding them to report. If they report on time, they will receive credit on their phone. The idea is brilliant, but instead of introducing yet another HIS, an effort to find someone to cooperate with should be put down – either by the project management, but preferably by the MOH, as they should have known what actors are already operating in the health care sector and what they can offer. Then, if *SMS for health*'s reminder SMS' and incentives were combined with DHIS Mobile, data would go straight into the database and would not have to be reported elsewhere. Also DHIS Mobile's java application can provide a simple user interface, as opposed to *SMS for health*, which is using letter codes (A, B, C, etc.) for medications, forcing health workers to look up which medication corresponds to which letter when reporting.

Currently there are discussions with *mSupply*[15] on how to integrate that system with DHIS 2 so that no duplicate data is reported. The goal is to have all data in a shared repository (ibid).

***Time-consuming reporting***

On a training session on DHIS 2 in Lower River Region the director of regional health commented on the many donor driven programmes in the country that want something in return. There were so much to be reported, he said, that about 40% of his health workers' time was spent on filling in forms and registers. Whether his time estimate is correct I cannot tell, but nevertheless, he was frustrated of the presence, let alone the reporting requirements, of all the different programmes, as he rather would see the health workers provide health services to the population. The situation is not unique for The Gambia; Kanjo et al (2009) found the same thing in Malawi: The reporting requirements distract the primary providers of health care at facility level from their primary responsibility of patient care.

### 6.3.3 Implementation challenges

Literature shows that lack of skilled personnel can cause implementation failures (e.g. Sahay et al 2009; Heeks et al 1999). The implementation of DHIS 2 was done using skilled personnel from the University of Oslo as well as involving British volunteers. The volunteers

[15] http://msupply.org.nz/

had no previous experience with DHIS 2, but as they were familiar with computers, it took them relatively short time to get familiar with DHIS 2. Now, when experiencing some trouble with DHIS 2 and as the Gambians have no foreign people to support them, their lack of technical skills will prevent them from fixing the errors.

When working on the importation of the 2009 data I had to communicate closely with the MOH staff to make sure everything was imported correctly. Also further work with upgrading the software and modifying it to meet local needs required close interaction with the HMIS head. As I learned a lot from the MOH staff and also taught them much on DHIS 2, we were constantly learning from one another. It was a continuous, mutual learning process that started out with, and still continues with, "exploration and struggle to make things work" (Titlestad et al 2009), as there still are errors that need to be fixed.

### 6.3.4 DHIS 2 training

In The Gambia the data entry clerks (DECs) from regional level were invited to Banjul in November 2009 for training. The main focus was on how to enter data in the data entry forms. When visiting the regional offices late January/early February 2010, the training seemed successful; the DECs understood how to enter data. On my second trip to the country I joined some MOH staff and a British volunteer on a training trek – we held a three day long theoretical training session in two regions. The result from the November and June trainings is similar to Chaulagai et al's (2005) findings in Malawi: practical training gives better results than theoretical classroom training. The target groups for the November training and the latter two were however different as well: The attendants on the November training were data entry clerks who were relatively used to computers, while the attendants on the June training sessions were regular health workers, and many of them had never used a computer. A theoretical training on the DHIS 2 computer software was thus way over their heads.

Kanjo et al (2008) emphasize the importance of training as well as retraining of health workers for sustaining the system. Users need to be trained (and retrained) to be *capable* to use the new tool (Torero & von Braun 2005), as technical skills are needed to benefit from ICT (POST 2006). Osterwalder (n.d.) also stresses the importance of capacity to understand and use applications. It is important for MOH to be aware that ICT not is a panacea (Torero & von Braun 2005) but rather facilitates development if the users receive the needed training (and retraining).

The data quality analysis in section 5.8 shows that many users have misunderstood data elements definitions. For instance do Figure 5- 25 and Figure 5- 34 illustrate that the workers at a facility continue with the erroneous reporting after the implementation of DHIS 2. When training the health workers in the use of the software it should thus also be focused on data element definitions. The many validation rules violations also show that it is very unlikely that the validation rules tool has been utilized. The violations revealed show great

inconsistency of reporting when comparing different organizational units. Data quality will be further discussed in section 6.4.

### 6.3.5 Human capacity

I have learned through my research that the human capacity amongst the Gambians is quite poor. The ICT knowledge is very limited, and I have observed MOH IT personnel fail in simple computation tasks. The maintenance responsibility of the national implementation of DHIS 2 lies on the MOH IT office, but as the situation is now, their general computational knowledge and specific DHIS 2 knowledge is too poor to succeed in the work. The IT office employees are also responsible for the maintenance of the regional implementations. When I left the country June 2010 there were different versions of DHIS 2 running on the different regional offices, and at national level they encountered problems when trying to import the exported data from the regions.

When the maintenance of the national implementation has proved difficult, the work with maintaining six offline DHIS 2 implementations was doomed to fail. If a modification is made on one of the implementations, the five others need to be modified as well. Without Internet access this task requires that skilled personnel physically travel around to do the modifications. With poor road infrastructure this work will be costly and time-consuming.

The experience from The Gambia thus shows that the maintenance of DHIS 2 requires skilled computer technicians. Paradoxically does DHIS 2 in The Gambia, where the human capacity is poor, require more computer knowledge to be sustainable than similar computer software in Norway, where the human capacity is significantly better than in The Gambia. The main reason, however, is that in Norway similar computer software is accessed “through the cloud” and not locally at every work place (e.g. DIPS ASA 2010). The Norwegian maintenance workers will thus not have to travel around the country to ensure that the implementations are synchronized.

The given example on management work shows that there is a need to build capacity amongst the MOH staff. The health workers also need to be trained to use the system, but the most important group to train is the MOH staff. When they learn how to use and manage the system properly, then they can train health workers how to use the system for simpler tasks. Human capacity amongst the MOH staff is thus more important to establish than capacity amongst the health workers.

A HIS also needs a well functioning infrastructure to work properly, and one could argue that an infrastructure is just as important as capacity. An important issue is, however, that infrastructures evolve more or less naturally over time. Human capacity, on the other hand, does not evolve in the same way and must be built. It is thus more important to build human capacity than to provide infrastructures when working with HIS’.

### *Internet connection*

November 2010 Internet access has finally been provided to the regional offices. That means that the national implementation of DHIS 2 now can be accessed by the regional offices so that they can enter data straight into the national database. The effort on maintaining six offline implementations will thus cease, and the IT office will only have one implementation to take care of. As the power supply is quite unstable in the MOH they should consider setting up the server a place with reliable power supply. Pristine Consulting has offered to host an implementation for free, and the British volunteers did also install DHIS 2 on one of Pristine's servers. That implementation has never been used for nothing but as a backup. A lot of upgrading has been done since then, and the MOH should therefore really consider updating the Pristine implementation and start to use that one as the official national implementation.

## 6.4 Data quality

Data quality "refers to the degree to which the data or statistics measure what was intended to be measured when the data collection system was designed" (Shresta and Bodard 2000). In The Gambia they have been using Excel spreadsheets to collect data. The spreadsheets contain all data that need to be reported and could in theory thus measure what is intended to measure. The use of spreadsheets is however vulnerable; e.g. cells are often cross-referenced and an unintended modification in a sheet might cause false cell-references (the "#REF!"-annotation in Excel, see Figure 5- 15).

Evaluating the quality of the reported 2009 data in The Gambia by using Heywood and Rohde's requirements of good quality data (2001: 42) shows that the overall quality is good, though there is room for improvements:

| **Good quality data is:** | **The Gambian situation** |
|---|---|
| Available on time and at all levels | Not all regions reported on time. When collecting data late January 2010, one of the regions did not report for November and December 2009, nor for the last quarter of 2009.<br><br>As data collection treks are performed four times a year, data are not available on time at national level. E.g. will MOH not have the January data until late April. |
| Correct, complete and consistent | 0 was reported when data were not collected. 0 should be treated as an actual value; it is better not to report than to report 0.<br><br>A lot of data were incorrect, e.g. the stock-related data |

| | |
|---|---|
| Reliable and accurate enough to support decisions | The reported data gives a good enough picture of the health care situation to support decisions |
| Represent all recorders of similar data | All records of similar data are represented |
| Comparable, i.e. using the same definitions of data items | The same data are collected throughout the country and should thus be comparable. There seems however to be misunderstandings on certain data elements definition, e.g. for *Total Deliveries* |

**Table 6- 2** Heywood and Rohde's (2001: 42) requirements of good quality data and Gambian examples

### 6.4.1 Poor data quality sources

The implementation of DHIS in South Africa has proved successful and increased data quality. It will be exciting to see if DHIS 2 will increase the data quality in The Gambia as well. The 2009 data was imported into DHIS 2, and by running the validation rules on the 2009 data some violations are revealed (see section 5.8.1). Heywood and Rohde (ibid: 43) give some examples of common sources of errors, and most of these can also be located in the Gambian HMIS:

| **Error** | **Gambian example** |
|---|---|
| Missing data | One of the regions did not report for November and December 2009, nor for the last quarter of 2009 |
| Duplicate data | N/A (Cannot use DHIS 2 to check for duplicate counting) |
| Thumb suck | Spot checks did not raise suspicions |
| Unlikely values for a variable | *Number of post test counselled* > *Number tested* (Should be less than or equal; See Figure 5- 36) |
| Contradictions between variables | Lab confirmed malaria cases almost 28 times more than uncomplicated malaria cases (Should be less than or equal; See Figure 5- 29) |

| | |
|---|---|
| Calculation errors | Hard to reveal, but it looks like there is a calculation error in Figure 5- 35, as the *Balance* value reported does not correspond with the reported *Opening*, *Received* and *Consumed* values. |
| Typing error | *Opening stock* for a month < *Stock out* for previous month (Should be equal; See cell *G236* Figure 5- 24) |
| Capture in wrong box | Maximum and minimum temperatures switched places. |

**Table 6- 3** Gambian examples on Heywood and Rohde's (2001: 43) common errors.

### *Inadequate staff skills*

Shresta and Bodard (2000) point at inadequate staff skills as a reason for inaccurate data reporting. The violations on the *Total Deliveries* validation rule serves as a good example of that from The Gambia. Many facilities do not add the numbers of *Fresh Stillbirths* and *Macerated Stillbirths* to the numbers of *Live Births ≤ 2.5 Kg* and *Live Births > 2.5 Kg* when they are summing up *Total Deliveries* for a quarter (Figure 5- 30, Figure 5- 32 and Figure 5- 38). Thus, the number of total deliveries found by the validation rule is greater than the reported number. The correct way to report *Births at health* facility is shown in Figure 5- 31.

The cold chain temperature also illustrates inadequate staff skill as minimum and maximum temperatures are switched. Another example is the erroneous reporting of medications and vaccines stock; for instance, the 2009 Excel return from one of the regions shows that a facility reports that the November opening stock amount is not equal to the October stock out amount (see Figure 5- 26).

### *Rearrangement of data*

Another possible reason Shresta and Bodard suggest can influence the data quality is rearrangement of data, such as graphs and figures. The Excel spreadsheets used in The Gambia presented graphs that were based on reported data. These were not modifiable, and the automated headlines in the graphs show which data are presented. It is thus likely that the graphs present correct information. Nevertheless, if false cell-references occur the chart(s) will become empty (Figure 5- 16), and creation of new charts is a relatively advanced operation for health workers not used to computers. The graphs in the Excel spreadsheets did not cause bad quality data, however, since the users could access the source data. Even though the charts could look complex and messy (as in Figure 5- 17), the source data could be accessed if desired.

As opposed to unintended false-reporting, intended false-reporting can, however, not be tracked down by analyzing the reported data.

### 6.4.2 Ensuring data quality

While Heywood and Rohde (2001: 43) suggest visual scanning to control *correctness*, *completeness* and *consistency* of reported data, Shresta and Bodard (2000) mention double data entry as a way to reduce errors. The latter is a more time-consuming task than visual scanning (comparing the entered data to the source data), but it is more secure, since it is more likely that a value will be overlooked when eyeballing than that the same error will be entered twice when double-recording data. DHIS 2 does not support double data-entry as of now; the users have to verify their entered data themselves. There is although some help in the validation rules, but as shown a lot of the violations revealed by applying the validation rules on the data are similar both for the 2009 and 2010 data (e.g. violations regarding total deliveries, malaria, stock and cold chain temperatures). It seems that there are a lot of errors that are due to typing errors (such as in cell *G236* in Figure 5- 24), so I really think HISP should consider supporting double data-entry in DHIS 2 to reduce the possibility of typing errors.

#### *Missing data*

DHIS treats missing data as zero-values, e.g. when generating charts and bars. Shresta and Bodard (ibid) emphasize the importance of having consistent protocols for the treatment of missing data so data quality can be determined. The way DHIS 2 treats missing data may thus be confusing to the user. For instance will an indicator value be wrong in a district where several facilities have not reported data. This district's indicator value will thus not be comparable to a district in which all facilities have reported the data. Then, when comparing these indicators using e.g. charts or the GIS, there is nothing telling the user that one of the indicator values is generated on data where one or more data values are missing. To ensure that indicator values are comparable data thus needs to be verified.

However, when comparing indicators for health facilities, missing data is easy to discover, as demonstrated by Figure 5- 10. DHIS 2 thus makes data more accessible than the previously used Excel returns, and if the users learn how to use DHIS 2 efficiently, data quality can be increased.

#### *Incentives and checking routines*

Incentives might be a way to make the data collectors put more effort into the data collection. Monetary incentives are one way to "push" the data collectors, but Shresta and Bodard (ibid) claim that the best incentive to ensure data quality is that if the collected data is useful to the data collector. Heywood and Rohde (2001: 43) also state that collected data will be more accurate if the persons who are collecting it are the ones who will use it. Also the Health Metrics Network (2008) stresses that if data production is linked to data use, the HIS will be strengthened. In The Gambia, the HMIS earlier had trouble "competing" with vertical actors in the country. Vertical actors paid "their" clinics to collect data, but the HMIS could not afford such incentives. The new vertical actor *SMS for health* also uses monetary incentives (mobile phone credits) to have "their" clinics report data on time, and the fear is thus that their data will be prioritized over other "HMIS data".

Positive feedback can also contribute to increased data quality, according to Shresta and Bodard (2000), and supervisors should devote part of their time to give feedback to staff. They claim that positive incentives are a better way than punishing workers who do not meet certain requirements. In The Gambia free things are, as noted, really attractive, and thus, if one can get free credit on the personal phone, the effort put in reporting some health data is totally worth it! The risk that personnel will falsify data just to get their credit is however still present, as pointed out by Shresta and Bodard. Checking procedures should thus be systematically performed to reveal "cheating". One of the ways to check data is to compare data from two sources. For instance, since much of the same data are reported both through the *SMS for health* project as well as through DHIS 2, such systematically comparison should be possible to perform in The Gambia.

#### *Training*

By learning the tools used for data collection and processing, Shresta and Bodrad (2000) mean that data quality can be increased and stress that retraining is important. The importance of retraining is also emphasized by Kanjo et al (2008). In The Gambia the DHIS 2 users have only been trained once, and the knowledge on the software is not that great. The plan is however to train some of the users to be "super users", so these can train new users of the system. My analysis of the data quality shows that the validation rules revealed many validation violations. Thus, if the DHIS 2 users learn how to use the tools provided by the system, data quality can be significantly increased. For instance, Figure 5- 8 shows that a maximum temperature is reported lower than a minimum temperature, and the stock of some medications are reported to be below zero, which is not possible. The validation result thus reveals some obvious reporting errors.

### 6.4.3 The Gambian 2009 and 2010 data

The Gambian data reported for 2009 and the first quarter of 2010 were analyzed using the DHIS 2 validation rules. The results show that the same violations occur for the first quarter of both years (see for instance Figure 5- 28 and Figure 5- 37). The most significant difference is the change in violations regarding medications and vaccines stock monitoring (see Table 5- 5 and Figure 5- 33). As pointed out the reason was that the Excel spreadsheet had a design error, where a subtraction was replaced by an addition. When not considering the stock violations for February, it was in fact discovered less violations in the 2009 February data than in the 2010 February data (Table 5- 5). Summing up the violations for the first quarter of those two years when omitting the February stock violations shows that there is almost no difference in the percentage of discovered violations: 2.11 vs. 2.00 violations per thousand reported values for 2009 and 2010, respectively.

According to the results it is likely to believe that the validation rules in DHIS 2 have not been applied. It is easy to validate a data entry form using the validation rules, as it is just a matter of clicking the button called *Run validation*. A popup window will then show the validation results, but the message here is somewhat clumsy and might be hard to understand at first glance (see Figure 5- 6). When visiting one of the regional offices I experienced that the data

entry clerk did not know how to activate popup windows in Firefox, so that might as well be a reason for why validation rules are not applied on the data.

The introduction of DHIS 2 has, however, increased data quality significantly for the stock related data. The data entry clerks cannot be blamed for the poor 2009 data quality as the reason for the validation violations originated from a design error in the Excel sheet. When migrating to DHIS 2 such design errors are avoided, and this example thus illustrates that Excel is far more vulnerable than DHIS 2.

### 6.4.4 Gambian data quality improvements

#### *Timeliness*

In The Gambia they are currently working on providing Internet connectivity to the regional offices. When they get online they can access the national implementation of DHIS to enter data. Timeliness at national level will thus be greatly improved, since the data now is being collected only four times a year. For instance, as of now, the January data is not available on national level until late April. It might then be too late to act upon that data.

In addition to Internet connectivity, the DHIS Mobile application will also improve timeliness of the data at national level since the data will go straight to the national database when the mobile phones are used for reporting. The downside, however, is that a double amount of work is required as long as the regional offices do not have Internet access. Since the regional offices cannot connect to the national database and access the data, paper forms will still need to be filled at facility level and sent to the regional offices.

*Note: Internet connectivity has now been provided to the regional offices. (November, 2010)*

#### *Completeness*

As (most of) the Excel sheets were designed to report 0 when data was not collected for a data element, it can be hard to know whether the dataset is complete or not. Confusion might occur and lead to questions like: “Are there 0 children that have received vaccination this month, or is the data value not filled in?” In DHIS 2, if data are not collected, no data will be stored. It can thus easily be seen in the data entry forms which data elements are missing data.

Furthermore, the Excel files did not offer any tool to help check for data completeness. DHIS 2, on the other hand, provides a data completeness reporting functionality. The user can check how many data entry forms are marked as complete or how many datasets have their compulsory data elements filled. DHIS 2 has thus improved the possibility for checking data completeness.

#### *Correctness*

Validation of the 2009 and 2010 data using the DHIS 2 validation rules showed that much data are reported incorrectly (See for instance Figure 5- 26, Figure 5- 27, Figure 5- 34 and Figure 5- 37). The fact that the same validation violations were present in 2010, after the

introduction of DHIS 2 (Figure 5- 25 and Figure 5- 34), indicates that the users have not learned how to use the validation rules to validate the data. DHIS 2 thus offers a great possibility to improve the correctness of the data if the users learn how to use the validation tools available in the system.

***Comparability***

The Excel files used for reporting contained only (collected and accumulated) data element values. As one Excel files only contained data element values from one region, the data were only suited for analyzing the trend within the region itself. If comparison to other regions is desired, indicators need to be calculated; the number of malaria infected people will obviously be bigger in an area with big population than in a less populated area. Values thus need to be collected from the Excel returns and re-entered in another Excel file to calculate the indicators.

In DHIS 2 it is fairly simple to create indicators. Once created, the user will not have to worry about calculating new indicator values when new data are reported. When data are reported the user can for instance immediately create a chart to see the indicator and compare it to other organisational units.

Heywood and Rohde (2001: 42) stress the importance of comparability of data element definitions. If not the same data are collected using the same tool it is not comparable. As seen from the data quality analysis the understanding of the data element definitions varies. A retraining focusing on data element definitions should thus be held to update the health workers' understanding of the data element definitions.

## 6.5 The Gambian future

### 6.5.1 Capacity building

Training sessions and workshops on HIS software, like the one held in Accra, Ghana, contribute to build capacity. Training and retraining are also held important by Kanjo et al (2008) and Shresta and Bodard (2000). In Accra the head of the Gambian MOH IT office met IT workers from other developing countries and discussed issues with them. Such workshops can thus play an important role to help build local capacity and thus improve the independence of the countries where the software is implemented. On a long term the hope is that they will be able to sustain the software themselves.

### 6.5.2 Adapting the software

As the UN has put requirements on the Gambian government to add gender dimensions to their data the data base will have to be redesigned. Also, NAS and mSupply are considering migration to DHIS 2. The DHIS 2 database will thus undergo significant changes. A problem is however that the capacity needed for such technical operations is still not sufficient within the Gambian MOH. An email that was sent to some HISP members from an MOH employee

illustrates this point, as the question in the email was whether it was possible to create new forms in DHIS 2. The need for further extensive technical training is thus important to build needed capacity in The Gambia.

### 6.5.3 Commercializing

A Vodafone representative stated in an email that there may be possibilities for cooperation between *SMS for health* and DHIS 2 in the future. The requirement was, however, that DHIS 2 had to fit in Vodafone's value chain. As Vodafone's goal is to make money, and HISP on the other hand is an idealistic network aiming at helping the world for free, wanting nothing but user participation in return, there is no way that HISP will fit in Vodafone's value chain. If Vodafone wants to see through cooperation with HISP they will have to modify their value chain and shift the focus from making money to helping the world instead of making money *by* helping the world.

One of HISP's foci is to build local capacity (Braa et al 2004). When implementing DHIS 2 in a country, the goal in the long run is that the locals can maintain the system themselves. *SMS for health*, on the other hand, does not foster capacity building, as they provide the users with everything they need.

### 6.5.4 Internet access

November 2010 the regional offices were finally provided with Internet access and can thus connect to the national implementation of DHIS 2 through Internet. As the power supply is unstable at the MOH, the implementation on one of Pristine Consulting's servers should be updated so that it can be used as the official national implementation of DHIS 2, as the power supply is reliable there.

## 6.6 Summary

In this section I have shown that HISP has chosen a more linear than iterative design process when implementing DHIS 2 in the country. As errors were discovered late in the implementation process, the cost of fixing them was thus expensive. A participatory design approach was chosen, and through the implementation of the system the locals have contributed a lot. The design team included software architects and domain experts, and through the design process they learned from one another in a mutual learning process. As The Gambia is such a small country, a top-down approach for design and implementation was chosen, and it did prove successful.

The implementation of DHIS 2 didn't require infrastructural changes, as only the reporting tool was changed. When trying to upgrade the software, it was discovered incompatibility errors; the versions 2.0.3 and 2.0.4 were not compatible with the installed version 2.0.1 of the software.

The lack of human capacities is one of the greatest contributors to the digital divide, and experiences showed that the computer capabilities in The Gambia were poor as well. The OLPC project has proved successful in contributing to bridge the digital divide by empowering people in the third world. HISP has also contributed to empower the people of the third world, especially within the field of health care. As DHIS 2 is FOSS and the fact that it does not require too much of a computer, it facilitates the adoption and adaption of the software at a reasonable cost.

History has shown that many HIS implementations fail, and Heeks et al (1999) present the ITPOSMO model as a useful evaluation tool. DHIS 2 was evaluated to be quite successful using this tool, but HISP needs nevertheless to be aware of the possibility of sustainability failure in The Gambia. Other actors are present in the Gambian health care, and the latest contributor to more fragmentation is the *SMS for health* project. People are already complaining over too much time spent on data reporting instead of patient care.

Foreign skilled personnel took care of the technical work during in the implementation process, but the lack of skilled personnel within the country might prevent the locals from maintaining the system themselves. Extensive training needs thus to be given to computer technicians. Also health care personnel need to be trained in using DHIS 2 to learn how to use the system efficiently. It is also more important to build human capacity than to provide infrastructures.

The 2009 and 2010 data were of relatively poor quality, and the validation rules showed that most of them simply are caused by misunderstandings. Training on data element definitions as well as the data validation tool in DHIS 2 can thus be the key to heavily increased data quality in The Gambia.

The Excel sheets used for reporting were quite chaotic. DHIS 2 organizes the content in a better way, and as it easily allows customizations, data are made much more accessible through DHIS 2 than through the Excel sheets.

International workshops foster capacity building. The changes that need to be done at the data base to meet UN's (and possibly NAS' and mSupply's) requirements are advanced and require skilled computer technicians. The Gambians will not be able to do that themselves.

# 7 Conclusion

## 7.1 Conclusive remarks

Literature stresses that human capacity is important when implementing computerized HIS'. My experiences from The Gambia confirm this. I have shown that foreign support has been vital to the implementation of the system. The ICT knowledge in the country, let alone in the MOH, is so poor that in order to maintain the system and secure sustainability, extensive support from foreign actors will be necessary, even in the future.

The implementation of DHIS 2 has however proved successful. The cooperation with MOH staff when designing the software contributed to a feeling of ownership of the system. DHIS 2 provides more advanced functionality than the reporting tools previously used, but still it is easy to learn and use the basic functionalities of the software. The conception-reality gaps were small and are likely to explain much of the success of the implementation.

Errors are however still present. As different versions of the software are implemented throughout the country, implications arise when trying to import data to the national implementation. When all the regional offices get access to the Internet, they can all access the national implementation, and the work on synchronizing six offline implementations of DHIS 2 will thus cease.

The data quality has increased significantly. The validation rules show that it was reported 5.77 violations per 1,000 reported data values in the first quarter of 2009, while the corresponding number for the first quarter of 2010 was 2.24. By utilizing the validation rules tool provided within DHIS 2, users can be made aware of the validation violations in their data. To increase data quality even more, users should be trained on data element definitions and how to use the validation rules to reveal validation violations in their data.

Before the introduction of DHIS 2, data was reported in relatively untidy and chaotic Excel returns which were hard to read. Data could thus easily be entered in the wrong cell. DHIS 2 provides a much nicer layout of the forms, making them more readable.

## 7.2 Research questions

Based on these conclusive remarks I can now approach my research questions:

- *How can a complex health information system such as DHIS 2 be implemented, maintained and used in a context with constrained and weak ICT knowledge, such as The Gambia?*

Sub questions:

- *How can human capacity be built?*
- *Can the quality of the data be increased through the use of DHIS 2?*
- *Can DHIS 2 ease data collection and reporting?*

There are several reasons contributing to a successful implementation of a complex health information system. Creating the feeling of ownership of the system is important, as well as keeping the conception-reality gaps as small as possible. Extensive training of health workers so they can learn how to use the tools provided by the system is also important. In addition computer technicians need to be trained on maintaining the system. Foreign actors will have to train the computer technicians, but when it comes to training the health workers a cascade-training approach can be utilized.

Both health workers at low levels and MOH staff need to be trained. The main problem in The Gambia is that they do not have the capacity to do vital changes to the system. Thus, the most crucial group to train is the MOH staff, as they are responsible for the system. When they learn the system well enough, they can be able to teach the health workers how to efficiently use the system.

The quality of the data has been significantly increased, and by learning how to use the validation rules in DHIS 2 the quality can be increased even more. The best way to increase data quality is, however, if the HIS can stimulate dissemination and use of data at all levels. Then the users will discover bad quality data and put effort into increasing the data quality.

The collection of data still happens in the same way as before, but reporting has been made easier for the users, as the layout of the DHIS 2 data entry forms are more user-friendly and readable than the Excel returns used before DHIS 2 was implemented.

## 7.3 A final remark

The overall research question of this thesis is somewhat wide. Finding a recipe to how an HIS implementation will succeed, no matter where it is implemented, is just not possible. This thesis only presents the case of the DHIS 2 implementation in The Gambia, and what succeeded there will not necessarily work for other HIS implementations in other contexts.

# 8 Abbreviations

| | |
|---|---|
| CRR | Central River Region |
| DEC | Data Entry Clerk |
| DHIS | District Health Information Software |
| DHIS2 | District Health Information Software, version 2 |
| FHIMS | Family Health and Information Monitoring System |
| FOSS | Free and Open Source Software |
| GFATM | Global Fund to fight AIDS, Tuberculosis and Malaria |
| GIS | Geographic Information System |
| HCIS | Health Care Information System |
| HIS | Health Information System |
| HISP | Health Information Systems Programme |
| HMIS | Health Management Information System |
| HMN | Health Metrics Network |
| ICT | Information and Communication Technology |
| IHP | International Health Partners |
| II | Information Infrastructure |
| IS | Information System |
| IXF | Indicator Exchange Format |
| LAN | Local Area Network |
| LRR | Lower River Region |
| MDGs | Millennium Development Goals |
| MMR | Maternal Mortality Ratio |
| MOHP | Ministry Of Health and Population (Malawi) |
| MOH | Ministry of Health (The Gambia) |

| | |
|---|---|
| NAS | National Aids Secretariat |
| NBER | North Bank East Region |
| NBWR | North Bank West Region |
| NGO | Non-Governmental Organization |
| NJMF | The Norwegian Iron and Metal Workers Union |
| OLPC | One Laptop Per Child |
| OSS | Open Source Software |
| PAR | Participatory Action Research |
| PD | Participatory Design |
| SL | Sierra Leone |
| UN | United Nations |
| URR | Upper River Region |
| WAHO | West African Health Organization |
| WHO | World Health Organization |

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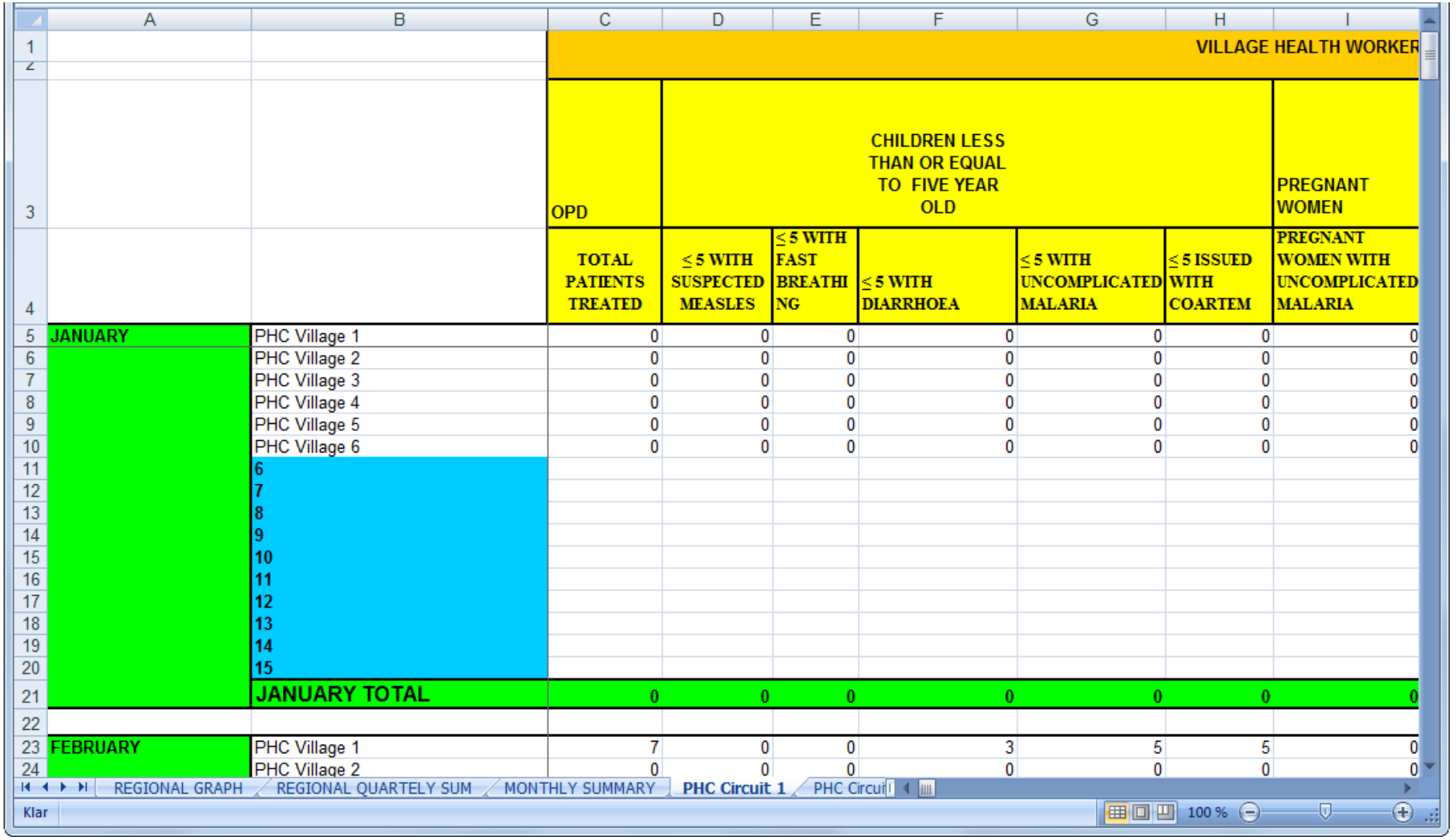
# Appendix A

## The Excel return sheets

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | JANUARY | | | | | FEBRUARY | | | | | MARCH | | | | | APRIL | | | |
| 2 | | RCH | OPD | TOTAL | INPATIENTS | | RCH | OPD | TOTAL | INPATIENTS | | RCH | OPD | TOTAL | INPATIENTS | | RCH | OPD | TOTAL | INPATIENTS |
| 3 | | | | | | | | | | | | | | | | | | | | |
| 4 | | CASES | CASES | CASES | CASES | DEATHS | CASES | CASES | CASES | CASES | DEATHS | CASES | CASES | CASES | CASES | DEATHS | CASES | CASES | CASES | CASES |
| 5 | UNCOMPLICATED MALARIA ≤ 5 YEARS | 0 | 22 | 22 | | | 0 | 8 | 8 | | | 0 | 15 | 15 | | | 0 | 16 | 16 | |
| 6 | LAB CONFIRMED MALARIA ≤ 5 YEARS | 0 | 3 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | SEVERE MALARIA ≤ 5 YEARS | | | | 0 | 0 | | | | 0 | 0 | | | | 0 | 0 | | | | 0 |
| 8 | UNCOMPLICATED MALARIA > 5 YEARS | 0 | 16 | 16 | | | 0 | 13 | 13 | | | 0 | 7 | 7 | | | 0 | 8 | 8 | |
| 9 | LAB CONFIRMED MALARIA > 5 YEARS | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | SEVERE MALARIA > 5 YEARS | | | | 0 | 0 | | | | 0 | 0 | | | | 0 | 0 | | | | 0 |
| 11 | UNCOMPLICATED MALARIA IN PREGNANCY | 0 | 1 | 1 | | | 0 | 4 | 4 | | | 0 | 4 | 4 | | | 0 | 1 | 1 | |
| 12 | LAB CONFIRMED MALARIA IN PREGNANCY | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | SEVERE MALARIA IN PREGNANCY | | | | 0 | 0 | | | | 0 | 0 | | | | 0 | 0 | | | | 0 |
| 14 | PNEUMONIA > 5 YEARS | 0 | 34 | 34 | 0 | 0 | 0 | 26 | 26 | 0 | 0 | 0 | 23 | 23 | 0 | 0 | 0 | 36 | 36 | 0 |
| 15 | SEVERE PNEUMONIA > 5 YEARS | | | | 0 | 0 | | | | 0 | 0 | | | | 0 | 0 | | | | 0 |
| 16 | DIARRHOEA > 5 YEARS | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 18 | 0 |
| 17 | DIARRHOEA WITH SOME DEHYD. >5 YEARS | 0 | 0 | 0 | | | 0 | 0 | 0 | | | 0 | 28 | 28 | | | 0 | 0 | 0 | |
| 18 | DIARRHOEA WITH SEVERE DEHYD. >5 YEARS. | | | | 0 | 0 | | | | 0 | 0 | | | | 0 | 0 | | | | 0 |
| 19 | DIARRHOEA WITH BLOOD (DYSENTRY) >5 YRS. | 0 | 4 | 4 | | | 0 | 0 | 0 | | | 0 | 1 | 1 | | | 0 | 3 | 3 | |
| 20 | SKIN DISORDERS > 5 YEARS | 0 | 18 | 18 | 0 | 0 | 0 | 9 | 9 | 0 | 0 | 0 | 16 | 16 | 0 | 0 | 0 | 46 | 46 | 0 |
| 21 | ANAEMIA > 5 YEARS | | | | 0 | 0 | | | | 0 | 0 | | | | 0 | | | | | 0 |
| 22 | SEXUALLY TRANSMITTED INFECTIONS | SEXUALLY TRANSMITTED INFECTIONS | | | | | SEXUALLY TRANSMITTED INFECTIONS | | | | | SEXUALLY TRANSMITTED INFECTIONS | | | | | SEXUALLY TRANSMITTED INFECTIONS | | | |
| 23 | MALE URETHRAL DISCHARGE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | FEMALE VAGINAL DISCHARGE | 0 | 3 | 3 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 |
| 25 | MALE GENITAL ULCER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 26 | FEMALE GENITAL ULCER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 3 | 3 | 0 |
| 27 | LOWER ABDOMINAL PAIN IN PREG. WOMEN | 0 | 3 | 3 | 0 | 0 | 0 | 4 | 4 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 18 | 18 | 0 |
| 28 | LOWER ABD. PAIN IN NON PREG. WOMEN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | NEW HIV CASES | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | SUSPECTED CASE BASE PRIORITY DISEASES | SUSPECTED CASE BASE PRIORITY DISEASES | | | | | SUSPECTED CASE BASE PRIORITY DISEASES | | | | | SUSPECTED CASE BASE PRIORITY DISEASES | | | | | SUSPECTED CASE BASE PRIORITY DISEASES | | | |
| 31 | SCHISTOSOMIASIS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 32 | MENINGITIS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33 | YELLOW FEVER | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 34 | OTHER VIRAL HEAMORRHAGIC FEVERS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 35 | HUMAN INFLUENZIA (H5N1) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | SARS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | CHIKUNGUNYA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | SMALLPOX | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 39 | ANTHRAX | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | DRACUNCULIASIS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

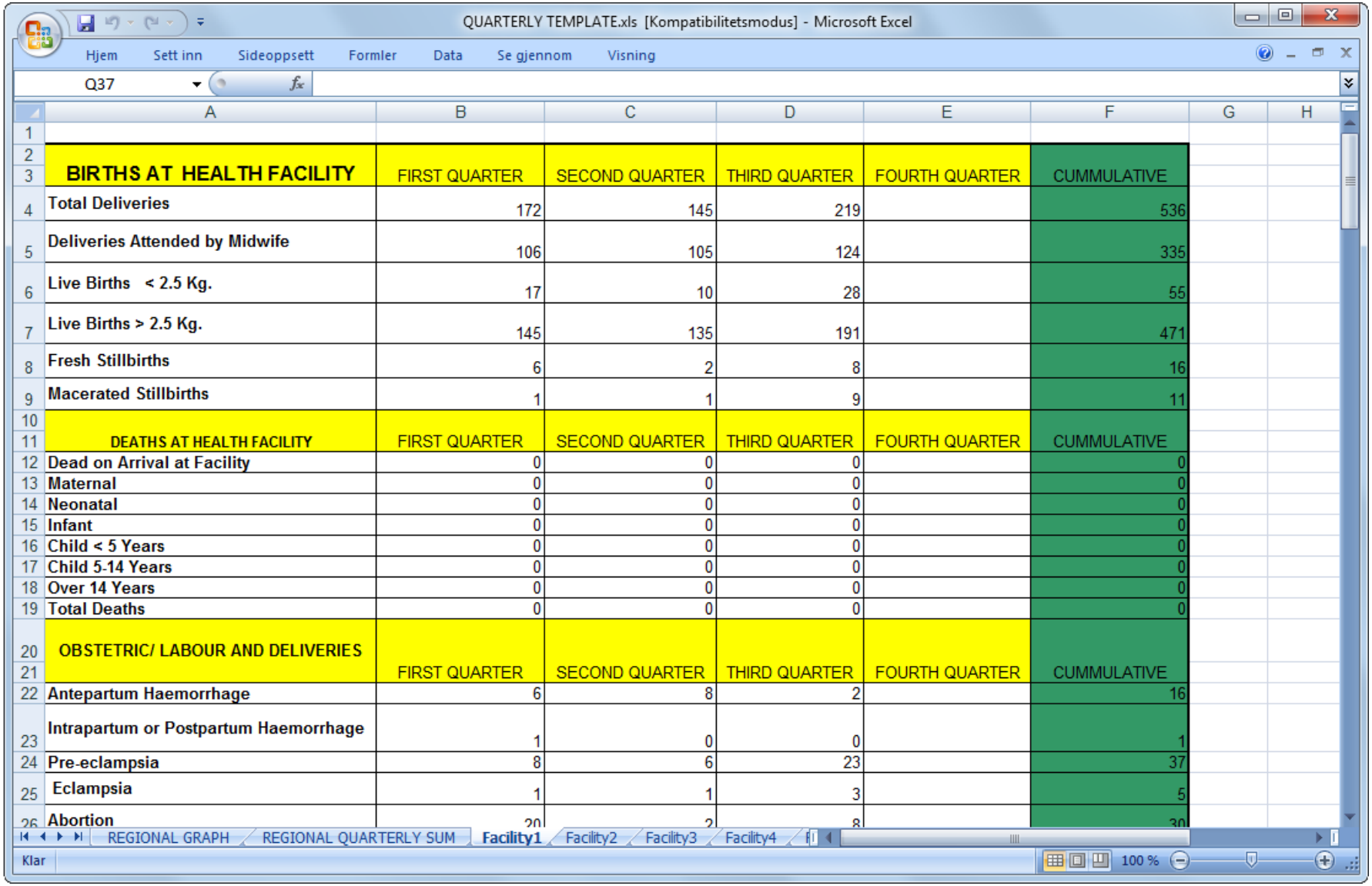
**Figure A- 1** Layout of the Excel sheet for health facility monthly returns



| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | VILLAGE HEALTH WORKER | | | | | | |
| 3 | | | OPD | CHILDREN LESS THAN OR EQUAL TO FIVE YEAR OLD | | | | | PREGNANT WOMEN |
| 4 | | | TOTAL PATIENTS TREATED | ≤ 5 WITH SUSPECTED MEASLES | ≤ 5 WITH FAST BREATHING | ≤ 5 WITH DIARRHOEA | ≤ 5 WITH UNCOMPLICATED MALARIA | ≤ 5 ISSUED WITH COARTEM | PREGNANT WOMEN WITH UNCOMPLICATED MALARIA |
| 5 | JANUARY | PHC Village 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | | PHC Village 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | | PHC Village 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | | PHC Village 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | | PHC Village 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | | PHC Village 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | | 6 | | | | | | | |
| 12 | | 7 | | | | | | | |
| 13 | | 8 | | | | | | | |
| 14 | | 9 | | | | | | | |
| 15 | | 10 | | | | | | | |
| 16 | | 11 | | | | | | | |
| 17 | | 12 | | | | | | | |
| 18 | | 13 | | | | | | | |
| 19 | | 14 | | | | | | | |
| 20 | | 15 | | | | | | | |
| 21 | | JANUARY TOTAL | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | | | | | | | | | |
| 23 | FEBRUARY | PHC Village 1 | 7 | 0 | 0 | 3 | 5 | 5 | 0 |
| 24 | | PHC Village 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



**Figure A- 2** Layout of the Excel sheet for PHC Village monthly returns




| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | **BIRTHS AT HEALTH FACILITY** | FIRST QUARTER | SECOND QUARTER | THIRD QUARTER | FOURTH QUARTER | CUMMULATIVE | | |
| 4 | **Total Deliveries** | 172 | 145 | 219 | | 536 | | |
| 5 | **Deliveries Attended by Midwife** | 106 | 105 | 124 | | 335 | | |
| 6 | **Live Births < 2.5 Kg.** | 17 | 10 | 28 | | 55 | | |
| 7 | **Live Births > 2.5 Kg.** | 145 | 135 | 191 | | 471 | | |
| 8 | **Fresh Stillbirths** | 6 | 2 | 8 | | 16 | | |
| 9 | **Macerated Stillbirths** | 1 | 1 | 9 | | 11 | | |
| 10 | | | | | | | | |
| 11 | **DEATHS AT HEALTH FACILITY** | FIRST QUARTER | SECOND QUARTER | THIRD QUARTER | FOURTH QUARTER | CUMMULATIVE | | |
| 12 | **Dead on Arrival at Facility** | 0 | 0 | 0 | | 0 | | |
| 13 | **Maternal** | 0 | 0 | 0 | | 0 | | |
| 14 | **Neonatal** | 0 | 0 | 0 | | 0 | | |
| 15 | **Infant** | 0 | 0 | 0 | | 0 | | |
| 16 | **Child < 5 Years** | 0 | 0 | 0 | | 0 | | |
| 17 | **Child 5-14 Years** | 0 | 0 | 0 | | 0 | | |
| 18 | **Over 14 Years** | 0 | 0 | 0 | | 0 | | |
| 19 | **Total Deaths** | 0 | 0 | 0 | | 0 | | |
| 20 | **OBSTETRIC/ LABOUR AND DELIVERIES** | | | | | | | |
| 21 | | FIRST QUARTER | SECOND QUARTER | THIRD QUARTER | FOURTH QUARTER | CUMMULATIVE | | |
| 22 | **Antepartum Haemorrhage** | 6 | 8 | 2 | | 16 | | |
| 23 | **Intrapartum or Postpartum Haemorrhage** | 1 | 0 | 0 | | 1 | | |
| 24 | **Pre-eclampsia** | 8 | 6 | 23 | | 37 | | |
| 25 | **Eclampsia** | 1 | 1 | 3 | | 5 | | |
| 26 | **Abortion** | 20 | 2 | 8 | | 30 | | |

**Figure A- 3** Layout of the Excel sheet for health facility quarterly returns

# Appendix B

## The DHIS 2 data entry forms

Health Facility Monthly Returns 1

**THE GAMBIA HEALTH FACLITY MONTHLY RETURNS**

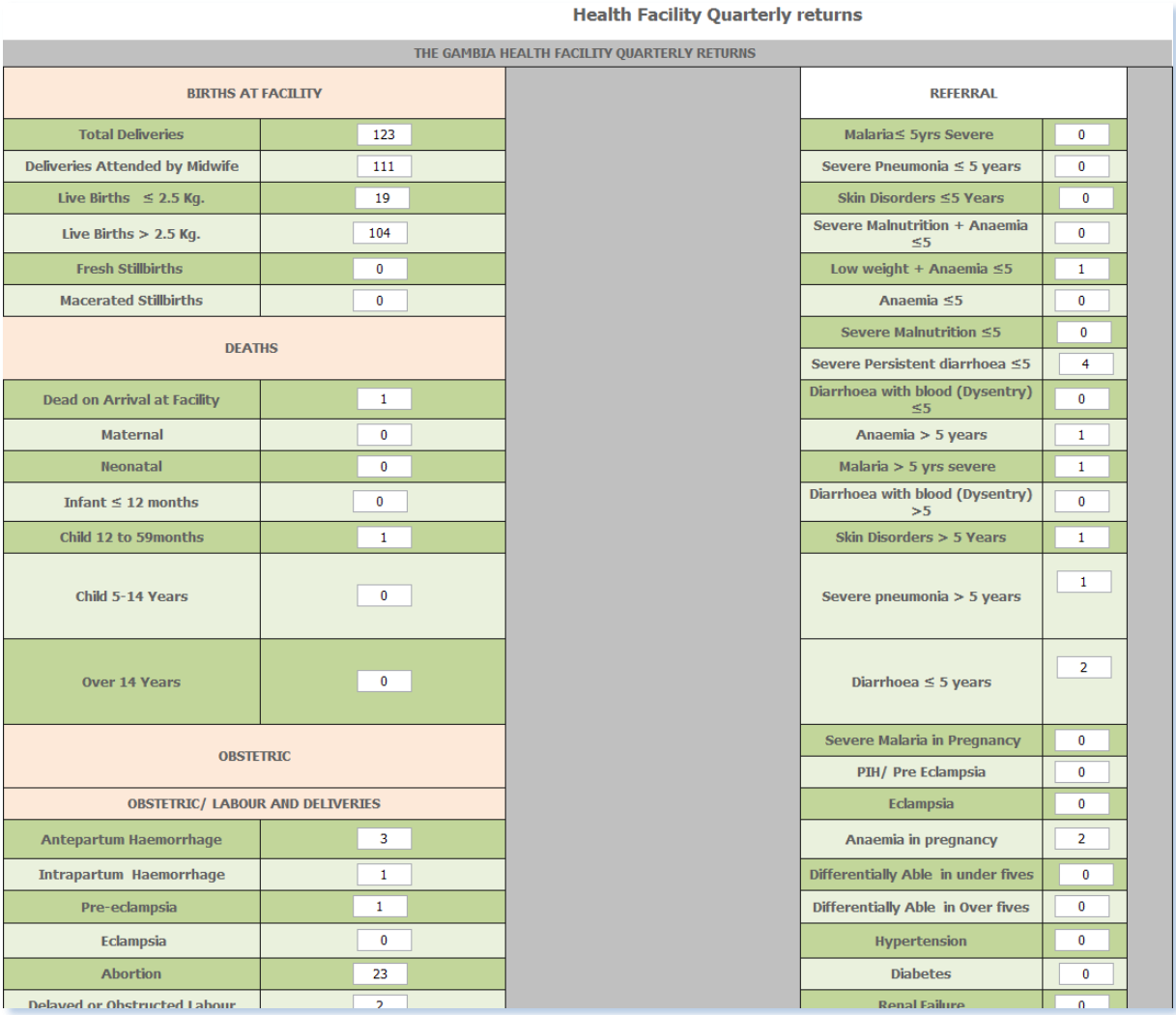
**DISEASES AND CONDITIONS**

| | RCH CASES | OPD CASES | IN PATIENTS CASES | IN PATIENTS DEATHS |
|---|---|---|---|---|
| UNCOMPLICATED MALARIA ≤ 5 YEARS | 5 | 443 | | |
| LAB CONFIRMED MALARIA ≤ 5 YEARS | 0 | 0 | 0 | 0 |
| SEVERE MALARIA ≤ 5 YEARS | | | 2 | 0 |
| UNCOMPLICATED MALARIA > 5 YEARS | 0 | 695 | | |
| LAB CONFIRMED MALARIA > 5 YEARS | 0 | 8 | 0 | 0 |
| SEVERE MALARIA > 5 YEARS | | | 2 | 0 |
| UNCOMPLICATED MALARIA IN PREGNANCY | 0 | 47 | | |
| LAB CONFIRMED MALARIA IN PREGNANCY | 0 | 5 | 0 | 0 |
| SEVERE MALARIA IN PREGNANCY | | | 2 | 0 |
| PNEUMONIA > 5 YEARS | 0 | 63 | | |
| SEVERE PNEUMONIA > 5 YEARS | | | 0 | 0 |
| DIARRHOEA > 5 YEARS | 0 | 35 | 0 | 0 |
| DIARRHOEA WITH SOME DEHYD. >5 YEARS | 0 | 72 | | |
| DIARRHOEA WITH SEVERE DEHYD. >5 | | | 0 | |

**IMMUNIZATION**

| | ≤ 1 Year | > 1 Year |
|---|---|---|
| BCG | 138 | |
| HEPATITIS B | 0 | |
| PENTA 1 | 163 | |
| PENTA 2 | 151 | |
| PENTA 3 | 118 | |
| POLIO 0 | 138 | |
| POLIO 1 | 136 | |
| POLIO 2 | 120 | |
| POLIO 3 | 126 | |
| Polio 4 & Plus | 126 | |
| Measles | 143 | |
| Yellow fever | 143 | |
| PNEUMOCOCCAL 1 | 138 | |
| PNEUMOCOCCAL 2 | 163 | |

**Figure B- 1** Part 1 of the DHIS 2 data entry form for Health Facility Monthly Returns



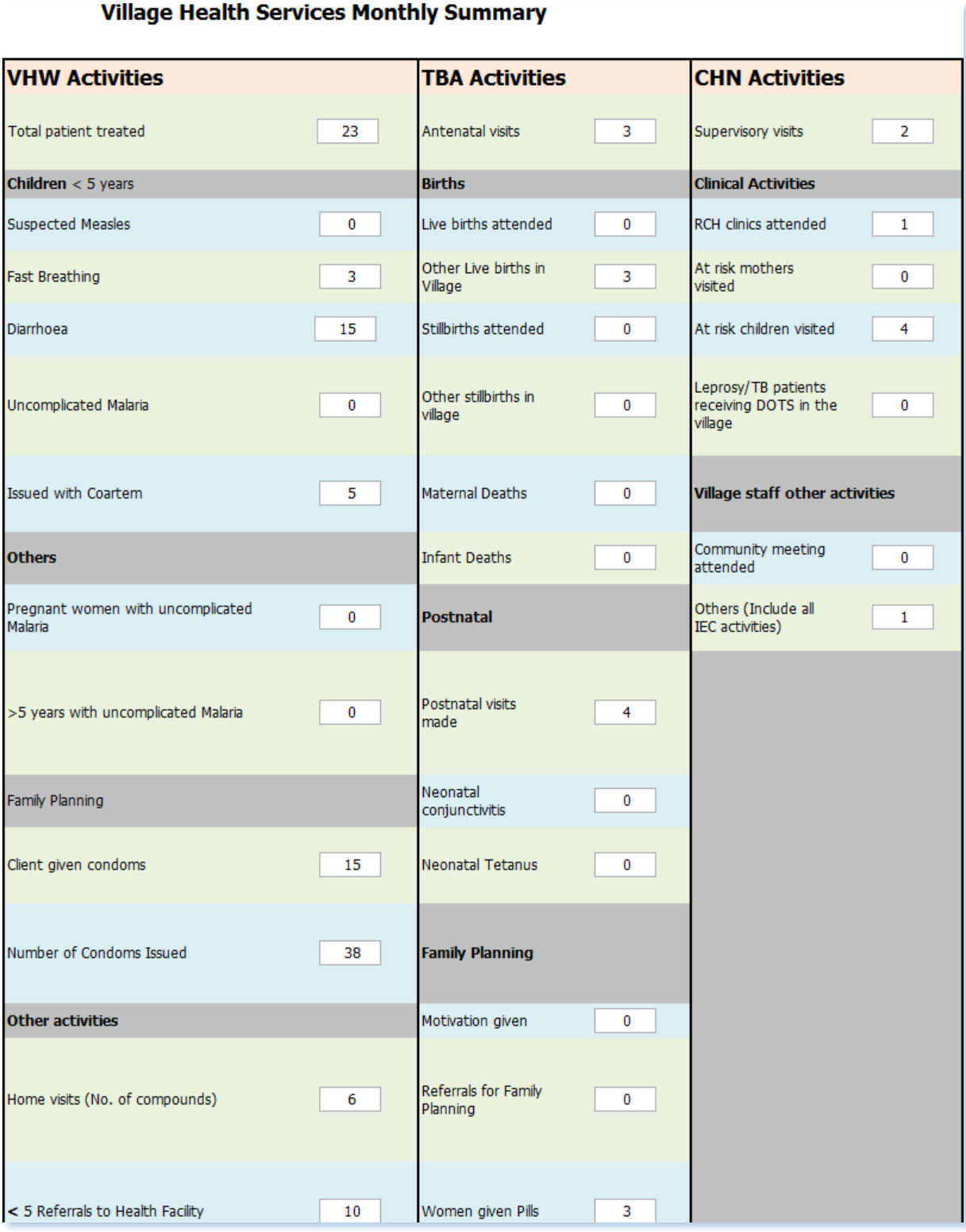
Health Facility Quarterly returns

THE GAMBIA HEALTH FACILITY QUARTERLY RETURNS

| BIRTHS AT FACILITY | |
|---|---|
| Total Deliveries | 123 |
| Deliveries Attended by Midwife | 111 |
| Live Births ≤ 2.5 Kg. | 19 |
| Live Births > 2.5 Kg. | 104 |
| Fresh Stillbirths | 0 |
| Macerated Stillbirths | 0 |
| DEATHS | |
| Dead on Arrival at Facility | 1 |
| Maternal | 0 |
| Neonatal | 0 |
| Infant ≤ 12 months | 0 |
| Child 12 to 59months | 1 |
| Child 5-14 Years | 0 |
| Over 14 Years | 0 |
| OBSTETRIC | |
| OBSTETRIC/ LABOUR AND DELIVERIES | |
| Antepartum Haemorrhage | 3 |
| Intrapartum Haemorrhage | 1 |
| Pre-eclampsia | 1 |
| Eclampsia | 0 |
| Abortion | 23 |
| Delayed or Obstructed Labour | 2 |

| REFERRAL | |
|---|---|
| Malaria≤ 5yrs Severe | 0 |
| Severe Pneumonia ≤ 5 years | 0 |
| Skin Disorders ≤5 Years | 0 |
| Severe Malnutrition + Anaemia ≤5 | 0 |
| Low weight + Anaemia ≤5 | 1 |
| Anaemia ≤5 | 0 |
| Severe Malnutrition ≤5 | 0 |
| Severe Persistent diarrhoea ≤5 | 4 |
| Diarrhoea with blood (Dysentry) ≤5 | 0 |
| Anaemia > 5 years | 1 |
| Malaria > 5 yrs severe | 1 |
| Diarrhoea with blood (Dysentry) >5 | 0 |
| Skin Disorders > 5 Years | 1 |
| Severe pneumonia > 5 years | 1 |
| Diarrhoea ≤ 5 years | 2 |
| Severe Malaria in Pregnancy | 0 |
| PIH/ Pre Eclampsia | 0 |
| Eclampsia | 0 |
| Anaemia in pregnancy | 2 |
| Differentially Able in under fives | 0 |
| Differentially Able in Over fives | 0 |
| Hypertension | 0 |
| Diabetes | 0 |
| Renal Failure | 0 |

**Figure B- 2** The DHIS 2 data entry form for Health Facility Quarterly returns



**Village Health Services Monthly Summary**

| VHW Activities | | TBA Activities | | CHN Activities | |
|---|---|---|---|---|---|
| Total patient treated | 23 | Antenatal visits | 3 | Supervisory visits | 2 |
| **Children** < 5 years | | **Births** | | **Clinical Activities** | |
| Suspected Measles | 0 | Live births attended | 0 | RCH clinics attended | 1 |
| Fast Breathing | 3 | Other Live births in Village | 3 | At risk mothers visited | 0 |
| Diarrhoea | 15 | Stillbirths attended | 0 | At risk children visited | 4 |
| Uncomplicated Malaria | 0 | Other stillbirths in village | 0 | Leprosy/TB patients receiving DOTS in the village | 0 |
| Issued with Coartem | 5 | Maternal Deaths | 0 | **Village staff other activities** | |
| **Others** | | Infant Deaths | 0 | Community meeting attended | 0 |
| Pregnant women with uncomplicated Malaria | 0 | **Postnatal** | | Others (Include all IEC activities) | 1 |
| >5 years with uncomplicated Malaria | 0 | Postnatal visits made | 4 | | |
| Family Planning | | Neonatal conjunctivitis | 0 | | |
| Client given condoms | 15 | Neonatal Tetanus | 0 | | |
| Number of Condoms Issued | 38 | **Family Planning** | | | |
| **Other activities** | | Motivation given | 0 | | |
| Home visits (No. of compounds) | 6 | Referrals for Family Planning | 0 | | |
| < 5 Referrals to Health Facility | 10 | Women given Pills | 3 | | |

**Figure B- 3** The DHIS 2 data entry form for Village Health Services Monthly Summary for PHC villages