Global Scaling of Health Information Infrastructures: Circulating Translations

By

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Abbreviations and acronyms used

COIA: Commission on Information and Accountability for Women's and Children's Health

CRVS: Civil Registration and Vital Statistics

DFID: Department for International Development (UK)

DHIS: District Health Information Software

HII: Health Information Infrastructures

HIS: Health Information System

HISP: Health Information Systems Programme

HMIS: Health Management Information System

HMN: Health Metrics Network

iHRIS: Integrated Human Resource Information System

MDG: Millennium Development Goals

NORAD: Norwegian Agency for Development Cooperation

OpenMRS: Open Medical Record System

SDMX-HD: Statistical Data and Metadata Exchange – Health Domain

UHC: Universal Health Coverage

WAHO: West African Health Organization

WHO: World Health Organization

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Abstract

The aim of this thesis, and the research behind it, is to shed some light on the topic of scaling of IS, specifically scaling of Health Information Infrastructures (HII). There are both theoretical and practical motivations behind this. Theoretically, scaling has been treated as a linear process of expansion, though there remains little consensus about the directions, mechanisms, and content of scaling in the current literature. Practically, I have been motivated by the inability of many IS-projects that fail to scale, especially within the domain of health information systems. The motivation is thus to improve our understanding of phenomena of scaling, and how this can be utilized to improve the success of implementation.

Approaching the research theme, I have drawn upon IS literature that deals with scaling, and also the theoretical strand of technology transfer and associated topics. The work on technology translation have been particularly important, in that it deals with the mechanisms of appropriation of technology scaled from one context to another. Translation is the process where the local context shapes the technology and its use, and work in this field has been important for understanding mechanisms of scaling, and what process that then take place in a new context. Furthermore, I have drawn on theories on information infrastructures, and their evolution.

The thesis is based on a longitudinal and international action research project called the Health Information Systems Programme (HISP), engaged in HII strengthening in over 30 countries. With a focus on Botswana and Sierra Leone over the last 7 years, complemented with experiences globally including 2 years with the Health Metrics Network, Geneva, this thesis examines the mechanisms of scaling and translations based on empirical work I have myself been part of.

This thesis presents a theoretical model called "**Circulating Translations**" for analysing processes of global scaling of HII. Successful scaling of HII is seen as being embedded in a local context, while retaining the flexibility to scale to new contexts and be embedded therein. The focus is thus to explain how this embedding produce translations, through the mutual influence of infrastructure, software, practices, and ideas. These influences have different levels of materiality, and thus interpretive flexibility, with different impacts on

scaling. These are termed as interaction effects, including processes of local appropriation, translation, and embedding. The local translations may in turn be disembedded, and scaled to new contexts, where they contribute to and also can be affected by local interaction effects. The mechanisms of this scaling to new contexts, called constellation effects, takes place through circulation of stories, material, people, documents, reports, etc, in short the circulation of any object carrying previous interaction effects. The level of materiality of these objects again determine how fast and at which cost they may circulate.

Together, interaction and constellation effects help to understand mechanisms of scaling, by showing how translations come about, and circulate. In these processes, there are elements of generification, and loss and gain. The software DHIS2, being used in over 30 countries by the HISP network, is becoming increasingly generic as it accumulates local translations and negotiates their generification. While the trend of development and progress of the software produces gains for the implementing actors, there are also losses involved, for example the reduction of inscriptions.

The articulated model has several implications towards the literature of scaling of information systems, technology transfer and translation. While technology transfer has treated scaling as linear and uni-directional, from one country to another, my model sees scaling instead as multidirectional, non-linear with potential to scale to other contexts. There are feed-back and feed-forward mechanisms, potentially allowing effects to initiate change in the original context. This thesis also provide some practical advice on HII strengthening, including how to manage increasing scale, and strategies for integration.

1 Introduction

This thesis studies mechanisms shaping the scaling (or not) of health information infrastructures (HII) in a global context. The motivation for this is twofold. Firstly, to improve our theoretical understanding of scaling in a global context, seeing it as multidimensional rather than one-dimensional and multilateral rather than unilateral. And, secondly, to address a practical reality of HIS often stranded as pilot projects, without ever scaling to levels of usefulness and sustainability.

These two motivations are strongly linked. Global scaling is an increasingly prominent feature of information systems, including HII, which at the same time has been given little attention in the Information Systems (IS) field (Pollock and Williams 2010, Williams and Pollock 2012). Large, international, initiatives driven by World Health Organization (WHO) and other agencies are increasingly aiming at both global reach of single systems to global monitoring needs, as well as transfer of best practices from one country to another. Many such initiatives start as implementation pilots, but fail to scale even nationally. This "pilotitis", the overcrowding of pilot studies which may have been successful, but failed to scale (see for example Kuipers, Humphreys et al. 2008, Anadach Group 2012, Germann, Jabry et al. 2012), results both from what seems to be an over-emphasis on one dimension, technology, and limited understanding of the mechanisms and strategies useful to adopt to support scaling processes. This thesis aims to contribute to filling this gap in our understanding in processes of global scaling.

The research for this thesis has been carried out within the Health Information Systems Programme (HISP), a global action-research initiative that since the mid-nineties has sought to improve HIS, predominately in Africa and Asia. Guiding principles for HISP have included participative design, open source, and a focus on local empowerment for using health data for informed decision making. Understanding and enabling scaling has been a key challenge the HISP network has been grappling with over the years (Braa et al 2004), and has achieved both successes and failures.

1.1 Theoretical motivation

The main theoretical motivation is to strengthen the understanding of global scaling as involving multiple and mutually influencing dimensions. Scaling "concerns the process through which [a] product or process is taken from one setting and expanded in size and scope within that setting and/or also incorporated within other settings" (Sahay and Walsham 2006 p. 185). Researchers have pointed to the problems of both scaling and sustainability (Heeks, Mundy et al. 1999), and their intimate linkages (Braa 2005). Research on scaling of IS has tended to focus more on the technological artefact, though of late other dimensions have also gained attention, opening up for a multidimensional understanding of scale. Dimensions of scaling has been seen to include both hardware, software, and network capacity (Bondi 2000), architecture (Lemley and Lessig 2001, Zittrain 2006), support structures and user maturity (Braa, Monteiro et al. 2004, Shaw, Mengiste et al. 2007), and ideas and practices (Edwards and Hulme 1992). Research on scaling has tended to be piecemeal and not focused on the multi-nature of it, and furthermore, our understanding of the interplay of design, development, and use, especially over time and across many sites, remains thin (Pollock and Williams 2010).

 A view of the phenomenon as one of an "information system" and not just of "technology" challenges us to look at various other facets of scaling in a totality. As a start, I outline my perspective based on an understanding of what constitutes an information system and information infrastructures.

I build this understanding on the concept of Information Infrastructures (II), which has been defined as "an evolving, shared, open, and heterogeneous installed base" (Hanseth 2000 p. 60). *Evolving* as in enabling change over time, *shared* by a larger community, *open* in that there is no clear-cut boundary as to what it includes, *heterogeneous* in that it consists of socio-technical networks and sub-networks, many of whom are very different in nature, *installed* as in always building on something existing. For the health sector, one can speak of Health Information Infrastructures (HIIs), where there are a range of open-ended networks of actors (doctors, nurses, managers, patients, policy makers, researchers, software, hardware, vendors, routines, formal and informal rules etc). The many human and non-human components of HIIs mutually influence their development, and it can be said that IIs are not built, but they evolve over time (Nielsen 2006). In relation to scaling of

HIIs, it is thus important to understand how these components, or actors, influence each other, and the relation between active guidance and autonomous evolution.

Various concepts from Actor Network Theory are found useful to start unpacking the mechanisms of scaling of HIIs. One such concerns inscriptions (Akrich 1992), which are intended or unintended characteristics of design that prescribe certain behaviour. Artefacts can be more or less flexible in the way they are used, and designers thus have some leeway in *inscribing* certain kinds of behaviour or evolution. Such inscriptions can be weak or strong. For example, a hammer has weakly inscribed behaviour, as it can be used in a range of ways, while an assembly line has less flexibility and prescribes behaviour in certain pre-defined ways (Monteiro 2000). Such inscriptions can then determine if and how something scales, and the unintended directions that this may involve. The example of the Internet, a truly global II, exemplifies the many unintended scaling trajectories taken over time. The weak inscriptions contribute to massive amounts of different (unanticipated) uses (Zittrain 2006, Zittrain 2008).

Linked to this issue of inscription is the debate about agency. Related to actions which have outcomes of consequences (Rose, Jones et al. 2005), agency is thus a capability to make a difference (Giddens 1984), and there exists a continuum of different stances as to who and what holds agency – between technology and society. The extreme positions are that only humans have agency, and use technology at their will, or at the opposite end; that technology autonomously prescribes human behaviour, known as technological determinism (Winner 1978). For my own research, I take the stance that agency is prolific, residing with human and non-humans alike, as described by the related concept of actant as used in actor network theory (Ciborra, Braa et al. 2000, Rose, Jones et al. 2005). Both human and human devices (institutions, technology), arguably, have agency. For the analysis of scaling, this implies that *not only human actors* determine scale and scope. This is important, as I will get back to in my analysis. I am by this not giving primacy to any "type" of actor in terms of agency, and believe it is context-situated.

 Orlikowski has written about the duality of technology, that technology both shapes and is shaped by human institutions and actions (Orlikowski 1992), and it follows that this necessarily is true the other way around also; institutions and actions shape and are shaped by technology.

On the other side, it has been argued that that this neutral stance on agency disregards the qualitative difference between human and non-human agents regarding morals and ethics (for an overview, see Walsham 1997). This symmetry of agency between technology and humans prescribed to by some ANT theorists has been criticized by, among others, Winner, who argues that technical solutions are always skewed towards certain social interests, which he calls elitism (Winner 1993). Such considerations I find useful in my analysis, and no doubt to hold importance when looking at power structures and agendas among the various actors of HIS. In this regard, I share similar sentiments to Walsham, who writes:

"This author has found it valuable to think of things as actants and to consider whose interests they inscribe, represent, and speak for. This is not the same as assuming a symmetric position for people and things, but rather can be considered to be a valuable analytical device." (Walsham 1997 p. 476).

In sum, I hold that scaling must be looked at as a multidimensional process, informed within a HII framework as evolving, shared, open, and heterogeneous installed bases. Furthermore, as both humans and non-humans hold agency, these dimensions, irrespective of their nature, mutually influence each other, albeit in different degrees as shaped by the context.

Taking this multidimensionality as offered by the II theory, I now turn to a second aspect of a proposed understanding of scaling; multilateralism. The current theoretical body is much thinner on scaling covering several and inter-connected countries (Pollock and Williams 2010), though there are some notable exemptions (Monteiro and Rolland 2002, Braa, Monteiro et al. 2004). A field which has at least focused on studying scaling from one country to another, is that of technology transfer, although typically concerning bilateral and not multi-lateral movements. I now turn to this and related theories.

The empirical base of my research is HII development in several countries, most notable Botswana, Sierra Leone, and Tajikistan, centering on the same (evolving) software and philosophy of information use, similar cadres of users, and similar yet different contexts. Scaling within these countries, and between them, is thus also informed by the debates around technology transfer, related concepts of technology translation (Akrich 1992, Nhampossa 2005) and of technology learning (Braa, Monteiro et al. 1995). The introduction of technology, be it physical or electronic artefacts like hardware and software

or principles of organization and institutions, in a context it has itself not been developed in, has earlier been labelled technology transfer. But as has been argued, there will be differences in contexts that leads to changes in the way this technology is adopted and applied in the new setting, not as a transfer or replication but more as a translation (Lind 1990, Akrich 1992, Sahay and Walsham 1999, Nhampossa 2005). This notion of *translation* (Akrich 1992)is a promising way to look at scaling: the growth of IS in and to new settings can be seen as technology being translated to new contexts, where modifications will take place both with the technology and its surroundings, leading to the creation and redefinition of the surrounding socio-technical networks, and with it processes of use and consequences.

Common between the above studies, however, has been a linear and bilateral view of scaling; in one direction from one country to another. But this is not necessarily so. The increased ease and speed of communication means that information technology based applications can travel faster than the physical machine described by Akrich (Czarniawska-Joerges and Sevón 1996), and that translations are not necessarily linear and unidirectional but can lead to network externalities (Stiglitz and Walsh 2002) spanning across countries.

Orlikowski's concept of time-space discontinuity between design and use of technology adds in addition to space, another element to technology transfer; time (Orlikowski 1992). With increasing ability to disseminate software speedily, for instance through online updates of national HII software, this physical discontinuity is arguably rapidly dwindling. Akrich described translation of bulky technology that would not be transported back to where it came from, but what are the effects of translations taking place in a networked community, spanning many different contexts, and how can producers of technology take advantage of the local translation (Bogers, Afuah et al. 2010)? This is the case of the empirical base this thesis builds on; distributed development and use in many countries. A key motivation for this thesis, then, is to understand scaling across this diversity and multiplicity, how it leads to alterations of the technology and behaviour, and how this feeds back (or not) to other users in the system as a whole. Based on this motivation, I define successful scaling of HIIs as being embedded in a local context while retaining the flexibility for scaling to other contexts. Scaling is thus seen as a potential along two axis, vertical embedding in a context, and horizontal scaling to new contexts (Braa and Sahay 2012).

1.2 Practical motivation

In 2000, the United Nations General Assembly signed the Millennium Declaration (United Nations 2000), and pledged to a series of goals that has become known as the Millennium Development Goals (MDG). Several of these are related to health, such as Goal 4 to reduce child mortality, and Goal 5 to improve maternal health. These goals represent a point of gravity for the international community, and today it is rare to find a development project without a reference to these MDGs. Several high-level initiatives, representing billions of dollars in investment in health, are in direct response to the goals and the targets set to be achieved by 2015. Among these are new organizations like the Global Fund to fight AIDS, Tuberculosis and Malaria, which has spent more than 22 billion USD since 2002, global partnerships like Roll Back Malaria, and special projects like the UN Commission on Information Accountability (CoIA) for health of women and children. This increased attention on health has not translated equally to the thrust for better health information, which continues to be in a poor state in many countries. As late as 2012, the WHO Director-General addressed the need to improve HII, stating that "Without information, we are working in the dark, pouring money into a black hole" (Chan 2012).

Things have started to improve though. As the need for better information has received more attention, both for countries to improve health service delivery and for international organizations to monitor and evaluate the large programs they support, so too has domestic and international organizations taken up the task of improving HII. The Health Metrics Network (HMN) represented the first global partnership initiative to address these issues, from 2005, and more established organizations have also changed their ways. WHO has classified HIS[1] as an essential building block of country health systems(WHO 2009). Yet despite this new momentum for strengthening HIS across the world, outcomes often are not commensurate with efforts . Pilotitis is still very much the order of the day.

1.3 Empirical basis

A detailed description of data collection and analysis is given in chapter 2, followed by a presentation of the context of global HII development in chapter 3. I will here briefly introduce the empirical basis of this thesis.

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[1] The unit of analysis of this thesis is HII, though the more widely used term HIS is applied when it refers directly to a source. Where HIS is used, I treat it like HII in seeing it as an evolving, shared, open, and heterogeneous installed base. The two terms are thus seen as equal for the subject matter of this thesis.

This thesis is based on active work to strengthen HII at many levels; from facilities, to local administrative levels, national, and the global level. I have primarily been working in Sierra Leone and Botswana, though also in other countries in Africa and Asia, as well as two years at the WHO in Geneva, Switzerland. The empirical basis for this thesis is thus coming from this work, and my engagement with HII development, scaling, and institutionalization in several contexts and countries. This has taken place within the HISP network, comprising several universities, ministries of health, NGOs, individuals, and partners both in countries and at the global level.

The focal case will be Sierra Leone, as it is where I have been able to be engaged the longest, as well as it having offered a multitude of perspectives on scaling. As part of regional work in West Africa, I have also taken part in processes to scale from Sierra Leone to other countries, and to see the international influences at play.

1.4 Research aims

In light of the above discussed issues, I have three research aims of this thesis. While they are connected to, and build on, each other, the first two are of a more theoretical nature, while the third addresses the practical motivation of increasing scalability of HIS projects. The first research aim is;

- To develop a theoretically informed model of scaling of HIS in a global context

To work towards such a model, I have identified four aspects in particular that will be important to help develop it. They are:

- What are the different dimensions of scaling?
- What is the nature of the relationships of these dimensions?
- What potential to scale do these dimensions hold?
- What are the interaction effects across these dimensions and their positive and negative implications?

Furthermore, this model needs to be complemented with mechanisms that drive scaling at a multidimensional and multilateral level.

- What are the mechanisms that drive scaling at intra- and inter-context levels?

The last research aim is a practical application of this model to address the many stories of failed HII scaling:

- Understand why projects don't scale and strategies to minimize that

1.5 Contributions

C1: With this thesis, I conceptualize scaling as taking place along several dimensions of HIIs. The main aim is to contribute towards a theoretical understanding of how this scaling takes place, and what triggers and governs it, and why it does not take place in certain settings. This includes an analysis of what is scaled, i.e. the various dimensions along which scaling manifests itself. A key contribution is a theoretical model for analyzing scaling as multidimensional and multilateral.

C2: Since scaling will necessarily mean the diffusion or transfer of institutions and technology, I also expect to contribute to the understanding of technology transfer and related aspects, through analyzing scaling from a multilateral point of view. While normally discussed as the movement of capital-intensive technology from the "north" to the "south", my research has been based in the "north-south-south" HISP network, where scaling and technology transfer has taken place in a manner quite different from the traditional view, and in a non-linear fashion.

C3: My study builds on empirical work in several countries, over six years, and this thesis thus provides a longitudinal and multi-contextual case study. This thesis thus answers to a call for studies to be longitudinal and focus on more than one site of implementation (Pollock and Williams 2010).

C4: From a practical point of view, I hope to also be able to contribute to knowledge and best practices for the improvement of health information systems, and help explain why HIIs so often fail to scale.

1.6 Organization of the thesis

Following this first chapter, the thesis is organized as follows.

Chapter 2 presents the methodological framework of my research, together with my epistemological standpoint. A discussion on the overall framework, Action Research, is

included, as are details about field work in the various countries I have been engaged in. The data analysis is presented, making linkages between my empirical data and the concepts I will use for the theoretically informed model of scaling.

Chapter 3 gives an overview of the context in which I have based my research; health information systems implementation in developing countries. Furthermore, a more detailed description of the focal case for my thesis, Sierra Leone, is provided.

In Chapter 4, I give a presentation of existing literature related to scaling, and as well explore other literature that helps shed light on the various dimensions of scaling.

Chapter 5 provides a summary of the five research papers that is included as part of this thesis. This includes the main findings and their implications for scaling.

In Chapter 6, I discuss the implications of my data analysis and findings for our current understanding of scaling. This involves both theoretical and practical implications

Chapter 7 presents my conclusions and current trends of health information systems, where I look at possible implications of these trends, and how the model for global scaling can be used to understand these.

The individual research papers are included in their entirety in the appendices.

2 Research approach

I will in this chapter present my empirical approach. First, I start by explaining my epistemological background, before describing the overall research framework and ideology. Then I present details about field work in the various countries I have been involved, and how data has been collected and analyzed. The focal case is Sierra Leone, and a more detailed description of the work engaged in there will follow in the next chapter.

2.1 Research foundations

I base my research on the epistemological strand of interpretivism. Seeing the world as socially constructed, a view which I as a researcher very much subscribe to, I submit myself to an un-accomplishable, and meaningless, task if I was to look for "the truth". My research is my subjective interpretation of the world, and based on others' interpretation of their realities and an understanding of the inter-subjective processes through which the realities are constructed. Through developing my research narrative in this thesis, I present my constructions of the empirical experiences, making it available for readers to develop their individual interpretations based on their particular backgrounds and interests. This is not to say all is relative, and that interpretations will be like snowflakes; none are ever alike. Interpretive studies "reject the possibility of an "objective" or "factual" account of events and situations, seeking instead a relativistic, albeit *shared*, understanding of phenomena" (Orlikowski and Baroudi 1991 p. 5, my italics). I would label my ontology as *internal realism* (Archer 1988, Walsham 1995), where reality is a shared construction, a de facto reality.

One of the consequences of interpretivism is of course that I, as the researcher, have a certain background that influences the way I see the world. I did not undertake this research from a value-neutral position. Rather, I acknowledge that I have certain assumptions that have influenced the way research has been conducted and interpreted. Chief among these are inherent in the tradition from which I come at the University of Oslo, which emphasizes local empowerment in the health sector, and the benefits of and moral obligations for participative systems development. Furthermore, especially as a former student of Latin American development studies, I've come to learn about the negative consequences of international organizations as monopolists of appropriate

strategies for development, such as the "Washington Consensus". Admitting that I both hold these views, and that my research is very much aimed at improving this situation, it is also fair to say that my research aims to be critical. How much I have succeeded in this effort, is an interpretation of the reader.

There seems to be a consensus in IS research that interpretivism and criticalism are two different things, out of a set of three research paradigms (Orlikowski and Baroudi 1991, Klein and Myers 1999)building on (Chua 1986). However, there seems to be no clear boundaries between being interpretive and being critical. The defining characteristic of interpretivism is the way it relates to knowledge, while critical research can be seen to be more concerned with how knowledge is used. "IS research can be classified as critical if the main task is seen as being one of social critique, whereby the restrictive and alienating conditions of the status quo are brought to light" (Klein and Myers 1999 p. 69). It is not immediately clear how the foundations of knowledge within interpretivism differ from that within criticalism. While it can be said that there is an assumption of a social reality within critical research (Myers 1997), it also has clear interpretive aspects of assigning importance to social interaction in the shaping of subjective realities. However, Orlikowski and Baroudi (1991) state that "critical researchers depart from their interpretive colleagues, in that they believe interpretation of the social world is not enough. The material conditions of domination need also to be understood and critiqued" (p. 20), and further, "researchers working in this tradition do not merely accept the self-understanding of participants" (p. 21).This thesis does not intend to go into deep discussions on the relation between interpretive and critical research, nor to discuss the possibility or even benefits of combining them (Mingers 2001); my research can be described to be interpretive in nature, whilst containing elements of criticalism. As noted above, I am critical of many historical and contemporary agendas and methods of development agencies, and I believe this must be understood and engaged with, primarily in the field of health informatics as in my case.

Furthermore, social structures around health information ownership is an area where my research has a clear objective; to decentralize and redistribute this ownership to empower local levels to improve health service provision. This thesis is based on work in several countries where this has been one of the main aims. A clear element of criticalism is the application of an action research methodological framework for this thesis. I am not only trying to understand, but also hopefully to contribute to processes of structural change.

2.2 Research methodology: Action Research

The overall methodological framework for this thesis has been Action Research (AR). AR is a form of participative research where the researcher takes part in the change processes in an organization, actively trying to improve some stated problem (Checkland and Holwell 1998, Avison, Lau et al. 1999). AR holds that understanding the social processes at play is best achieved by introducing change and observing the effects of these efforts (Baskerville 1999). While it was initially not used much in IS research, and had a lot in common with anthropology and social studies, it has over the last two decades increasingly become accepted as a way to generate very relevant research findings on technology in its human and social context (Baskerville and Wood-Harper 2002, Baskerville and Myers 2004, Davison, Martinsons et al. 2004).

AR was first articulated by Lewin in the mid-forties (Lewin 1946), and used to address social problems such as minority issues and extremist views and movements. About the same time, the Tavistock Institute developed a similar methodology; to both solve social challenges and create knowledge about the same phenomena (Susman and Evered 1978). There have later emerged several strands of AR, so that it is now more a term used to denote a class of methods (Baskerville 1999), while the more original version is coined canonical AR (Davison, Martinsons et al. 2004), to "formalize the association with the iterative, rigorous and collaborative process-oriented model developed by Susman & Evered" (p. 66).

The iterative nature of this canonical model presented by Susman and Evered is sketched in the figure below. There are various versions of this cyclic action/evaluation process (Baskerville 1997, Checkland and Holwell 1998), with differences mainly in the details. The important element is the cyclic nature itself, of planning, intervention, evaluation, learning around both practical and research related issues, and then starting over again. With such a cyclic approach, evaluation is not only to assess progress towards the stated goals and adjust the course of action, but also to extract learning and making it public; in short, conducting academic research.
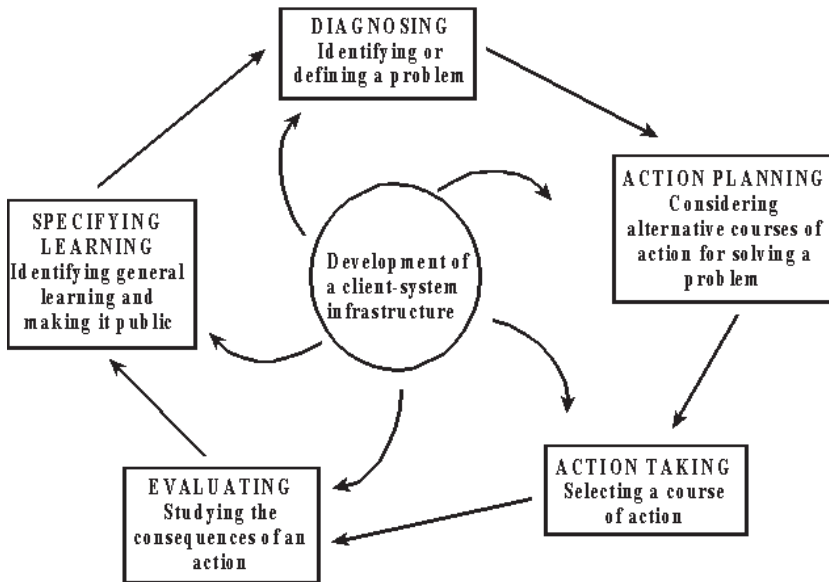
Figure 1 AR cycles (Susman and Evered 1978 p. 588)

2.2.1 Common critique of AR

While Action Research has evolved as a method, also in the IS field, it has also been subject to critique (Davison, Martinsons et al. 2004). A common critique has been the tendency of the *action* gaining primacy over the *research*, and that little distinguishes it from consultancy. While much of what this thesis builds on has been carried out in ways that can be seen to be similar to consultancies, I hold that this is not incompatible with research. This follows from the AR cycle presented above, where consultancies could be seen to exclude some of the stages, particularly the "last" of identifying general learning and making it public. The challenge is in finding the right balance. In my research, based as it is on many visits to several countries for field work, the cyclic nature has come naturally. The stage of specifying and disseminating learning, as well as reflecting upon it and using it to make and revise plans, has taken place both during field work (short, daily cycles of more practical orientation) and while away at "home" (longer cycles). Research papers included in this thesis are the results of such short and long cycles, based on both on-site analysis and longer periods of reflection and comparison with literature, typically in my home institution in Oslo.

Another critique to AR concerns arguably its lack of rigor (McKay and Marshall 2000), which has been interpreted as strict relevance and exactness. Davison et al. (2004) point out that it has been claimed an inverse relationship exists of such relevance and rigor (Senn 1998). Thus, it resembles the consultancy argument in that if AR is to produce relevant knowledge for practitioners, researchers have to compromise on the rigor of their methods. They conclude, however, that this is not necessarily so, quoting Lewin (1945) that there is "nothing so practical as a good theory" (p. 67). Lindgren, Henfridsson and Schultze (2004) have argued that adherence to the five phases of canonical action research as presented by Susman and Evered (1978) contributes to achieve both relevance and rigor.

2.3 The HISP tradition of Action Research

As mentioned above, the research presented in this thesis has been carried out within a tradition of a research group at the University of Oslo. Within the HISP project, described later, action research has been used from the initiation in the mid-nineties, and later in several and diverse research settings (Braa 1997, Braa and Hedberg 2002, Sæbø and Titlestad 2004), resulting in a number of theses and publications.

The origins of the HISP tradition can be traced back to the Scandinavian critical research projects that centred on industrial democracy, starting with the Norwegian Iron and Metal Workers Union project that looked at planning, control and computerization from a trade union perspective in the 1970s (Bødker, Ehn et al. 1988). User-participation and emancipation stood central in these projects, and this critical thinking has also influenced the initiation of HISP. This was also the point of entry for development of a new HIS in South Africa after the fall of Apartheid (Braa and Hedberg 2002), which signalled the birth of HISP as a critical movement. Participative design of the new HIS was sought rigorously, leading to very rapid prototyping and real-life testing of the District Health Information Software (DHIS), a combined data collection and analysis tool for health management.

Participatory design has not only been a method for design and development of DHIS within HISP, but also for research – as a process and object of study. A distinct participatory action research approach developed as HISP became active in other countries. This two-way participation holds that not only do researchers engage in the work-processes in a given setting, but that the workers in that setting also engage in research (Greenwood and Whyte 1993). Within HISP and Oslo, several educational programs, both at Master and PhD level, were established, and included also "subjects" from the earlier action

research. Thus HISP came to absorb many of the workers in the AR settings into research positions, and there has been a steady circulation back and forth of people between research and applied HIS work. This absorption of subject workers into research has had implications for the way action research is done within HISP, and for the research presented in this thesis. There is at any point of time a diverse community present also at the University of Oslo, such that the distinction between the "field" and "home" becomes less evident. Critical reflection and data analysis can be done, and is done, together with now-turned-researchers from countries where HISP is engaged. The "pool" of HISP researchers then contains both medical doctors and informaticians, and people with thorough knowledge of their respective countries on which I base my research.

In 2004, Braa, Monteiro, and Sahay articulated the *networks of action* approach for the HISP project. Firstly, this was answering the need to reduce risk as pilot projects have been prone to delays and shut-downs. Secondly, it was a strategy to increase sustainability by circulating key personnel, technology and knowledge between various nodes of the project. And thirdly, this was done to increase learning and basis for generalization by conducting research on a series of comparative cases rather than isolated instances (Braa, Monteiro et al. 2004). This was based on earlier studies of action research concluding with the need to situate the action within networks rather than on singular units to achieve enough momentum to attain sustainability: "from single organizations and workplaces…to networks" (Engelstad and Gustavsen 1993 p. 209).

One reason to base AR in networks was to be more pragmatic and flexible towards making change in the research setting. The researcher seldom has control over interventions or developments in the larger organizational framework within which they work (Mumford 2001). Being based to a large extent on pilot projects in a highly political environment (Sahay, Monteiro et al. 2009), where long-term goals are aimed for within the endemic constraints of short-term funding and other resources, the modus operandi was to go for the "low-hanging fruit" to be able to achieve the incremental success needed to secure further support. This *action* of course influenced the *research* of AR also, but that does not mean there was no overall direction of research agenda. Rather, the strategy can be coined as "directional improvisation" (Sæbø, Braa et al. 2011), where situations largely determine how the overall goals of both action and research are pursued. In her classic book "Plans and Situated Action," Suchman describes the differences in approaches of a European and Trukese navigator (2007). While the former works by first creating a plan and then acts in

relation to that, the Trukese has a vision of direction in place, and then takes advantage of the existing conditions (the wind, the waves, stars etc) to navigate the path. The HISP approach is akin more to that of the Trukese, the broad direction is known, but the conditions – such as political support, available technologies, resources etc – are a product of the here and now which have to be acted upon with best effects. For this to be viable, the HISP approach to action research needs to be very flexible, and, like the Trukese navigator, build on being sensitive to the changing environment while being agile to take opportunities as they arise.

With the continued scaling of HISP activities to more than 30 countries, the strong participation of users in the design process has been challenged, especially the last few years. Not being in a position to actively work together with users in all these countries for reasons of capacity, some countries have necessarily played a larger role in providing their inputs to software and system development. With thousands of users in some of the larger countries, new ways of fostering participation have been sought, with some successes like the creation of a user discussion forum implemented as part of the system (Braa and Sahay 2012).

Since the research presented in this thesis comes from the HISP tradition of AR, involving principles of participative design and networks of action, I will in the next session describe the research settings included in my research, covering many countries, sub-projects, and years.

2.4 Data gathering

In this section, I give a short overview of the fieldwork I base my research on. I will try to show the diversity of activities I've participated in, so not all work would necessarily be included here.

2.4.1   Data collection methods

While the research framework is AR, I have applied a range of specific methods within this overall structure. These are not often pre-planned in detail, but have been applied as needed and as possible within the given contexts. This does not mean that they have been ad-hoc and without rigour and direction. Rather, like the directional improvisation guiding the HISP activities, the selection of methods has often been based on flexibility; to adapt to the circumstances and opportunities. This has involved combining methods where possible,

and to employ methods that are seen as beneficial to both solving practical problems and generating knowledge. A guiding principle has also been that it is not so much of how people *see things*, but rather how they *do things* (Silverman 1998), as shown in the picture below depicting the workflow at a child health post in Sierra Leone.

Figure 2 Following health services and the steps of data collection, aggregation, and reporting; A makeshift clinic in Sierra Leone, where children are weighted and vaccinated. Mothers start at the table to the right, and pass by several "stations", where health services are given and records are taken.

Without going into details when describing the methods and tools applied in each research setting below, a short summary of the main methods will be presented here. Descriptions of specific methodology are also presented in each research paper, which are included in the annexes.

Both quantitative and qualitative methods have been applied. Participative design has been a common theme, both as a development approach, and as a research method. My work has thus been carried out in close participation with stakeholders at different levels of the health systems to develop, refine, adapt, and implement HII; software, databases, data collection tools, routines, information products, etc. The work has thus been both technical, like solving database issues and working with hardware configurations, and also "social",

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like negotiating information requirements with health program directors. Quantitative analysis has also been applied, for example measuring incidence and degree of data recording mistakes as part of work with nurses to explore ways of helping them to simplify routines and strengthen data quality.

The single most important method of data collection has been participating in training and capacity building efforts in countries. Training, carried out through visits to particular countries and through the DHIS2 Academy initiative, has offered a great opportunity to learn from those who attend. Countless discussions have resulted from exercises included in training, which have led to better understanding, on my part, of relevant issues in the context. For example, during a three-week training for managers and HIS officers in Sierra Leone held in 2008, I would use the opportunity to let participants themselves explore the various aspects of HIS through exercises and discussions rather than through one way monologues in the form of lectures from the teacher (me). On several occasions, I could just sit back and take notes after "lighting the fire". Issues of corruption, mismanagement, poor design, and neglect would emerge in heated discussions between district staff and national managers. Religious rules interfering with provision of health services was debated, and so also perverse incentives in the reporting of drug management data. These issues could have been difficult for me to encounter had it not been for the dynamics of the training sessions and the informal relationship developed with the participants.

The various modes of data collection are summarized in the table below. Naturally, data collection when not present in a country is a bit more difficult, but frequent direct contact and email communication with the key partners has made this easier.

Place of work	Setting	Data collection methods
Field work in country	Formalized training	Participant observation, discussions, exercises for participants, photography, filming, database study
	Customization work	Document study, participative design, prototyping exercises
	Implementation and field visits (district offices, facilities)	Observation, interviews, photography, document study, participative training/guidance and discussions
Support from abroad	Customization of DHIS2	Emails/dialogue, document study (data collection forms,

| | | reports, plans) |
| | Planning/reporting | Database study, document study, writing reports |

Table 1 Summary of main data collection methods in various activities

2.4.2 How data was recorded

The most common ways of recording data throughout this research has been the notebook – a field diary , email archives, and pictures. Notes were taken throughout the fieldwork, including examples and learning from training sessions which have been incorporated into updated training material. Over the many visits in countries, several notebooks have been filled. Any kind of information would be written down in the notebooks, as exemplified by the two following excerpts:

Gaborone District council 23/10 06: Some clinics appear as 2 in standard forms, but as 1 in DHIS. They are one facility, but several departments. Report independently.

Corruption: Mentioned/hinted at week 3 batch 1 [of training]. [Senior representative] revealed to Bob that they "hate to announce" positions, as they will get CVs from relatives of powerful people (politicians), and come under pressure to hire them. Politicians then call them and tell them who to hire.

Hundreds of pictures have been taken, to supplement notes, such as of data collection forms, charts on walls in clinics and other information products. The picture below is documenting incorrect use of a data collection form, where the fields to be filled out have been misunderstood by the person collecting the data. There are also others showing situations, such as the position and movement of nurses during vaccination sessions, ways in which doctors fill out data forms, representatives to district evaluation meetings, etc. Trip reports have also been written, most notable from work in Sierra Leone, intended to be shared with my colleagues. In this regard, I have also had access to trip reports from others – a requirement of the funding agency. A few videos have been recorded, used primarily as material for courses. Most verbose have been the thousands of emails, which in addition to being records of my work being discussed with others while engaged in the field, also have been a mode of my involvement remote to the study site.

Figure 3 Picture taken to document misunderstanding of data reporting form. In this form, the number of each vaccine that has been discarded the previous month due to it expiring should be recorded, not, like here, the expiry date itself. For the maximum and minimum fields, the actual maximum and minimum temperatures of the facility's cold storage should be recorded.

2.4.3 Selection of fieldwork

In the following sections, I describe the various research settings I build this thesis on. Primarily, that has involved work in Botswana and Sierra Leone, but also a range of smaller engagements in other countries. The common denominator is that all work has been within the HISP project, or strongly related to it. Why were these sites chosen – both at the country and sub-national levels?

The answer is that these countries, among many in the "network of action" that is HISP, offered the long-term and nationwide involvement that would be beneficial for looking at issues of scaling. The project in Botswana had started in 2005, with funding secured until the end of 2007, and I had been involved from before I started this study. I could then build on existing processes, already having a knowledge of the situation, people, and organizations. Unfortunately, little local ownership developed over the remaining years of the project. Even though scaling had continued in Botswana, this was only in a very limited manner through the forking of the project into primarily HIV/AIDS monitoring and evaluation. I could have continued with this limited project, though getting funding and

support were going to be challenging. Sierra Leone then offered three new angles to look at scaling; it was a different country, adding a study for comparison with Botswana; national roll-out to all districts had been decided upon, rather than just a pilot as in Botswana; and the implementation was to use the new online version of DHIS2, offering new possibilities to look at the role of technology for scaling. Also, it offered a relatively well-funded implementation study, with political legitimacy from the Health Metrics Network (HMN). In sum, Sierra Leone was a good opportunity to study the issues of focus in this thesis, even though there were other countries I could also have been more engaged in, like Tajikistan, Tanzania, or a state in India, which were also real options to consider for analysis.

The work in Sierra Leone also led to an opportunity to spend two years at HMN in Geneva, Switzerland. While not originally part of the research design, this position offered a global perspective on HII strengthening, and in large part my responsibility was to coordinate the project in Sierra Leone.

Throughout the duration of this thesis, I was also involved in the HISP "core", at the University of Oslo. Much of the software development and coordination of support to countries, especially in the early phases, take place in Oslo. I was thus engaged in discussing implementations, scaling, software development, and requirements not only in the countries I was directly involved in, but all countries where HISP is present. For instance, while DHIS was not used for patient registries in Botswana and Sierra Leone, I were engaged in discussing development strategies to support this new functionality design and development due to demand in other countries, like India and Ghana.

2.4.4 Main fieldwork

Prior to formally commencing of my PhD work, I was involved in the first phase of the BEANISH project in Botswana[2] in 2005. It was thus natural for me to base my initial PhD research here, as I knew the people, organization, and challenges present. Also, as I had been involved in piloting the introduction of the new HIS as part of the project, I would get a longitudinal perspective on my research topic - the process of scaling.

While the project in Botswana led to several papers, two of which are included in this thesis, it eventually came to a halt due to external reasons that I had no influence over. An

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[2] Building Europe Africa collaborative Network for applying IST in Health care sector, an EU-funded program 2005-2007

emerging, similar project, indeed building on knowledge from the BEANISH project, gave me the opportunity to continue my research in Sierra Leone. This project offered the same prospects of working with issues around scaling, and it was thus selected for my focus over other potential projects. The Sierra Leone project was about to start up, aiming as in Botswana first to integrate various information sub-systems into a central data warehouse and then to implement this in the 13 districts of the country. Thus implementation work in this country, and later in other parts of West Africa, became the second major focus of my research.

The work in Sierra Leone in turn indirectly led to my two-year engagement at the HMN, a partnership of the WHO based in Geneva. While this position was not formally part of my research at the University of Oslo, from which I took leave, I include the experience of this stay here as it both allowed me to continue to be directly involved in Sierra Leone (the project was funded and coordinated by HMN) and helped give me an important perspective from the global level of the working of international organizations. Thus, this two-year leave period, in fact was foundational to my understanding of HII, and their global scaling challenges.

While my main focus shifted from Botswana to Sierra Leone, and further to the regional and global levels, there is a consistency in development of ideas and practices. Concepts first encountered in Botswana, like interoperability as a promising strategy for integration and scaling (Sæbø, Gill et al. 2008), were later developed further in Sierra Leone. It is thus natural that even though much field work was done in Botswana, few papers from that period have been included in this thesis. That research has matured and later found its application and refinement in Sierra Leone and other places.

I will in the following sections provide an overview of my practical involvement in these settings.

2.4.4.1 Botswana

The table below summarizes my involvement on the ground in Botswana, both the number and duration of stays, the main organization I was working with, and what I was doing. The table only shows field work conducted in Botswana, while I for the interim periods were also supporting the implementation from Oslo.

Time	Primarily working for	Description of involvement
June – August 2005 (Before commencing PhD studies)	Botswana, Ministry of Health	Intern Project initiation Setting up four pilot districts
October 12-27 2006	Botswana, Ministry of Health	Project assessment Strategic planning for project and my involvement
January 20-March 10 2007	Botswana, Ministry of Health	Project participation, including visits to health facilities, database work, meeting stakeholders, planning roll-out, additional training
July 2007	Botswana, UNAIDS	Preparing training of District AIDS Coordinators in the use of DHIS
October 2007	Botswana, Ministry of Health and Ministry of Local Government, UNAIDS, University of Botswana	Planning and teaching two week-long courses in information management and use for 44 new Health Information Officers. Participate in project work

Table 2 Summary of field work in Botswana

Before I list the types and forms of interaction in the project, a clarification of my role is relevant. When working as an intern during the summer of 2005, I had no research agenda per se, but acted as an extended arm of the HISP software development team in South Africa, as well as of the project coordinators in Oslo. Returning to Botswana from October 2006 onwards, my role had changed to that of a researcher, though much of the work involved the same things as earlier. However, looking back at it critically, a clearer description, and agreement of my role, was necessary. As will be described later, the project in Botswana lacked a clear leadership and division of responsibilities, especially related to the IT department at the Ministry of Health being formally organized by a different ministry. Coming in as a researcher in such a leadership vacuum posed many challenges, especially with respect to project management and my role in this. From one point of view, I was very preoccupied with practical work in the project, while on the

other side, it gave me a lot of freedom in terms of time and my need to focus when in Botswana. .

My empirical work in Botswana can be divided into four main and inter-connected arenas:

- National level brokering
- District piloting
- UNAIDS integration
- University of Botswana training and planning

At the national level, I was mostly involved with the Ministry of Health, IT department. An important part of this work was trying to enrol health programs to the piloting of the DHIS in four districts. For this, I would spend considerable time visiting program directors to discuss collaboration on integration and standardization among their programs. These meetings would take everything from five minutes to one hour, and would typically represent a conversation along the lines of an unstructured interview. Health programs visited at least once include Masa (Anti-Retroviral Therapy programme), Tuberculosis programme, Prevention of Mother to Child Transmission programme, Health Statistics Unit, and Department of Policy, Planning, Monitoring and Evaluation (PPME).

At the IT department, I worked full-time with one IT officer responsible for the software part of the project, as well as meeting daily the head of the IT department, who had the overall responsibility for the project in Botswana.

There were four pilot districts, which I visited on short day trips to check up on progress with the community nurses working on the DHIS, collect data entered into the software, and discuss improvements with the nurses and the Public Health Specialists, who were the users of the data at the district level. These visits often took the form of conversations, talking about technical problems, data entry forms, lack of reporting from the facilities, etc. Districts close to the capital, South East and Kgatleng, were visited four times each, on day trips. I would then sit with the nurse or assistant who was in charge of data collection, typically starting to look at data reporting completeness. Due to the offline nature of the system, data had to be exported monthly from the districts and carried physically or sent by email to the national office. Since email was not readily available for the assistants, I would take the opportunity to get an export of the latest data and offer to carry it with me to the national office. This action would also trigger discussions on missing data, i.e.

facilities which had not handed in their paper forms, or data received but which had not been entered into the system yet. This in turn led to discussions about the challenges related to data collection, mistakes in the reporting forms, and interpretations on the underlying reasons. These meetings would take around an hour, as the nurse or assistant would also have other issues to attend to. I would always go with a colleague from the national level, who, being trained in computer science, would then do maintenance work on the computer, including running virus checks, updating anti-virus software, and updating to the latest version of the DHIS software.

Gaborone City Council, being in the same city as the MoH, was visited more often, sometimes for just 10 minutes at the end of the day. Okavango district in the far north-west of the country was visited only once. Naturally, most inputs from the district level came from Gaborone, with some additional field work done in the nearby districts.

Starting in February 2007, I was approached by UNAIDS, who together with the National AIDS Coordination Agency (NACA), was looking for a software primarily for data entry. They were using a UNAIDS-developed software for HIV/AIDS monitoring in all districts (called CRIS), but were not satisfied by the data entry process, which was seen as very cumbersome. They had been introduced to DHIS and wanted it to be part of a bundle of software that included:

- DHIS for data entry
- Country Response Information System (CRIS) for data processing and analysis
- A "switchboard" to facilitate easy communication between the two modules, and produce predefined reports

My work with UNAIDS thus took on more of a technical nature, adapting the DHIS to the needs of the HIV/AIDS monitoring unit and discussing possibilities and limitations with the local developer of the switchboard. This was a first attempt at developing interoperability that would become more central in later work carried out in West Africa.

Lastly, I was engaged at the University of Botswana for designing and holding a week-long course on health information use. The course was held twice in October 2007, in collaboration with the Ministry of Local Government. Some of the students would later work in health district offices.

My research in Botswana thus stems from a wide range of sources. Most importantly, I was involved in the day to day work of translating the DHIS to various contexts, through active participation in all activities, from database modifications to ministerial meetings. No formal interviews were conducted, but during a day I would typically be involved in several informal discussions with stakeholders at the national level, and I participated in a handful of official meetings with high-level attendance of ministry officers.

My document analysis involved meeting minutes, health reports, data reporting tools (mostly paper-based), posters, the statistical yearbook, project documentation, and my own notes from meetings and field work. The analysis of existing documents provided an overview of the formal institutions of data collection and information flows, while my own field work could add to this with personal accounts and observation of practices and informal institutions that both challenged and confirmed the official documents.

Such document analysis was applied also in other countries, and an example of such is the "emergency form" in Tajikistan, pictured below. In this form, 8 essential diseases were listed (and spaces left for others), and were reported by the different rural health centres (shown as columns). This form was used for local purposes in addition to the standardized recording and reporting forms (prepared for national reporting).
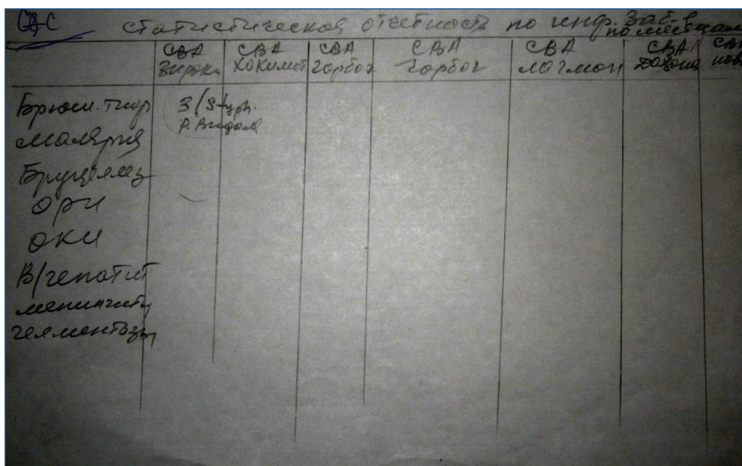
Figure 4 Emergency form in Tajikistan. This was used in parallel to the official data collection forms, as the latter did not cater the management needs of the local hospital

During the time in Botswana, I was increasingly removed from the district level to work on national level subprojects. Part of this was the increased importance given to the national

level, like the interoperability between DHIS and CRIS, and another reason was the difficulty of arranging transport to the districts. Only Gaborone district was easily reachable, to go to the other districts I would have to apply for transportation a few days in advance. When the project shifted its priorities, this became harder to obtain, constraining my participation.

Most of the practical field work was done on site in Botswana. However, while working with UNAIDS in developing eBRHIMS, the name given to the interoperable suite of DHIS and CRIS, a lot of preparatory work was done in Oslo, such as defining the data structure in DHIS. I would then be sent, by UNAIDS, the soft copies of the paper forms, which I used to build up the database. This was done mostly during two-three weeks in July 2007. Apart from that, I was in regular contact with the Botswana project team for strategic planning. My theoretical studies were mostly conducted in Oslo, as have been the evaluation phases of the action research cycle, between the field trips. Two research papers were developed from my Botswana engagement, one of which is included in this thesis and describing work to integrate various fragmented sub-systems of reporting into one system, and another describing the development of the eBHRIMS suite.

My involvement in Botswana ceased at the end of 2007, due to the end of the project and no national commitment to continue the efforts initiated.

2.4.4.2 Sierra Leone

Sierra Leone presented itself as a good opportunity to continue the research from Botswana when the HMN approached the University of Oslo in 2007. They sought a contract for technical collaboration in their project to implement the strategic plan for HIS, which called for an integrated data warehouse at use at the national and district levels. As a project funded for the next several years, with a clear mandate to pilot and scale nationwide, it presented a good case for studying scaling. The table below summarized my direct involvement in Sierra Leone, though I have also been working from both Oslo and Geneva in following up the project.

Time	Primarily working for	Description of involvement
May-June 2008

7 weeks | Ministry of Health and Sanitation, Health Metrics Network | Training: 3 weeks for 2 batches of district and national teams. District visits to Bo, Moyamba, and |

		Kono districts
Fall 2008 1 week	Health Metrics Network	Data quality assessment in Bo district. Observation of vaccination procedures in one clinic, quantitative study of data in another.
July 2009 1 week	Health Metrics Network	Write up of HMN material. "News story" of success in Western Area district. General support for Ministry.
September – October 2009 10 days	Health Metrics Network	Make plan for roll-out of new forms. District visits to Western Area and Moyamba districts
February 2010 1 week	Health Metrics Network, various international organizations	Health partners workshop. Training for NGOs and international organizations in how to get their data from the MoHS system. Implementation of revised forms in DHIS2.
February 2010 1 week	Health Metrics Network	Set-up of OpenMRS for ART tracking, one day at largest national hospital. Discussion on integration of this data into DHIS2

Table 3 Summary of field work in Sierra Leone

I first became involved in Sierra Leone in 2008, as the University of Oslo was contracted by the HMN to support the development of a national health data warehouse, using DHIS version 2 (DHIS2). As part of this, I was to create and hold a course for district monitoring and evaluation (M&E) officers and district managers to efficiently utilize DHIS2 for district planning and evaluation. The course was loosely based on the HMIS course taught at the University of Oslo, which I had myself taken during my earlier studies, and later taught as part of my PhD. obligations. The course ran for 3 weeks, and was held twice over May-June, followed by one week of follow-up activities in a couple of the first pilot districts. This training was held for M&E officers from all 13 districts (2 from each), as well as the 6-7 M&E officers from the Department of Planning and Information (DPI) at the Ministry of Health and Sanitation (MOHS) centrally. The first week covered basic

computer skills, to get everyone to the same level. Some had never used computers before. The second week was dedicated to training on DHIS2, while the last week focused on health information principles, applied to DHIS2. This meant that we discussed information needs, current practices, challenges and opportunities of the new system and newly harmonized data collection forms, and other issues related to strengthening local data management and use. This training thus provided me with open discussions from 26 district staff as well as those from the national level, over a period of 3 weeks. The last week in the training program was extremely useful in understanding the situation at district level, and the tensions between the existing system, the local and the central levels. Since I by then had already worked two full weeks with the participants, I felt the tone of interaction was informal and there would on several occasions emerge impromptu discussions on potentially sensitive topics such as religious practices, perverse incentives, and poor management that adversely influenced data quality. A last week was spent visiting three of the districts (relatively close Bo and Bombali districts, and far-off Kono district, at the opposite end of the country) giving extra on-site training to the same M&E officers and making sure the hardware and DHIS2 was functioning correctly.

Subsequent work was undertaken in collaboration with the national HIS team, which included the IT officer and the district supervisor at the DPI. For more high-level work, such as discussing plans and presentations to other departments, I also worked with the head M&E Officer there, who supervised the two mentioned above. I would work full time with them while in Sierra Leone. Due to communication challenges, especially during the rainy season, the time spent visiting districts was limited, and in most cases only districts neighbouring the capital would be accessible for a day or even an overnight trip.

More fieldwork was done later the same year, now with a research agenda from the HMN to look at data quality. During this trip, quantitative analysis of data was carried out, as well as observation of routines for data collection and recording and understanding underlying reasons of for errors in data. This trip was partly to the district of Bo, both visiting a weekly child health clinic (related to market day in a town), and the district head quarters. The rest of the time was spent at DPI offices in the capital.

The rest of the work in Sierra Leone was carried out after I assumed a position at the HMN myself, from March 2009, and is not formally part of the PhD work. However, this work was crucial for me to understand processes of scaling in the country and subsequently

regionally. Naturally, this represents a major change in my role, from student doing specific tasks such as training or improving data recording routines to serving as an international civil servant responsible for a project of several hundred thousand dollars , employing three people locally in Sierra Leone. As such, this influenced my research also; who I met, and how they relate to me. For instance, I also gained greater exposure to global dynamics, funding politics and the roles of other international actors, all of which had an influence in shaping my understanding of the in-country dynamics around the HII in Sierra Leone.

My involvement was also influenced by other external factors. Most importantly, the financial situation for WHO, HMN, and other international agencies, deteriorated as governments cut down on funding. The result was less money, more competition for the money that was still available, and increasing donor expectations to measure how their money was contributing to "saving lives", not just strengthening HIS. During the two years at HMN, I was mostly active with Sierra Leone during the first year, as funding for this activity was not renewed.

During my stay at HMN, I was in Sierra Leone several times, which also contributed to my understanding and thus are relevant for my research, and this thesis. This work included:

- National and district level support
- Writing up experiences and best practices for HMN material and press release
- Customize DHIS2 for new revised data collection forms in 2010
- Coordinate set-up and pilot of OpenMRS as ART system in main hospital
- Offer training for Health Development Partners, a network of international organizations based in the country, to access and use information from DHIS2

The data collection in Sierra Leone came, as in Botswana, from various sources, reflecting the many natures of my involvement at different levels. Training has been an important source, including both formal training sessions and more informal training on-site in districts and at the national level. Customization work and work related to reaching consensus on new data collection forms and information products has allowed me insights into the flows of information and various actors' information needs. And work with more peripheral partners such as the International Rescue Commission, The World Bank, Japan International Cooperation Agency etc, has been important to get an understanding of the international level and how they influence and relate to the national health system.

Back at the University of Oslo, I continued the online support for Sierra Leone, and engaged again with the core national team of 3 people during the ten day "DHIS2 Academy" held in Ghana in late 2011. These meetings, although outside the country, helped to provide continuity to the research.

2.4.4.3 Health Metrics Network

In March 2009, I started a 2 year period of leave from the formal PhD program, to work as a Junior Professional Officer at the HMN in Geneva, Switzerland, which provided continuity to my earlier work in Sierra Leone. I have thus included it as part of research and fieldwork leading to this thesis.

During the two years in Geneva, in addition to continued support to Sierra Leone, I also engaged in a wider initiative to develop interoperable HIS architectures, primarily partnering with the West African Health Organization (WAHO), in which Sierra Leone was also a partner country.

Three trips were made to Sierra Leone in conjunction with work related to the West African Health Organization (WAHO), through which the focus moved from national scaling to regional scaling. Though similar, scaling across national boundaries presented new insights to my research.

Furthermore, work at HMN gave a chance to work at the global level. This level is important at least in the following aspects; as end-users of information from countries, as funders of, and thus priority-setters of, national HII, as developers of standards and policies, and in having their own HIS, often replicated or "forced upon" partner countries or local instances of the global organizations. Understanding this level is crucial to understand the HII in any country, and even more so in countries more dependent on international funding and expertise. Working at this level allowed me to learn about the above issues, and also to look at the mechanisms by which the local and global interact. One example is the SDMX-HD standard, developed to share aggregate data between health information applications. The standard and its development is described in more depth in one of the papers included in this thesis (Sæbø, Braa et al. 2011). Related to my research methods, my position at HMN in Geneva allowed me to be involved at all levels of its development and implementation. At the more technical level, I continued to liaise with programmers and take part in the technical discussions around SDMX-HD and providing a test-case for it in Sierra Leone. I would also promote its adoption by other software

developers globally and locally. Finally, at a more implementation-oriented level, I discussed its implications with partners at national, regional, and international levels.

2.4.4.4 Other engagements

Being part of the global HISP network, I have naturally been involved for shorter time periods also in other countries and contextual settings. This is integral to the networks action research strategy.

Tajikistan: 1 visit in January-February 2008, to set up a pilot of DHIS2 and give recommendations on appropriate HIS development strategies for the country, as part of an Asian Development Bank led project. The trip involved quantitative and qualitative analysis of the HIS at national, sub national, and facility level, and training of district staff in entering and processing data in DHIS2. This work is the basis for one of the articles making up this thesis.

WAHO: The West African Health Organization is part of the Economic Community of West African States, an independent international organization made up of 15 member states. While originally engaged with the organization as part of my work in Sierra Leone, I have later been involved as a resource person for development of HIS policies and standards for the region.

DHIS2 Academy: The DHIS2 Academy is a semi-formalized regular occurrence to offer expert training within the larger HISP umbrella. It consists of around 10 days of training and discussion, and brings in people from many countries. As such, they were excellent for providing research insights, which developed during the discussions around HII challenges and strategies. I have participated in three such sessions; two for West Africa (roughly corresponding to the member states of WAHO), and one for South Asia (Indian subcontinent as well as Tajikistan, Philippines, Indonesia as participants), leading discussions on data quality, information use, implementation strategies, and the like.

Armenia: Short-term consultancy to assess national HIS and propose a strategy for HIS strengthening on behalf of The Global Fund and the Armenian Ministry of Health. This involvement, while fitting very well with critique of AR as being not different from consultancy, nevertheless complemented previous research, for example by adding to the lessons from another post-soviet country, Tajikistan.

Latin America: Several nascent implementations of DHIS2 have been initiated after collaboration with the Enlace Hispanoamericano de Salud (EHAS) and their main partner Rey Juan Carlos University in Madrid. My involvement has been three seminars with participants from Madrid and Latin America, as well as initial configuration of DHIS2 through teleconferences with partners in Colombia and Nicaragua.

In addition, being active in the HISP community through email-lists such as those for users, implementers, and developers of the DHIS2 software has provided an invaluable source of day-to-day interaction and learning from HIS practitioners around the world.

2.5 Data Analysis

Data analysis has involved several levels of iterative cycles, all contributing to different kinds of insights and at varying points of time. First, daily analysis was done when conducting field work. With days filled with practical work, hectic schedules, and many meetings, discussions with colleagues on-site or through e-mails have been conducted on a daily basis to solve issues that have arisen. This can be analysis related to practical problems, like how information processing is working or not and how it can be improved, to more theoretical concept-building to explain processes related to my research questions.

Then, analysis of data from a given interval, usually after a field visit, when back "in the office". A typical way analysis was conducted is that colleagues, which were part of the field visit or not, have met and discussed the recent activities to both adjust future plans for action, and to specify learning. Some notes on the use of theory are useful here. Walsham (1995) uses the metaphor of scaffolding, describing theory as a support mechanism, which is then removed when your building is completed. Some times theory has been used in this way, for example in the paper on networks of networks (Sæbø, Braa et al. 2011), where the notion of networks of action (Braa, Monteiro et al. 2004) was used for analysis. Other times, the analysis was more reminiscent of grounded theory (Glaser and Strauss 1967), where the phenomena not analyzed earlier were explored. One example is the paper on institutional logics from Tajikistan (Sahay, Sæbø et al. 2010), where we, on returning from field work, discussed the challenges encountered. In lack of a better term, we arrived at differences in mindsets on several topics of the actors involved in Tajikistan as the main challenge. We developed our analysis around this concept, which was our interpretation of the occurred events. Van Maanen calls this the construction of second-order concepts from first-order data (Van Maanen 1979). Only from this concept, did we explore existing

literature and turned to the literature of institutional logics, then adopting not a grounded theory approach.

The third level of cyclic analysis has a much longer time span. Given the involvement in several countries, over several years, a cycle of *refinement* of and *comparative* analysis has been going on in parallel to the shorter, more active cycles. This has led to some comparative studies, like on integration (Sæbø, Kossi et al. 2011), and a gradual elaboration of concepts, based on more than just the latest case study. In effect, an interplay of field experiences and theories have been in place throughout the work with this thesis. Topics first explored in the early phases have been written in papers, compared with then existing literature, and submitted for peer review in conferences and journals. Thus sharpened, focused, or given new alternative paths and interpretations, these topics have then been revisited in the field, and again in later papers. This interplay has also taken place in a changing environment, as described in the introductory chapter.

Data analysis has generally followed two objectives, which are not unrelated; practical problem solving, and building theoretical understanding. Different methods would be applied, and this, I believe, is one of the strengths of action research. In pursuing practical problem solving, I engage in data analysis that also contributes to the theoretical understanding, and vice versa.

Both macro and micro level perspectives have been used. For instance, working both in health clinics trying to understand how information routines are applied there, and at the international level pursuing understanding of global health agencies' agendas, it has been important to adjust the level of "blackboxing" entities accordingly. This construction of actors follows the advice by Monteiro: "It entails that the 'actor' of an analysis is of the 'size' that the researcher chooses as most convenient relative to the direction of the analysis" (Monteiro 2000 p. 82).

An added benefit of working within the HISP network is the range of background co-researchers have. Analysis has also been facilitated by sharing early work with colleagues and other PhD students, many of which are medical professionals and come from similar settings as where I've based my research. This has helped the process of extracting a more general theory and concepts from particular cases. Collaborative papers covering many contexts have also resulted from such analysis (Damtew, Miscione et al. 2010).

The following table shows how at least three data analysis cycles have been applied within the AR framework.

Level of analysis/Data analysis cycle	Purpose	Methodology
First order data Collected through day-to-day in field engagement	Mainly practical: Advance HIS strengthening, capacity building, clarify challenges	Document study, reflection on interviews and discussions. Technical work related to database development and modification
Second order concepts Developed in-between field work, Time span: weeks and months.	Practical: evaluate and plan further interventions Theoretical: Conceptualize findings. Writing papers	Field notes analysis. Conceptualize events and processes through coding.
Third order constructs Developed during longer cycles between work in different countries. Time span: months and years	Mainly theoretical. Comparative studies. Abstraction of earlier conclusions to a wider framework of scaling. Writing papers and dissertation	Review previous work, Compare longitudinal efforts in several countries. Bring in the global level, and interplay with field work.

Table 4 Applied data analysis cycles

Coding of field notes has taken place on an ad-hoc basis, particularly related to writing of articles for conferences or journals. From the many notebooks I have kept through the field work, I have later used post-it stickers to single out references to change (of scale or scope). This has helped to identify the various dimensions in which scaling has taken place. For the individual papers, and also from the various presentations both at the university and with partner organizations and non-academic conferences, I have written rich case descriptions. These case descriptions have then documented much of the action, and in some cases also include an analysis of events.

The flurry of existing health information products have lent themselves to a hermeneutic analysis. Typically a large part of the practical work has been occupied with the study of data reporting formats, reports, health bulletins, and various other official documents. While at the same time, these documents would often need to be translated from a paper sheet to a data model and eventually a user interface, carrying with them the underlying ideas, logics, practices, and policies of the health sector context in the respective countries.

Analysis of such documents, then, has not only been important to "get the job done", but to understand the wider health information system, the role of the data collected, and the power structures around the information. As such, *interpretation* of these documents have been an important part of the data analysis. As an example, one can grade to which extent the existing HII is geared towards centralism or decentralism by looking at the kind of data collected, at what interval, and to what level of detail. Such coding of data reporting tools, and to follow changes or the lack of when they are evaluated (which for instance has happened twice in Sierra Leone since 2008), has been an important part of the analysis due to the large amount of such documents analyzed for practical purposes.

 I have also applied various forms of quantitative data analysis. For data quality assessments, comparing data values in each step of the collection process allowed me to identify where it changed, i.e. an error was introduced, and thus make quantitative analysis of rates of errors. The figure below shows such an analysis, where I tracked figures through three steps of data aggregation; daily tally sheets, monthly summary forms, and finally, as entered into DHIS at the district level. When looking at how to reduce the amount of health data to be collected through revised data collection tools, I would do counts of items in the various forms, and compare the content, to determine the amount of duplication among existing forms and estimate potential reduction. In this way, much day to day work in the field featured statistical analysis, relating both to health data for the purpose of identifying trends (which I myself alone do not have the relevant knowledge to interpret) and at a meta-level like when looking at data quality.

	ANC 1			Bednets given			ANC 2			ANC 3		
	Tally Sheet	Sum. Form	DHIS	Tally Sheet	Sum. Form	DHIS	Tally Sheet	Sum. Form	DHIS	Tally Sheet	Sum. Form	DHIS
Jan	26→20	20	20	26→20	20	20	10→8	8	8	7	7	7
Feb	40	40	40	40	40	40	12	12	12	10	10→12	
Mar	12	12	12	0	0	0	15	15→20		4	4→10	
Apr	24	24	24	0	0→8		8	8→13		13	13→2	
May	31→30	30		0	0	0	11→10	10		6	6	6
June	15	15	15	0	0	0	6	6	6	5	5	5
July	12→13	13		0	0	0	6→9	9		2→4	4	
Aug	8	8	8	0	0	0	13	13	13	12	12	12

Figure 5 Table used to analyze data quality. Figures for four data elements (ANC1, Bednets, ANC 2, ANC 3) was collected from the tally sheets at a facility, the summary form they were reported on from facility to the district office, and in DHIS2 at the district. The arrows represent a change of value, amounting to 43 % of the 4 elements over 8 months.

2.5.1 From data to concepts and constructs

In this section, I present the process of analyzing data into the concepts and constructs this thesis builds upon. Examples of empirical data, which concepts I have extracted from them, and in turn built into constructs, are shown in the table below.

Construct	Concept	Example of empirical data
Interaction effects: The four dimensions, of diminishing materiality, exert force upon each other	Infrastructural influence; The infrastructure influence the system	Offline implementation in Sierra Leone and Botswana due to lack of connection Low voltage computers employed to function off car batteries in Sierra Leone Unqualified local support would re-install windows and overwrite DHIS software in Botswana
	Software influence; The software influence the system	Integration of duplicate reporting structures in DHIS led to agreement among actors to harmonize reporting forms Interoperability between DHIS and other applications increased legitimacy, interest, and resources for system Functionality on data completeness led to increased focus on this issue Multidimensionality in DHIS allowed continuation of massive tabular forms in Tajikistan

		Online implementation change the way people report data
	Practices influence; New and existing practices influence the system	Perverse incentives lead to low reporting on logistics data
		League tables increased data completeness
		IT department in charge of DHIS led to less involvement in the project from the health professionals
		District supervision in Sierra Leone offered an opportunity for offline electronic data collection
	Idea influence; Ideas influence the system	Integrated data warehousing and integrated architectures shift focus (towards interoperability) and legitimacy
		Annual reporting of large datasets for central statistics in Tajikistan, and dimensionality in DHIS2
		Difference of the meaning of "0" and "blank" in reporting??
		Logic on access to data drives restriction functionalities in DHIS
		Logic of data ownership determines outsourcing of server or not
		Open source software, software as a public good
Constellation effects: The sum of interaction effects in one context exerts a force upon other contexts	Best practices;	Mobile modems used for online implementation in Kenya led to same approach in Ghana
		League tables at national level in Sierra Leone influenced practices at district level
		Success of integrated data warehouse in Sierra Leone led to similar efforts across West Africa
		Implementers (including myself) draws upon a pool of experiences from other context, consciously and unconsciously influencing new contexts
	Shared, inscribed, material	DHIS "tracker" functionality developed for Indian needs adopted for anonymous patient registry in Ghana
		Multidimensionality of data entry forms developed to suit Tajikistan needs applied in Sierra Leone
		Training material originally developed in and for South Africa used in other countries

Table 5 Constructs and concepts derived from empirical data

The concepts of influences arising from infrastructure, software, practices and ideas show how the four dimensions relating to the scaling of an HII influence each other. These four dimensions serve as a useful analytical lens, representing four different levels of materiality. Infrastructure is most material, representing the hardware, cables and wireless towers, buildings and other supporting structures. Software, while abstracted to electronic format, needs some hardware to function, and cannot completely be detached from it, even though it can literally travel instantaneously over the computer networks. Practices are even less tangible, but are manifested through material objects, such as reports, hardware, organization of the working space. Ideas are the least material, or rather, most immaterial, existing as thoughts. However, even ideas are linked to material objects, such as policy documents, presentations, and information products.

These four dimensions pull on each other, each one contributing to determining the nature of the HII, constituting what is termed as "Interaction effects" (Sahay, Sæbø et al. accepted with revisions). The four dimensions interact through the possibilities and restraints they pose for the other dimensions. Interaction effects describe how any configuration of the four dimensions influence the overall system in a particular setting. However, the empirical material shows many cases where the system is also influenced by systems in other contexts, both nationally and internationally. These contribute to two concepts through which this inter-contextual influences (called constellation effects) takes place; best practices and shared (inscribed) material. The former denotes the many examples of imitation of success stories, which circulates through various means. The latter is more material, where software, training material, and reports would be adapted in a new context. Given the inscriptions, both restrictive and promotive, embodied in the shared material, they exerted influence on how the HII would develop in this new setting. Together, these two concepts show how interaction effects in one context circulate to other contexts (constellation effects). In other words, the constellation of infrastructure, software, practices, and ideas in one context influence the HII in another context through inscribed material, innovation, translation, and the circulation of experiences and individuals between the contexts.

2.5.2 Time and space of analysis: My changing roles and focus

This research has taken place within the HISP tradition of AR, which is oriented towards networks of action. It is thus natural that my research has been carried out in a number of settings, with deeper involvement in a few countries. This has had many implications for

my research. Some implications are related to the diversity of perspectives I've been exposed to, some related to the longitudinal nature of my research, but most to a mix of these two dimensions. The first is the various roles I have assumed.

The same way as my research has matured theoretical ideas and directions, so too has the role of me as a researcher gone through changes over the years. My role has changed several times, and it is also fair to assume that the way it has been perceived has influenced my research, how it has been carried out, and how others have related to me as a researcher. First, I was introduced to the work in HISP before starting my PhD, through my Master's degree focusing on DHIS implementation in Cuba in 2002-4, which led to an internship in Botswana in the summer of 2005. Holding a fairly "low rank" supporting role, I found it hard to get much access and attention within the formalities of the Ministry of Health there. This of course being part of being an inexperienced junior researcher. Nevertheless, it continued to direct the way the practical AR could be carried out also in the later stages of the project, when I was doing research for this thesis in Botswana. In Sierra Leone a similar development can be seen. My first role was one of peripheral support, then as lead of a 6 week training program for the whole country, and later as the official representative of HMN helping with budgeting and auditing and conducting job interviews.

This changing role has had implications for several aspects; what kind of people I would meet, how they would relate to me, including what they would tell me, the kind of issues I would encounter, and the perspectives I would see things from. For example, In Armenia, I was invited as a consultant while still at HMN to provide guidance on HIS development in a very fragmented setting. In addition to meeting and hearing the perspectives of various health programs and district managers, this consultancy included several high-level meetings with WHO. I was there on behalf of the Global Fund[3], and found myself in situations I would not encounter in my role as junior researcher in, say, Botswana. Relating to the changing role in Sierra Leone, the initial period of close participation with district staff through training and implementation had established a quite informal and inclusive relationship. We could discuss sensitive issues such as data quality, mistrust in data, mechanisms creating perverse incentives, etc. This relationship was , luckily, maintained even if my role changed and less time was spent on-site in districts.

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[3] The Global Fund to fight AIDS, Tuberculosis, Malaria

Linked to the discussion on my many roles is the situation of these roles. In the in-country work, primarily in Botswana and Sierra Leone, I have been able to work extensive periods at all levels of the health hierarchy; from spending days with training and meetings at clinics, to district level offices, and national headquarters. Furthermore, through the work at HMN and with WAHO, I gained insights from the international arena, both the mostly Geneva-based international health community, as well as the more regional work at WAHO. Working with these issues across different levels has given me the opportunity to analyze them from various viewpoints. One example is the development of the data exchange standard SDMX-HD, which I've been able to follow along the entire "value chain". From meetings in Geneva on what this should be, through discussions with developers far and wide, to implementation of it's first pilot in Sierra Leone, and acknowledgment by WAHO.

Another benefit for my research has been the involvement in several countries. Working with the same issues in Botswana and Sierra Leone, namely how to sustainably scale small pilot projects, has created a better base for understanding the general mechanisms at play, as well as what is particular for each setting. The shorter involvements in other countries, and discussions with colleagues in the research group of their particular experiences, has added to this understanding.

In addition to the diversity of cases and roles, this research builds upon a diversity of methods. Within the overall action research framework, for data collection, I have applied semi-structured and unstructured interviews, participatory design, observation, health data and data quality analysis, database development, conducting training, and so on.

It is here important to point out that while research papers on Botswana do not feature prominently in the list of included publications of this thesis, it has more to do with the fact that this earlier research has been incorporated, in a perhaps more nuanced and mature way, in later work.

2.6 Ethical considerations

In this section, I point out a few ethical considerations related to my research, and how I have approached them. The central ethical dilemmas I have identified relate to the following issues:

- Access to sensitive health data

- Confidentiality of interviewees and partners
- The agendas of partners, funders, and good governance in the countries I have been involved
- Developing reciprocity and mutual benefit
- Topic of research and aim of interventionist actions

I have, through the work with this thesis, been actively engaged in strengthening HII. It is thus natural that I have had access to a lot of health information, especially from Botswana and Sierra Leone, information that could be considered sensitive and confidential. However, the data I have dealt with are almost exclusively aggregated, with no way of tracing them to individual patients. The one occasion where I had access to individual data, when testing the OpenMRS software for ART tracking in Sierra Leone, no personal records were taken of this data. For the aggregate data, verbal consent was acquired before referring to it in research papers, for instance a chart showing increasing institutional delivery rate in one district (which was published in Health Metrics Network 2010).

Interviewees and partners have been made anonymous where I have referred to them in my research papers, for instance when quoting. In such cases, I would have to strike a balance between anonymity and keeping the context of the quote intact. For instance, I would in general reveal only the type of position of the interviewee, as this would be the most important characteristic of the quote. In cases where this could potentially lead to the disclosure of the person, I generalized further, using "senior", "local", and other prefixes to anonymize. In general, I would reveal information to the degree that no quote can be tracked back to the individual.

It is no secret that international organizations, and in particular government aid agencies, have different kinds of agendas, involving both political and altruistic elements. Funding has in my case come primarily from University of Oslo sources, NORAD, EU, and The Gates Foundation through HMN. While being aware of this, I have no reason to believe the source of funding has compromised how I have carried out work and research. Of the two countries I primarily have worked in, both have had their projects mainly funded by the EU and the HMN.

As to good governance of the countries I have worked in, I must take into consideration the possibility of corruption and mismanagement of funding, hardware, and the data obtained through my work. Botswana ranked 32 of 182 countries in Transparency International's

Corruption Perception Index for 2011, while Sierra Leone is ranked 134[4]. The aura of corruption surrounding workshops is well known (Norad Evaluation Department 2012), and is the area where I have been approached for "favours" related to organizing workshops, such as not telling a participant's organization that we have already sponsored travel and accommodation. Needless to say, such offers have been declined, but it is important to be aware of the prevalence of such activity. Furthermore, I have been reliant on local assistance in collecting quotes from venues and hotels for workshops and conferences, work that would be very hard to do from abroad in a context where very few of the reasonable options catering the local market are online. In such cases, I would not be in a position to know of any "kick-backs" to local staff, instead relying on the quotes I would get compared with quotes I would be able to obtain myself. In summary, I have been aware of potential for corruption relating to my field work, especially in relation to organizing training through workshops. My range of tools has been limited, but I have always strived for openness in the planning, including clear communication to third party funders who should benefit from (and thus come to) the workshops, what is covered and not by fees, and the like. Where subsistence allowance has been included, this has been organized by daily recording of participation as well as signature collection when disbursement is made. In a few cases, I have been asked to provide scans of participation records to third party funders.

For both of the issues raised above, of the role of the funding agencies and me holding a position where I handle money, it has been important that I have been conscious about my role, and being explicit in stating this role. For instance, when shifting from a role in Sierra Leone of trainer and implementer from the University of Oslo to an official representative of HMN and WHO, I had to be aware of the position I held, and clearly communicate with partners in-country about my various intentions, expectations, responsibilities, and loyalties.

The fourth ethical dilemma is that of reciprocity and mutual benefit. One aspect of that is working towards a common goal with partners in the countries through participative methods. In my projects, I would have to find a balance of good relationship (which has luckily been a trivial task) with the country partners, and the integrity to say and act as I think best in the given situation. That of course leaves a lot of responsibility for me to

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[4] http://cpi.transparency.org/cpi2011/results/

interpret what would be most beneficial to *strengthen health information systems*. In an action research projects, working on an equal level with the health staff engaged in improving health information, I think it is a moral obligations to put that goal before research. My disagreements with partners have thus at least been in what would be best to do from my view of HII, rather than on priorities related to my needs for research. Overall, I can only describe my relationships with partners in Sierra Leone and Botswana as that of friends, which I feel adequately describes the common experiences we have had through the years, in all sorts of demanding situations.

Another aspect relates to the production of knowledge and of writing scientific papers. Data collection was collective, but writing was in most cases individual. Two of the papers included in this thesis has co-authors from the partner countries (one from Botswana, one from Sierra Leone, and one from Kenya), and this also applies to other papers that are not included. However, the remaining papers still build on research data collected through the collaboration in the projects, where local staff obviously had a facilitating role in the collection of this data. On reflection, this is an area where I could have been more explicit in stating the role of local staff.

Lastly, and perhaps the elephant in the room, is the issue of trying to achieve change. This can be related to change through my research, but arguably in my case more related to the engagements through action research. I want to improve HII, and concealed in that phrase is also promotion of transparency and accountability. Is this ethically defendable? I do think so, but it raises a couple of other issues. One is to what degree I can promote this to people who might not want it, and even impose it. In Sierra Leone, to provide districts with some comparative data they could use to assess themselves with, we made district league tables. In these, we ranked districts according to their performance in key health and HII indicators, and distributed this widely. One concern was that this might not be popular among the poorly performing districts. However, the accountability this introduced was well received, and I can not say that this later influenced the way we thought and acted in relation to transparency of health data.

Then, is the way I try to achieve this the right way? Are my actions and methods sensitive to those I work with and for, and are they appropriate to reach the goal of better information systems? For this, I can only say that the plans for action were discussed with the problem owners, i.e. the colleagues at the ministries of health in Botswana and Sierra

Leone. And that there has been progress made, also in terms of better health service provision. Luckily, my research and action has not taken place in a void, but constantly been surrounded by a large environment of like- and not so like-minded. I have strived to be open about why I suggest the action I do, and there has been a general agreement both among fellow researchers and colleagues, local actors such as ministry of health employees, and third party actors like donors. No-one can really tell the best way to achieve improved HII, or if there is such a way, but it has been important in the work throughout my research to get second opinions and reach consent and agreement of the involved actors.

3 Research context: HIS, Development, and the Health Information Systems Programme (HISP)

In this chapter, I present the context of my research, namely HIS development in "developing countries" (see note on this term below). I also present a chronological review of events in Sierra Leone, the country in which I have been most engaged empirically. With this contextual description, I provide an overview of the empirical events that will help answering the research questions.

Three overall aspects of the research context have had great influence on this thesis. First, the research has concerned HIS as the applied field. Second, it is based upon field work in multiple countries, and finally, it has taken place within the framework of the Health Information Systems Programme (HISP), a research and development network centering around agendas of open source, information for action, and local empowerment. I will now turn to these three aspects, before providing a summary of events in Sierra Leone.

3.1 Health Information Systems

An important concept that needs to be included in this thesis is that of *health for all*, which when adopted as a WHO goal in 1978 (WHO 1978) puts the emphasis on providing equitable health services at the community level. Universal Primary Health Care (PHC) was seen as the strategy to achieve this goal, and this again has implications for the historical development of HIS. While hospitals and specialized services have certain information requirements, so too has the general management of PHC, where services essential, for example for the MDGs, are given. There is a strong imperative for correlating information from different sources, but due to a number of institutional-technical reasons this is often not easily achieved, as these systems have evolved as multiple and separate sub-systems. One example is that of vaccinating children, which may necessitate access to population data (how many children need the vaccine?), service data (how many did we immunize?), logistics data (how much vaccine do we have?), human resource data (do we have enough staff with the right skills to provide vaccination services?), financial data

(what does it cost?), other service data (what are our priorities?), etc. Answering these questions together is often not possible as the data is stored in independent systems.

The fragmentation of health data in various, incompatible, sub-systems has several reasons, which may or may not be relevant in each specific context. First of all, health is an intrinsically diverse domain due to its high level of specialization (Weisz 2003), making it an extremely complex domain for developing supporting information systems (Norris 2002). The information needs for eye surgeons are very different from that of a psychiatrist, or a general practitioner, and so on. This naturally leads to a range of specialized information systems where the needs for integration and coordination may not be important at the micro-level. However, at the macro-level of district, province and national planning, statistics from these various systems are useful to be integrated for priority setting and resource allocations. Another reason for fragmentation, is the tendency to set up new, independent information systems for each health program, even where they may have similar information needs and the data is handled the same way. The health programs are often quite autonomous and uncoordinated when it comes to information systems, and this challenge is often augmented by the role of international donors. The reasons for this is often that the donors require data to be submitted in certain formats, and because the donors do not have trust in the existing systems to provide what they deem necessary for evaluation.

This last point, in many cases, leads to a vicious cycle; donor- or program-driven information systems will create a new specific system due to lack of a quality local information system. In turn, such fragmentation will undermine exactly such a system, since resources are spread thinly over the increasing number of sub-systems. This in turn leads to creation of yet more systems, out of both ignorance and necessity, and the vicious cycle gets reinforced. Of importance is also that such sub-systems typically use different technologies and platforms, unable to share data in an efficient manner if and when this is desired.

Since important management data is quite often not available together, one of the main global priorities over the last decade has been *integration*, and related, *interoperability*. The first denotes the act of forming, coordinating, or blending into a functioning and unified whole[5], while the latter denotes the "ability of a system [ ]to work with or use the

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[5] http://www.merriam-webster.com/dictionary/integration

parts or equipment of another system"[6]. Interoperability is then one strategy to achieve integration. These have important implications on the scaling of systems, as I will later argue.

For instance, the HMN Framework (Health Metrics Network 2008) calls for integrated data warehouses to serve all users of health information within a health systems framework. Since data is often collected through and stored on a range of technologies, interoperability between these is a key strategy for achieving virtual integration. This is increasingly being followed by donors and countries alike, with a recent example being Uganda calling a "stop work order" to ensure that the plethora of initiatives fulfil requirements of interoperability with the national data warehouse [7].

True to their slogan of "Better information, better decisions, better health", HMN also pointed to an oft-forgotten aspect; it is better health that is the end result of an HIS, not the HIS itself. This shifts focus to the role of the HIS in the wider health system; to better and more efficiently manage health service delivery at all levels. In countries that this thesis covers, a well functioning HIS is not a second priority luxury, but a cornerstone of health systems and with it human development: "it's not because countries are poor that they cannot afford good health information; it is because they are poor that they cannot afford to be without it"(Health Metrics Network 2006).

3.2 Trends of global development and HIS

The changes around HIS, especially relating to "developing countries", corresponds not surprisingly to changes in the international development scene. Over the last decade, various best-selling critical literature with titles such as Dead Aid (Moyo 2009), and White Man's Burden (Easterly 2006), with sub-titles "Why Aid Is Not Working and How There Is a Better Way for Africa" and "Why the West's Efforts to Aid the Rest Have Done So Much Ill and So Little Good", respectively, have reached and resonated with a wide audience. The main arguments carried in these books, written by ex-employees of international development agencies, is that development policies of the "West" have failed, and in many cases made matters worse. Aid, they argue, has been too wide in scope, too disentangled from results , and not put under scrutiny and evaluation, leading to poor results and encouraging dependency and corruption.

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[6] http://www.merriam-webster.com/dictionary/interoperability
[7] http://www.ictworks.org/news/2012/02/22/ugandan-mhealth-moratorium-good-thing

Why not free of controversy, the above mentioned books represent a larger trend of critique of development models. Two strands of these trends have impacted also health information systems. The first is the acknowledgment by the development community that "from-scratch" initiatives often have negative outcomes, and even is a root cause of the problem they seek to address. In other words, poor information systems have traditionally been sought fixed by introducing a completely new system, like described above as a vicious cycle. Partly in response to this, most countries and international organizations signed the Paris declaration on aid effectiveness (2005), which aims to align donor countries to developing countries' needs and strategies, and harmonize development efforts to reduce duplication. In addition, it constituted a shift towards measurable results. It was followed up by the Accra Agenda for Action (2008), which states that "*Aid is focused on real and measurable impact on development*". This leads to the second shift in the way international development functions; the increased focus on measured effects.

For development agencies and their partner countries, such measurement is dependent on well-functioning information systems. Pay for performance schemes ("P4P"), an increasing trend also in poorer countries (USAID 2009), are dependent on proper information for the incentive system to be effective, including relating to the information itself. The WHO created the *Commission on Information and Accountability for Women's and Children's Health*(COIA) to strengthen "global reporting, oversight and accountability on women's and children's health". In response, COIA has released 10 recommendations to both tracking results related to health, *and* tracking donations and their management (WHO 2011).

These trends combine to fuel a rapid rise in interest in and funding for HIS. The HMN Framework has become a guiding document for strengthening HIS in many countries, building on the existing systems and the needs of the country. At the same time, funders have acknowledged the important role a strong national HIS has for both the country and for monitoring the funders' investments.

3.3 The Health Information Systems Programme

Within this landscape of HIS and development, the Health Information Systems Programme (HISP) has grown from a small pilot in Western Cape province in South Africa in the end of the 90s (Braa and Hedberg 2002), to become an international network of people related to health information strengthening in more than 30 countries in Africa and

Asia. The research presented in this thesis builds on work done within HISP. It now comprises faculty and students from the University of Oslo, universities in Tanzania, Mozambique, Malawi, and Sri Lanka, and health professionals from various countries, as well as independent consultants and both government organizations and NGOs using the free and open source software District Health Information Software (DHIS). The overarching agenda of HISP has since the inception been to apply action research to improve health information use while at the same time generate knowledge around systems development. The original implementation in South Africa is now supported fully by an independent organization, HISP South Africa, while most subsequent implementations have been initiated and supported by researchers and practitioners connected to the University of Oslo, supported by regional groups like HISP India, HISP East Africa, and HISP West Africa.

HISP has since its inception been based on a few guiding principles, that continues to be important today, albeit often to various degrees from country to country. First, it has focused on information for action, which means putting the information needs for health management first, rather than the data or technology itself (Heywood and Rohde undated). This has often meant that HISP is engaged in revising data collection forms and working towards an essential data set (Shaw 2005); a limited set of key indicators to monitor the provision of health services. This has often been contrary to those who want larger amounts of data, needed for statistical analysis and research (Sahay, Sæbø et al. 2010). In relation to scaling, HISP has thus historically aimed for a downscaling in terms of data collected, and scale up the use of indicators that draws upon different data sources. This underlies the basic principle of information for action.

Second, to support this, HISP has employed participatory design methods to develop HIS with the users at all levels. The success of this approach has been mixed, from the successful growth of bottom-up initiatives in South Africa(Braa and Hedberg 2002) to the collapse of formal collaboration in Cuba between HISP and the Ministry of Public Health (Braa, Titlestad et al. 2004). Participative design is however well inscribed in the DHIS2 software, which since 2004 has been made with the view to allow users unskilled in database languages to make changes in their HIS through the user interface. The software, another cornerstone of HISP activities, is developed based on feedback and requests from the implementing countries. As HISP has scaled to work in more than 30 countries, this participation as we understood it may be getting increasingly compromised. On-site visits

by researchers and developers are not possible to the same extent as before, and the intimacy of local interactions are lost. But maybe, in the time of the "cloud", new forms of participation are being ushered in such as recent innovations related to online messaging board within DHIS2, which opens up a new channel for feedback and communication (Braa and Sahay 2012).

The third guiding principle is that of free and open source software development, manifested as DHIS2 . This software handles primarily aggregate statistics, which serves the needs of managerial tasks, thus occupying one end of the spectrum of health information processes as shown in Figure 6 (Norris 2002). While coordinated from the University of Oslo, the development is distributed with also India and Vietnam being important hubs[8]. DHIS2 is not only open source, it is platform independent and seeks to use open source auxiliary programs and open standards for data sharing. This has implications for scaling as the start-up costs in terms of licenses are non-existent. Quick implementations can be organized to evaluate the appropriateness of the software with minimal financial obligations. Several organizations have in fact downloaded and set up DHIS2 independently, completely free of charge, and often unknown to actors within HISP. No user license is required, which also has implications for scaling in countries with often thousands of users. Collaboration with other open source application developers is sought, and has so far resulted in interoperability with a medical record system, OpenMRS, and a human resource management system, iHRIS, through the WHO-supported open SDMX-HD standard. This has allowed the potential implementation of a software architecture, where virtual integration can be achieved with these interoperable applications. This modular approach is important to scale across various information domains (statistics, patient data, financial data, etc) without having to develop support for all these within DHIS2. However, the successful implementation of such an architecture has not materialized at scale in any setting as of yet.

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[8] For more info on DHIS2, see dhis2.org
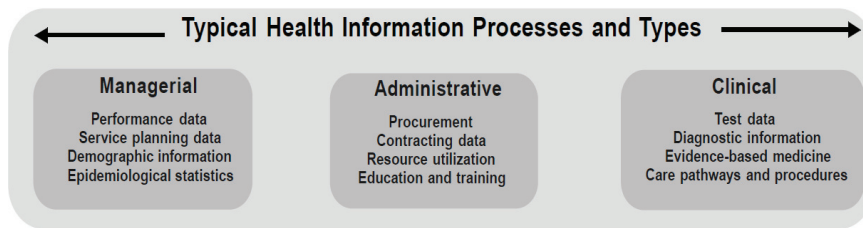
Figure 6 **HISP primarily works with managerial data, but seeks collaboration and interoperability with other systems covering clinical data (figure from Norris 2002)**

The fourth aspect is that of capacity building. This extends from single-day training of health workers to formalized Master and PhD programs. In relation to implementations of HIS strengthening activities in countries, training has been offered both as workshops and on-site in district offices and clinics. Masters programs exist in several countries in the south , and several HIS practitioners have completed a PhD degree at the University of Oslo, becoming experts upon their return to the ministry of health in their own country. A semi-formalized "DHIS2 Academy" has been established as an annual event in three regions; East and West Africa, and South Asia. These academies aim to bring DHIS2 implementers from many countries in a region together to receive training in the use of DHIS2, discuss strategies for implementation, and improve the capacities to reform national HIS towards action-led systems. The DHIS2 Academy has been held since 2011, and is a key strategy to cope with the increased amount of users. An important aim is to develop capacity of the participants to conduct training in their own countries, what we term as training of trainers. This is fundamental to be able to scale up further, as there are now literally thousands of users in many countries. The development of the DHIS Academy continues to be high on the agenda for HISP to help manage the challenge of scale.

Another important aspect of HISP has been the network building, collaborating widely with other actors in the field of HIS. This includes WHO and HMN, West African Health Organization (WAHO), development agencies like NORAD, open source groups such as CapacityPlus, and other universities. This has led to scaling in many directions, like to new countries (Sierra Leone with HMN), in terms of interoperability between DHIS2 and other applications (with WHO, CapacityPlus), and towards strengthened HIS policies for the entire West African region (with WAHO). Perhaps most important has been the diversification in terms of legitimacy that such collaboration has brought. All scaling has an element of legitimacy behind it, and collaboration with other actors helps to develop

that at different levels. For instance, working with HMN has provided HISP with political legitimacy at the national and international level, while working with universities has provided academic legitimacy that has been important for example when arguing for open source systems.

Over the last 15 years, HISP has both developed according to the changing trends of HIS and development, and has significantly contributed to these changes. One example is the development of the standard SDMX-HD, led by WHO but with a developer from HISP being key. The standard was first implemented in the two open source HIS applications DHIS2 and OpenMRS, and piloted in Sierra Leone in a project with technical support from HISP. So while the international HIS community has started to focus on integrated architectures(Stansfield, Orobaton et al. 2008), HISP has been integral in furthering this work this both in terms of technical solutions as well as in policy development (Braa and Sahay 2012).

My research on scaling has thus taken place within a changing environment. HISP has scaled considerably itself, with increasing speed the last few years. Both in terms of countries supported, of which I have been directly involved in only a handful, but also in terms of heightened technology and user maturity. DHIS has until the last couple of years only covered aggregate data, but now also includes functionalities for patient data, a very different domain. It has also become interoperable with other software, rapidly increasing the potential scope of its implementation as part of a country HIS architecture.

3.4 Note on the terms developing country, the south, poor countries:

While the empirical work this thesis builds upon has been done in several countries that traditionally would be lumped together as "developing countries", I feel it is important to make certain reflections about what binds them together, and clarify on the terms used. First, while countries like Sierra Leone and Tajikistan are classified as low income economies by the World Bank[9], Botswana is classified as upper-middle income economy. All of them had a real growth of GDP above 5% in 2010[10]. Ghana, another country I've been involved with, has an estimated growth of 13.5% for 2011, and within the big cities

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[9] http://data.worldbank.org/about/country-classifications/
[10] https://www.cia.gov/library/publications/the-world-factbook/rankorder/2003rank.html

the availability of technology and services is not inferior to any other country in the world. However, there are some commonalities, that are also important for my research. Most important, and linked to the term "developing country", is that of a development context, i.e. that large international organizations are present with various projects, experts, and agendas. Of Sierra Leone's total expenditure on health, 20% came from sources outside the country[11]. For Botswana the figure is 18, and for Tajikistan 11. For other HISP countries, it is even higher; 99% in Malawi, 56% in Tanzania, and 47% in Liberia. This dependence on international organizations, bilateral agreements, and foreign NGOs is perhaps how I would classify "developing countries" today, but then rather as countries with a "development context". The dependence on external funding and expertise is arguably of great importance in countries, as it means they often have to follow programs and projects not necessarily best suited for the local needs, and that these do not come with predictable and long-term funding. One implications of this is that many projects are not deeply rooted within the local public institutions, but are funded and supported only as long as the international donor prioritizes it, and live and die as pilot projects (Heeks, Mundy et al. 1999).

Second, there may be huge inequalities within a country, relating to both economic and political power, but also infrastructure, education, and communications. For whatever reason, there are marginalized areas and populations that differ markedly from the bustling, often urban, areas. Even over small geographical areas, as within cities, can there be huge differences in both health problems and means to counter them[12].

Finally, if there is one common denominator for the various countries this thesis covers, it is that they have fragmented HIS, various non-interoperable technical solutions, and generally little use of health information compared to the amounts collected. But that is not necessarily unique to development context countries.

3.5 Sierra Leone – an overview of scaling processes

The empirical material of this thesis has been carried out in several countries, most notably Botswana and Sierra Leone. I will in this section present an overview of scaling processes in Sierra Leone, which covers the longest time span of involvement (2007-2012) of the

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[11]http://data.worldbank.org/indicator/SH.XPD.EXTR.ZS?order=wbapi_data_value_2009+wbapi_data_value +wbapi_data_value-last&sort=asc
[12] For a vivid description of slums in Sierra Leone's Freetown, please see http://www.economist.com/blogs/baobab/2012/09/cholera-sierra-leone

two, as well as a process of scaling from initial stages to national roll-out, maturation, and innovation. I have also held different roles throughout my engagement in Sierra Leone, which provides additional perspectives on the scaling process there. Furthermore, I have also been involved in the wider West African initiatives that have sprung out of the Sierra Leone project, providing me insights both within and beyond Sierra Leone. I provide this overview both to give some information about Sierra Leone, the context, and the various actors, and to tell a story of scaling in many directions, within and beyond the country, with multi-level mutual influences.

This is a description of events related to reforming the HII in Sierra Leone in the period 2006-2012, a process still ongoing. Sierra Leone is a small country in West Africa, with approximately 5 million inhabitants, and has as recently as 2001 come out of a decade-long civil war. With this background, many international organizations have been present in the rebuilding efforts, and in 2006 Sierra Leone was selected along a few other countries to be a "wave one" country by the HMN, a Geneva-based partnership with the WHO. This spurred the events described in this section, of which there have been many participants; from the local clinics and district health offices, to national authorities, NGOs and donors in-country, international organizations like WHO and HMN, research institutions like University of Oslo, and other regional actors like the WAHO.

3.5.1 Overview of scaling processes

The story below illustrates the various dimensions of scaling that has taken (and are taking) place, and a short summary will hopefully provide a clearer frame to attach the various details to. DHIS2 was introduced in 2007 to collect aggregate data from all facilities in the country, at district level. The first two years were thus about implementing hardware and software in 13 districts and to include as many health programs as possible, and train the district and national staff that would be engaged in the day to day use of the system. Once geographical coverage had been achieved, the utility of the data increased, and expansion in this phase (2009-10) shifted towards creating the demand for information, including capacity building at the national level and for NGOs. With increasing demand there were also interest in expanding the system, and the introduction of interoperability between different software applications meant that by 2010 the overall system had scaled into a new dimension; patient data, not just aggregate data. While this was achieved only in a small pilot, the result was that the whole project took a very international turn. Both the

interoperability achieved, and the political legitimacy gained by being promoted as an HMN success, meant that the project was seen as a model for other countries.

The concepts from Sierra Leone are now being scaled to other countries, while in the country itself the scaling is about more advanced use, strengthening support structures (hiring more people centrally), and continue to "hook up" information users to the existing data warehouse. While, due to lack of funding, the process has slowed down recently, there are several plans on the table. First, due to success of an online model in Kenya and Ghana, the plan is to move from an offline model of 13 stand-alone installations to a similar online model where districts connect to a central server using mobile modems. Second, as the HIV/AIDS agency has decided to join forces with the Ministry of Health and Sanitation, there are plans to extend the use of the software to also cover patient tracking, based on experiences in India and Ghana. The table below summarizes the scaling of HII in Sierra Leone and beyond through three analytical phases 2007-2012.

Phase	Dimension of scaling	Activities
I 2007-2009	"Scaling up": health programs covered by DHIS2 "Scaling down": amount of data collection forms	Customizing paper forms into electronic forms. Solving duplications, reducing amount of forms.
	Geographical coverage of DHIS2	Installation of hardware and DHIS2 in 13 districts
	Capacity building	Training for national and district staff
II 2009-2012	Increase use of information	Piloting various simple information products for dissemination. Training health partners at national level. Continuous training of district staff, in information use
	Interoperability with OpenMRS	Development of SDMX-HD protocol, implement OpenMRS for tracking HIV patients at main national hospital
	West African Health Organization promoting the "Sierra Leone" model across 15 member states	Regional meetings and workshop to showcase Sierra Leone results and offer training in DHIS2. Implementation in several countries started. All countries signing regional policy on HIS
III 2013-	Continued expansion across West Africa	Implementation of WAHO policy across the region.
	Potential inclusion of HIV patient tracking by the HIV/AIDS agency in Sierra Leone	Training of HIV/AIDS agency staff during late 2012

Table 6 Summary of scaling processes in Sierra Leone and West Africa

3.5.2 Sierra Leone – Context and early phase

HMN was established to improve HIS through working both at the global level, to lead harmonization of approaches between international organizations, and at national level by supporting countries to assess and plan HIS reforms. For this, two documents were developed; HIS Assessment guide (and score sheet), and an HIS Strategic Planning guide. Over 80 countries would eventually receive "seed-money" to perform the assessment and make a strategic plan, rooted in broad consensus among actors such as Ministries of Health, Central Statistics Offices, and their various sub-programs involved in handling health-related information.   Five countries were selected to also receive funds to implement their strategic plans, to provide experiences on also this phase for all countries to use when looking for funds to implement their respective strategic plans. Sierra Leone thus did their assessment and went through a process of developing a strategic plan through 2006-7. In short, the plan suggested the use of a data warehouse to include all fragmented information streams then currently present, and strengthen the district as an administrative unit that could successfully collect, process, analyze and use relevant health information for local action. At the HMN secretariat, the person responsible for assisting Sierra Leone in this contacted the University of Oslo inquiring about possibilities of implementing DHIS2 and training district information officers to reach the aims of the strategic plan.

3.5.3 Implementing a data warehouse: Scaling in geography

The first step (2007) was to revise the many data collection forms. Due to inherent fragmentation in the health sector, the various health programs had developed data collection independently, leading to duplication. In this way, HIV test results for pregnant women would be recorded in the form on antenatal care, while this data would also be part of the HIV-specific form, and also in the form for infectious diseases. There is common acknowledgement that such redundancy leads to more work for nurses and those processing the data, poorer data quality, and less trust in the data. However, while two new forms had been made to incorporate most primary health care services, as a first step towards harmonization, the legacy forms were still in use and they were all implemented in the DHIS2 software.

DHIS2 was then implemented in four pilot districts (out of 13); the capital, two neighbouring districts, and one distant district. As part of the support from HMN, low-voltage computers were set up to run off car batteries, which could run even when electricity was not constant (and eventually be equipped with solar panels. This, however,

never happened). Data entry clerks were trained centrally and set to enter data from the last year so there would be something to conduct training on data analysis on. In May 2008, training were held for all districts, also those yet not using DHIS2. Together with other students from University of Oslo, I planned and held the training; 3 weeks of general computer use, using DHIS2, and analyzing and acting upon data.

The redundancies and duplications between the various forms had been solved "behind the scenes" in DHIS2, in that once data was entered for one form (for one health facility for a specific month), it would automatically show up in other forms from the same facility/month, without the need to be entered again. An analysis of duplication was done, and presented to representatives for most health programs (typically owners of a form, such as Malaria program, Tuberculosis program, Mother and Child Health program etc). An agreement of a second revision of forms was reached, which has since become a yearly process.

Over the rest of 2008, the remaining districts were equipped with servers pre-installed with DHIS2. The setup with low-voltage computers (supplied by a private company) was discontinued due to emerging problems of low capacity and frequent failures that could not be solved without sending spare parts from the US, despite interest from HMN in continuing this to learn about suitability in other countries. A typical setup would be DHIS2 running on a Linux server (to save it from computer virus), with a small wireless access point so that existing computers in the districts (due to various donors, there would be at least a couple of machines) could access the system. Two Monitoring and Evaluation(M&E) Officers which had taken part in the training would be in charge of entering the monthly forms received from facilities, check data quality, and help the District Medical Officer (in charge of the district's public health services) prepare and present data for analysis. At the national level, four people were in charge; an IT-officer which were also receiving training on HIS issues, his supervisor the national M&E expert, a district supervisor with limited IT-skills, and a driver, all paid for by HMN or other international donors at very competitive rates. While DHIS2 is web-enabled, so that it could technically run off one central server, the connectivity in Sierra Leone was seen as unreliable for this, thus each district had their copy of a master database, and would send monthly data exports by memory sticks by whatever means possible.

The offline setup described had some implications. During 2008-9, reporting could be very slow, as data was usually not imported into the national server until someone had physically delivered it. There could be a delay of months, though the data was of course available at the district for local administration. More severely though, any changes to the database would have to be distributed to all districts physically. As more users pointed out such shortcomings, the system needed a lot of changes, for instance in definitions of indicators and validation rules. Also, the data to be collected was under constant revision, and changes would occur every now and then. If these changes were not shared with all districts during the same month, there was a risk of discrepancies in the database content, leading to severe problems when importing district data into the central server. During the first year, much time and effort was spent by the local team in Sierra Leone roaming the countryside collecting data and updating the database, as well as giving additional training.

3.5.4   Creating demand: Scaling up use of information

The use of the information collected through DHIS2 was pursued from the start of the project. From the early training sessions, the focus was on collecting, processing, presenting data that is *useful*, i.e. can help the districts make better decisions about their priorities. Districts were already holding regular review meetings, and a yearly national review was also done at the ministry headquarters. But the use of information for evaluation was often lacking, the focus was on taking new decisions, rather than looking at how last years' decisions were effective. To change this culture of information use is a long-term process, but simple data use exercises were including in all training, both in workshops and on-site.

A problem with information use is often the data quality, which tends to be poor. If data is of poor quality, it is considered untrustworthy, and not used, and if it is not used, it's quality tends to deteriorate even further. So increasing information trust, and use, is also about looking into data quality, and accepting that the best way to improve it is to start using the data, even if it is of poor quality. A few investigations into data quality found that it was extremely poor, with more than 50% of figures likely to be wrong. However, it was still used in national league tables (described below), which at least triggered real discussions about the quality of data and how to improve it.

One way to increase the use of the information that was now available was to aggressively share it with others that may have a use for it. The building of an information culture in the

Ministry of Health was slow, but much of the data was collected because international organizations, that support the health programs, have reporting requirements both domestically and to their parent organizations. A strategy to link this demand to the DHIS2 system was followed early on, even if the data quality was still quite poor. The goal was that a) they could be a force on the Ministry to provide monthly, good quality data, and b) they would consider implementing their new (often changing) reporting requirements in DHIS2 instead of a new parallel structure. With this in mind, we invited all international organizations and NGOs for a workshop, offering training in how to access the data. Those working in the capital should access the wireless from the Ministry of Health building, but due to poor installation of the hardware this was not functioning. Rain and humidity proved a challenge on the equipment, even inside buildings, and there was no local resources or skills to properly fix this, once broken. The data would in any case be available through memory sticks, like NGOs working in districts would access it. In addition, we urged the ministry to create and share quarterly bulletins with some information and analysis also to NGOs, and not only to units within the ministry, to create awareness of what was available. The results were mixed, but several organizations started to approach the HIS-unit in the ministry for data, and the rising awareness contributed to strengthening the position of this unit as the sole provider of health information. This would become very valuable when DFID later invested massively in health in Sierra Leone (described later).

3.5.5 Institutionalization, politics, and interoperability: Scaling in different directions

At the end of 2009, the process in Sierra Leone forked, largely based on new international agendas. The three most important parallel processes were 1) revision of reporting forms and continuation of process to strengthen health management using the data and DHIS2, which is linked to 2) the increasing pressure (linked to funding constraints) on HMN to show results *beyond* implementation (again linked to more international emphasis to evaluate based on health impact rather than more easily measured outcomes), and 3) developments related to standards for exchange of statistical health data.

The first process is a continuation of the processes in the preceding years: Improve the data collection forms by removing duplications, improve language to make forms less ambiguous, and add or take away a few items here and there. During the last year, data reporting had increased for the most important forms (from approx 60-70% of expected

facilities per month to 80-90% in 2009), partly in relation to official, public "league tables" which ranked districts on a few key indicators. These indicators were both health related (coverage rates for antenatal care, institutional deliveries, and immunization rates), and HIS-related (data completeness and quality), and the league tables were creating a lot of discussion about the reasons for the various performances. Some districts even copied the template, ranking their chiefdoms, representing sub-districts which did not have a health administration by themselves, but who were partly autonomous through paramount chiefs who could implement "laws" or advice its population. This was a very powerful, new, and transparent way of looking into quality of service. The better performing districts could report of strong paramount chiefs who were taking their position in the league tables seriously; discussing with health staff how to make the population use the public health services, how to provide incentives for giving birth at a facility, and the like. Not all districts responded in the same way, but at least a few were beginning to use information through DHIS2 in their monthly review meetings and making action plans based on these core indicators. The strongest example comes from the Western Area district (the capital Freetown), which initially scored very low on institutional deliveries. Seeing this, the DMO published a note in a newspaper stating that all mother and child health services were now free in his district, and also implemented other measures to improve his indicators. For example, since the capital has many more private health facilities than the rest of the country, he agreed with them to collect a least data on deliveries, while they are in general sceptical against sharing data.

The second process was more taking place at the global level, though a close collaboration with the national team in Sierra Leone and HMN was essential. As the core funding for HMN was about to end (more than 90% funded by Bill and Melinda Gates Foundation 2005-10), the financial crisis was slowly affecting its host WHO (as countries cut down general funding), and there was a growing concern about the effectiveness of reaching the MDGs, HMN was finding it harder to obtain funding for further activity at the same level. Concerns about results from the HMN Board (consisting mostly of representatives from other international donors, and only one person representing a "developing country") led to Sierra Leone being proclaimed a success, and efforts were made to link the success to the MDGs. The other Wave One countries could not show similar results, and HMN thus featured Sierra Leone prominently in online photo diaries, a Results Report, and regular reports to the board and possible funders. Sierra Leone could show some results of *better*

*information, better decisions, better health (*HMN's slogan), linking the inputs provided by HMN and its partners to health impact that were directly related to the MDGs. The examples of improved indicators and the use of information mentioned above were documented and distributed globally – there was a scaling of legitimacy of the HMN endorsed integrated approach. Figure 7 below shows the positive trend achieved for the institutional delivery rate of Western Area district, as distributed globally by HMN.
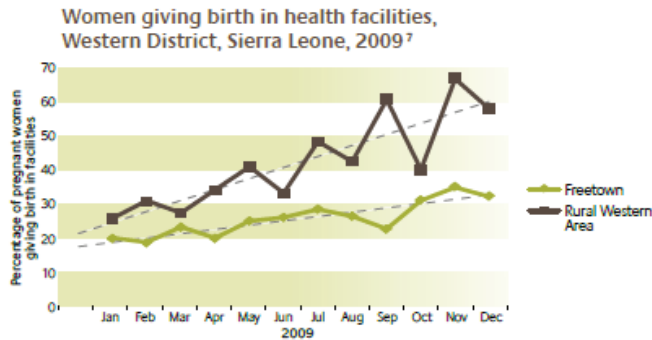
Figure 7 Increasing institutional delivery rates in Sierra Leone, from the HMN Results Report (2010)

The project in Sierra Leone was thus pushed to the fore by HMN, who needed to legitimize their investments. To further strengthen the example, HMN suggested to use Sierra Leone to pilot the new SDMX-HD protocol for aggregate health data exchange, an XML-standard developed by WHO to allow different software applications share data.

To pilot this, it was decided to set up the patient management software OpenMRS in a clinic in Freetown to manage patients on antiretroviral therapy (HIV+ patients). DHIS2 was used for health statistics only, and all data collected through it was aggregate in form. OpenMRS is for patient management, and the data will then be personal, like name, age, address, lab results, history etc. The HIV unit was fairly autonomous, due to its relative strong financial situation. The UN organization UNAIDS has not only poured money into fighting the disease, it has also propagated the independent nature of its organization to similar organizations in various countries. The HIV department had thus not earlier been willing to collect their data through DHIS2, as they had their own well-funded reporting structures (some HIV related data was collected anyway, when relevant for the other programs), but had asked for assistance to set up OpenMRS for patient management. Hoping to bring the HIV department on board also for DHIS2, HMN offered to help set up

OpenMRS at a major hospital, where patients come to get their drugs, which could share its data in aggregate form with DHIS2. This "second level" integration would then include other types of data in the system; from integrating all aggregate data ("first level" integration achieved in DHIS2), to further include different types of data using various software ("second level" integration achieved with interoperability between DHIS2 and OpenMRS). The implementation of OpenMRS in one hospital in Sierra Leone was the first running instance of SDMX-HD in the world, and the experiences accelerated and contributed greatly to its development.

The establishment of this interoperability, together with the fact that HMN were pushing the success of Sierra Leone globally, led to regional interest in "the Sierra Leone model".

3.5.6   Networks of networks – Scaling of organizations and legitimacy

In the months after setting up the DHIS2-OpenMRS installation, not much follow-up was done. The group who had sponsored one OpenMRS expert to contribute had no further plans in Sierra Leone, and internally in the ministry there was very limited capacity. Nevertheless, the power of the example was growing, and a representative from Sierra Leone and one from HMN was invited to a workshop held by the Human Resource division of the WAHO, who wanted a presentation of the Sierra Leone DHIS2/OpenMRS model, and how this could possibly be expanded by linking up with the iHRIS software, a USAID-sponsored open source human resource management system. This workshop took place in May 2010, and included representatives from most of WAHO's 15 member states. As an outcome, it was decided that WAHO, University of Oslo, WHO, HMN, and CapacityPlus (behind the iHRIS) would invite to a regional workshop offering training in the three software (DHIS2, OpenMRS, iHRIS), as well as support the development of interoperability between them. This was held in Accra, Ghana, September 2010, with 80 participants including a large delegation from Ghana Health Services (about to start implementation of DHIS2), representatives from other Western African countries (many of which were considering or in the planning phase for either or both DHIS2 and iHRIS implementation), donors, developers, international organizations etc. Here, data exchange between all three software in question was demonstrated for the first time, and the WHO representative that led the development of the SDMX-HD called it an official launch of the new protocol.

The technical solution to interoperable systems now existed, and the organizational and institutional challenges and opportunities of this interoperability were discussed heavily at the workshop by representatives from the various countries. A follow-up workshop, in Dakar, Senegal, a couple of months later, was wholly organized by WAHO, as a first step towards adopting common strategies and standards for HIS in the region. In 2011, WAHO had taken the lead to formalize regional collaboration, focusing on developing DHIS2 as a regional data warehouse as well as help countries adopt the standards that would enable interoperability between their systems and data.

The interoperability achieved between DHIS2, OpenMRS, and iHRIS in the Accra conference had the effect that various networks now could work together to build common systems. The network implementing DHIS2 in Sierra Leone; University of Oslo with the larger, global, HISP behind it, HMN with their global partners such as WHO, and the Ministry of Health with all their local partners, now found that the demand for interoperable systems grew rapidly. Only by working with other networks, CapacityPlus/USAID and WAHO as one, people working with OpenMRS as another, could enough skills, available people, and funding be leveraged to provide these systems. The workshops described above came about as these networks worked together. The attractors that made these networks come together were the interoperability potential created by SDMX-HD, and open standard with WHO approval, and the constant stream of documentation from HMN of the successes in Sierra Leone. With SDMX-HD enabling various applications to combine to form software packages, the networks involved with each of the individual applications now would also be drawn together. Each of these networks would bring in new skills, funding, and perhaps most important; new bases of legitimacy. One particular important actor in this regard, brought into the process by their work with human resources for health, and thus the software iHRIS and the group CapacityPlus, was WAHO. In Sierra Leone HMN had a legitimacy coming from WHO, and University of Oslo had a legitimacy coming from a track record of working "on the ground". WAHO had a regional perspective, and it was an organization made up of the 15 West African countries themselves. Their funding was independent of the global organizations, and it was locally rooted. ECOWAS, the Economic Community of West African States, is a customs union, and WAHO, it's health department, is 90% funded by taxes on imports to the region. It has thus a local connection and legitimacy, based on ownership. One can say that by scaling from single networks to networks of networks, the

most immediate effect in this case was the scaling of legitimacy, where the various sources of it were complimentary.

3.5.7   The current situation in Sierra Leone

At the same time as the "Sierra Leone model" was looked at in the region, final acknowledgment of it's success came in Sierra Leone. What Western Area district had done independently, namely to offer free maternal health services, became official policy in April 2010 as DFID supported Sierra Leone massively to implement this country-wide. To measure the impact of such a costly project, DFID and the Ministry of Health would need a strong monitoring and evaluation plan, and it was decided that the DHIS2 was robust enough that no new reporting structures had to be created. Meanwhile, HMN's presence in Sierra Leone, and West Africa, was reduced to nil as the organization all but ceased to exist. The financial continuation of the HIS by other donors (DFID and World Bank) signifies quite an outlier from the norm, which would typically be new systems introduced to cater for specific, time-bound needs. While the transfer of financial responsibility from donor to government has not yet taken place, the transfer from donors (from HMN to DFID/World Bank) not in other ways collaborating is a great achievement for medium-term sustainability.

The current situation is one of institutionalization of the system in Sierra Leone, and adaptation of the experiences to other countries in the region. The University of Oslo has not been directly involved over the last two years, but offered regional training that the Sierra Leone team has participated in. In November 2012, the HIV unit, long opposed to formally working with DHIS2, decided to switch based on urging from their main funder, The Global Fund. They are now learning from Kenya and Ghana on how to bring DHIS2 in Sierra Leone forward as an online system which can also support individual patient data, as the piloted OpenMRS application has come to a standstill due to lack of support.

Meanwhile, over 10 countries in the region have started with DHIS2, or made a shift from DHIS version 1 to version 2, based on the experiences from Sierra Leone and the promotional work done by WAHO. These include Liberia, Togo, Nigeria, Benin, Niger, Burkina Faso, Guinea Bissau, Guinea, the Gambia, Ghana, and lastly, Senegal.

3.6 Summary of context – implications for research

The case of Sierra Leone presents the scaling of HII in many directions, including the international aspects of it. The rich material I have been so lucky to have access to, has informed my understanding of scaling both from a theoretical and from a practical point of view. From the above case description, the following directions of scaling can be identified;

- Scaling geographically across the country, with diverse infrastructural conditions
- Scaling of use and user maturity
- Scaling of technology, including new functionalities in DHIS2 and interoperability with OpenMRS
- Impulses from other countries, bringing in the regional and global context
- Influences that emanate *from* Sierra Leone, contributing to scaling trajectories in other countries

The project in Botswana shared the aims of that in Sierra Leone, but failed to reach the desired scale. It thus not only contributed empirical material to compare to Sierra Leone, but also to contrast it. What worked, and why did it work, in Sierra Leone and not in Botswana? Many of the same challenges and trajectories were present also in Botswana; a data warehouse for all aggregate health data (Sæbø, Braa et al. 2007), capacity building focusing on district staff, interoperability as a strategy for integration (Sæbø, Gill et al. 2008), and challenges related to infrastructure and poor maintenance of hardware and software configurations. Comparing the details of strategies to address these issues have been useful not only to understand scaling better, but also to learn what works or not, which has real practical applicability (Sæbø, Kossi et al. 2011). One notable difference is the technology used, with DHIS version 1.4 in Botswana, and DHIS version 2 in Sierra Leone. While both were early versions at the time of implementation, the opportunities they posted and their development trajectories were different. Botswana and Sierra Leone thus also presents a comparative study of the role of technology in scaling.

Sierra Leone also contributes a strong case for looking at international aspects of scaling. From the very start, Sierra Leone was based on software, ideas, and experiences from other countries. From Botswana I would bring my experiences and training material, India had

the first running instance of DHIS2, and HMN provided a standardized framework for the HII architecture. Throughout the project there was a strong international presence, and the software was continuously improved based on requirements from around the world. People and material would circulate and be adapted to the local context, and the international organizations were involved as partners, funders, and users of the information coming out of the HII. At the same time, the flow went also out of Sierra Leone; software functionality, interoperability with OpenMRS and iHRIS, training material, results, information products, and experiences. With Sierra Leone playing a key role as a "success story" both at the global level through HMN and at the regional level through WAHO, I could follow the translations of the above issues in other countries.

To conclude, while building on my experiences from Botswana, Sierra Leone presented a rich case of multi-lateral and multi-dimensional aspects of scaling. I thus focus on it as a reference case, to study scaling of HIS in a global context.

4 Related research

In this chapter, I will present relevant literature for this thesis. In the introductory chapter, I stated that I look at global scaling of Health Information Infrastructures (HII), and that two main aspects are important for understanding this; multidimensional and multilateral scaling. I will approach related research with these two aspects in mind, rounding off this chapter by summarizing and providing my understanding of them, and a proposed perspective from which to analyze my empirical material.

I first present relevant research from the broader body of IS literature which deals with scaling, to assess various dimensions through which this take place. I then review literature around technology transfer and technology translation, both phenomena that share similarities with the topic of global scaling. As will become clear, research on scaling of IS tends to be inconclusive with regards to the dimensions covered, and technology transfer is primarily treated as a unilateral one-way movement. These form the point of departure for my theoretical analysis, and provide the backdrop against which my contributions are framed.

From an HII scaling perspective, I then address the issues of multidimensionality and multilateralism. To help identify relevant dimensions, I organize my literature review with respect to arguably two key mechanisms of scaling: integration and institutional change. These mechanisms, I argue, help to trigger other "second-order" causalities for scaling across different dimensions and involving other mechanisms. Turning to multilateralism, a key shortcoming of the technology transfer literature is the lack of attending to feedback mechanisms from one country to others. Such mechanisms have been covered in literature on CSCW and global ERP development, and I incorporate them in my analysis of HII scaling.

This chapter concludes by proposing a conceptual perspective of global scaling that I subsequently draw upon in my theoretical analysis.

4.1 Scaling

Despite many attempts by various researchers, a clear definition of scaling still seems elusive. The Merriam Webster dictionary defines scale as "distinctive relative size, extent,

or degree"[13]. This sets the stage for the common theme among the various IS scale descriptions; that it can be several things, not necessarily linked to material *size*, but also to more abstract dimensions as *degrees* of something.

Sahay and Walsham describes scaling as concerning "the process through which that product or process is taken from one setting and expanded in size and scope within that same setting and/or also incorporated within other settings" (2006 p. 185). Braa, Monteiro, and Sahay also describe scaling as "the problem of how to make one, working solution spread to other sites, and be successfully adapted there. Beyond merely the technical aspects of scalability, our concerns lie in how to reproduce and translate the necessary learning processes alongside the spreading of artifacts, funding, and people" (2004 p. 338). Others have seen scaling as replication in a self-similar nature, like the branches of a broccoli (Eoyang 1996), or to successfully utilize technical capacity to handle a larger workload (Bondi 2000). Edwards and Hulme (1992) have focused on the scaling impact of organizations, which can happen either through extending your own organization, collaborate with or influence other, similar organization, or spread your ideas and approach wider in society for systemic change. In this, they look at scaling the results, rather than necessarily scaling the means to achieve it.

There is also research which argues for qualitative differences in how scale can be measured. Shaw (2009) introduces the opposing directions of *widening* and *deepening*, i.e. that there can be scaling along (at least) two axes, doing so by using the example of scaling health information systems in geography and scope. In terms of geography, a widening of the scale involves taking the system across new geographic entities, like from one province to another. Within such a province, a deepening takes place when the system is propagated to lower hierarchical levels, such as districts and sub-districts. Likewise, a widening of the scope of the system is achieved through incorporation of more health programs, while a higher level of sophistication of data and functionality can be termed a deepening.

Scaling is usually discussed in terms of expansion, but any change to a system's extent and use would be tantamount to a change of scale. Partial failures of IS projects can be seen as a form of "de-scaling" of initial expectations for a system (Heeks, Mundy et al. 1999). In some cases, de-scaling is sought intentionally as a strategy to later scale up, for example to reduce the scope of a system to strengthen its usability (Braa and Hedberg 2002, Thorseng

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[13] http://www.merriam-webster.com/dictionary/scale

2008). The action *scaling* then, is not to be treated as always outwards, expansion, growth, and nor is it to be considered only in quantitative terms of numbers and geography.

Scaling can then be summarized to involve change, most often expansion, and this change can take place in a multitude of dimensions and directions. For an HII, these dimensions can include amount of users, types of users, roles of users, the maturity of users, and so on, and further the same dimensions of other aspects of the HII, like functionality, templates, standards, organizations etc. Sahay and Walsham, in describing the case of the health information system in India, concludes that "what is being scaled is not simple or a uni-dimensional listing of factors. It can be described as a scaling up of *complexity*" (2006 p. 196), a term which has been defined as "the dramatic increase in the number and heterogeneity of included components, relations, and their dynamic and unexpected interactions in IT solutions" (Hanseth and Lyytinen 2010 p. 1).

Despite this view of scale as a measure of a complex web of interconnected dimensions, research on *scalability* has often focused on the design and technical characteristics of systems, like the architecture (Lemley and Lessig 2001), openness and ease of mastery (Zittrain 2006), use flexibility and change flexibility (Hanseth 2001), and elasticity of supply (Mell and Grance 2011). But scalability is also dependent on other factors, beyond the potential or restriction of technology. In the comparative study of Nigeria and Ethiopia, Shaw, Mengiste and Braa (2007) present a framework for analyzing scale in relation to organizational capacities. They see the ability to handle increased scale and scope of data as dependent upon human and technical resources. They propose to follow a strategy of mindful innovation (Swanson and Ramiller 2004), balancing the available human resources, access to technology and the type and volume of data collected by the system through cultivation. Pragmatism, in their case, takes hold over absolute requirements, as the change of complexity by scaling needs to be taken into account with the available resources.

 Scaling, then, is a concept which has been given some attention in the IS field, though no uniform definition has yet settled. The literature shows that scaling can take place in a multitude of dimensions, both technical and non-technical. However, the focus of previous research has been on what determines scalability across these dimensions. What happens *as* scaling takes place in the various dimensions, and especially from one setting to

another, has been given less attention. A strand of theory that can shed some light on this is that of technology transfer, to which I now turn.

4.2 Technology transfer and translation

The above included references to scaling, and the associated dimensions or aspects, are useful to get an understanding of how and where scaling takes place and which factors contribute to this. However, this tends to be limited in explaining the changes to *what is being scaled* itself. The broccoli-metaphor of Eoyang (1996), of self-replication, is not capturing any changes that might take place either at the main branch, or the sub-branches, to follow the metaphor. Braa, Monteiro, and Sahay (2004) get a bit closer in referring to translating learning processes around the scaled artifact and processes. It is worth following this thought, and I will in this part of the chapter look at some other promising theories that inform an alternative view of scaling; as translation.

Seeing scaling as expansion "within other settings" (Sahay and Walsham 2006 p. 185), is very reminiscent of literature on technology transfer. This theoretical field developed much about at the same time as the growth of the international development scene, where it was assumed the "south" needed to be given the technology which the "north" is developing. Rogers' (1962) early S-shaped curve aimed to describe the diffusion of technology, assuming a centre and periphery. He saw this diffusion as passing through five stages; knowledge, persuasion, decision, implementation, and confirmation. His writings influenced the IS field, through the Technology Acceptance Model (TAM) (Davis 1989), describing how users come to accept new technology. Such centre-periphery replication logic has later come under critique. For example, Nhampossa argues how the cognitive basis of these models tends to limit our understanding of the system in its broader context (Nhampossa 2005). Many have pointed out that cultural, institutional and infrastructural differences have made such replication challenging (Lind 1990, Braa, Monteiro et al. 1995, Sahay and Walsham 1999, Heeks 2002). With development taking place detached from the setting the technology will be used, such "design from nowhere" (Suchman 2002) can lead to design-reality gaps, an important contributor to failed IS projects(Heeks 2002).

Braa, Monteiro, and Reinert argue for speaking of technology *learning* rather then *transfer*, as technology has to be learned within the new social and cultural contexts of use to where it is being moved (Braa, Monteiro et al. 1995). A nice example of how important this can be is provided by the story of the Zimbabwe Bush Pump, which takes into account the role

of the community and social practices even in it's user manual (de Laet and Mol 2000): "If the village women do not want to use the well, if it has been bored without consulting the nganga or was put into operation without his consent, the well is dead. Sometimes literally" (p. 234).

Later, Reinert has conducted an impressive analysis of technology transfer from an economic point of view, arguing that successful economies are based on industry protection that facilitates *learning* of technologies, i.e. that only by being given time for learning and adapting technology, can industries stand a chance of being sustainable in a competitive setting (Reinert 2007). Evocative of the expression "teach a man to fish..", the core is that it is not the technology, the fishing gear, that feeds a man for a lifetime, but learning how to use it in his waters.

A more useful concept, which also takes into account changes of the technology, not just its use, is technology *translation* (Akrich 1992). In a study of the "transfer" of a forestry waste pulping machine from Sweden to Nicaragua, Akrich shows how the interplay between the context and the technology changes both, one small step at a time. Modifications to the machine to handle cotton stalks instead of forestry waste, changes in storage facilities and methods to combat a certain Nicaraguan insect, and the development of a completely new economic niche to sell the resulting product to local bakeries are all changes created through the interplay of the original technology and the Nicaraguan context. The technology is slowly translated into the "local language", though it is perhaps misleading to use this linguistic term. Rather, translation in this sense points to both movement and transformation (Sahlin and Wedlin 2008).

Nhampossa traces such translations of the introduction of an HIS developed originally in South Africa to Mozambique, and shows how they occur as the system is scaled up (Nhampossa 2005). One example is the development of multilingual support in the software, to accommodate local needs to use Portuguese. He argues that "technology is developed as a result of the interaction of culture (manner or way of thinking, talking and acting), context or environment (e.g. country, organization or department), work practices, and the material characteristics of the technology itself" (p. 139). This translation is not a one-off event, but characterized as a successive chain of smaller translations, each contributing to the coming together of different socio-technical configurations (Law 1996).

Another important aspect in reconceptualising technology transfer as translation is the higher degree of "interpretive flexibility" (Orlikowski 1992) associated with information technology as contrasted with the more fixed materiality of technologies like machines and equipment. Interpretive flexibility implies the potential of the same technology being perceived by different social groups in varying ways leading to different and unexpected consequences. Barley described how the same CT scanners were interpreted differently by the radiologists and doctors in two hospitals in Massachusetts, leading to different consequences (Barley 1986). Sahay and Robey similarly described different consequences of the same Geographic Information Systems (GIS) technology in two county government organizations in South Florida, and attributed these to how geographers and computer scientists interpreted the technology in varying ways in these two settings (Sahay and Robey 1992). By virtue of its "virtual materiality", information system software can relatively easily circulate across different settings, thus becoming vulnerable to varying social constructions and associated translations. As a result, scaling processes tend to be non-linear, involving unanticipated consequences.

In summary, the literature on technology transfer has come to emphasize the importance of local adaptation to suit the new context. Such adaptation, also called technology translation, is unanticipated, depending on the new users' surroundings, practices, and institutions, and the potential and flexibility of the technology. The local translation of the technology is the focus, and the literature does in general not treat the issue of how these translations are fed back to where the technology came from, or how they affect further dispersal to yet other settings. In this, the literature is predominately unilateral, it's perspective is the introduction of technology to a single country and what happens to it there.

4.3 Scaling of Health Information Infrastructures

In the introductory chapter, I stated that Health Information Infrastructures (HII) is the unit of analysis for my research. Information Infrastructures (II), which I am looking at from the angle of health, has been defined as "an evolving, shared, open, and heterogeneous installed base" (Hanseth 2000 p. 60). *Evolving* as in enabling change over time, *shared* by a larger community, *open* in that there is no clear-cut boundary as to what it includes, *heterogeneous* in that it consists of socio-technical networks and sub-networks, many of whom are very different in nature, and *installed* as in always building on something

existing. They are pervasive, existing for decades rather than years, and are entangled in yet other IIs beyond their own scope (Monteiro, Pollock et al. 2012). Ribes and Finholt (2009) use three scales of (information) infrastructures, namely as a technological venture, in organizing work, and as an institutional venture. The first concerns the goal of enacting work and collaboration, and automating tedious tasks. The second denotes the work practices involved, both of "primary" users and of those supporting and maintaining the II. Lastly, IIs seek to make more lasting, institutional impact. The long term nature of IIs, and the mutual shaping of work practices, technology (Nielsen 2006, Monteiro, Pollock et al. 2012) and institutions "encourages a consideration of how today's planning will effect tomorrow's technologies through the practical work of designing, (re)constructing, and then maintaining these systems" (Ribes and Finholt 2009 p. 377). HIIs are thus evolving, long-term, open-ended installed bases in the health sector.

These characteristics of HIIs means that they are never designed from scratch. Rather, they evolve according to influences from a range of actors. The most precise way of formulating this depends on how much agency for change is attributed to these actors, or if the HIIs are rather autonomous. Nielsen (2006) talks of *building of an II*, as a dialectical process of more autonomous evolution and more directional construction, where the roles of heterogeneity, standards, II builders, politics and institutions must be taken into account. When scaling HIIs, the same dialectical process will apply; "Scaling an II will necessarily require drawing upon and being shaped by what already exists, which at the same time is influenced by scaling processes" (ibid, p. 79). Edwards et al. (2007) argue that speaking of building downplays the importance of non-technical challenges; "Since infrastructures are incremental and modular, they are always constructed in many places (the local), combined and recombined (the modular), and they take on new meaning in both different times and spaces (the contextual). Better, then, to deploy a vocabulary of "growing," "fostering," or "encouraging" in the evolutionary sense when analyzing cyber-infrastructure" (p. 7). They thus give the actors involved in II development and scaling less control, and a role more like nurturing an inevitable growth. Scaling of HIIs can thus be seen as a dialectical process between the existing and the new, where the role of actors to define the trajectory of scaling is at least influenced by what already exists.

The interaction of a new HII with what exists can be seen as embedding, where the HII continuously encounters other HIIs and get's entangled with them (Vaast and Walsham 2009, Monteiro, Pollock et al. 2012). The process of scaling is thus also a process of

aligning with existing systems and institutions. With this in mind, I will now look at two main aspects relating to scaling, and the tension of engaging in existing HIIs. They are;

- Integration
- Institutional change

These two aspects, this thesis argues, cover important mechanisms of scaling HIIs. Integration is a primary driver for scaling, both in a normative way as promoted by global agencies as the Health Metrics Network, as well as in a practical way of the logics of integrated care and management within the health sector. Furthermore, integration is a key mechanism in which HIIs come to be entangled with other HIIs. Through such integration, tensions between new and existing institutions are inherent. New technology, practices, and ideas, have the potential to disturb existing institutions, and can in many instances necessitate change to work as intended. At the same time, scaling of HIIs can be used by some actors to intentionally promote certain institutional change, for example to promote new work practices. The implications of scaling for institutional change, and vice versa, will be the second main mechanism explored.

4.3.1   Scaling through integration

The importance of integration for scaling of health information systems has been emphasized by many scholars (see for example de Kadt 1989, Braa 2005, Braa, Hanseth et al. 2007, Sahay, Monteiro et al. 2009). Johannesen and Ellingsen (2009) describes how scaling of a health information system involves its integration with other systems, software, and work practices:

"In accordance with agile methodology, the development had started at one end, integrating with one laboratory system and one EPR system. Now it was time for the product to expand, and the generification process at this stage was related to the different needs that emerged as the microbiology laboratory at UNN was included. This implied adaption to new work practices as well as integration with another laboratory information system" (p 620).

Integration thus involves more than making technological artefacts speak to each other, and includes standards, work practices, organizations etc. This is inherent in embedding HIIs with the already existing HIIs, where integration takes place at several levels. Integration is thus by definition multidimensional. While integration is a commonly

referred to concept, its application in the field of IS is not uniform (Wainwright and Waring 2004, Gulledge 2006). A wide definition holds that systems are integrated when "they appear seamless from the point of view of the individual user" (Vernadat 2007 p. 137). I focus here on integration as a process, to achieve this user-perspective of seamlessness.

The strategies to achieve this, however, vary (Hasselbring 2000). Health information has been pointed to as a particularly complex area of integration, where issues such as complexity of medical data, security and confidentially concerns, and a general lack of unique patient identifiers contribute to this (Grimson, Grimson et al. 2000). The Health Metrics Network framework shows integration from a health management point of view, implying the availability of various data sources in a central data repository, without necessarily stating how this integration should be achieved (Health Metrics Network 2008).

A framework of dimensions of integration can be a point of departure for devising strategies. Hasselbring (2000) introduce three layers within an organization where integration can take place; the business layer, application layer, and technology layer. Wainwright and Waring (2004) echoes this, and identified four domains of integration, namely technical, systems, strategy, and organizational. They argue that the importance of the organizational domain has been downplayed in the IS literature, and calls for its increased attention. This is supported by Sahay, Monteiro and Aanestad (2009), who argue that integration literature has been too technology-oriented. They argue that shifting political realities drives integration possibilities, and that any system must be configurable to align with the current scope for integration offered by the political environment.

Another useful model for looking at integration at several levels is presented by Carlile (2004), and modified by Braa and Sahay (2012). Here, the three levels of syntactic, semantic, and pragmatic integration represents an increasing complexity and differences in views. In relation to health information systems, their syntactic level relates to unique identifiers and protocols for data sharing, the semantic level represent shared definitions of indicators and meta data, while at the pragmatic level the various organizational and human actors need to agree to the need for standardization, the what and how of it, for integration to take place. Hence their view is that integration typically needs to take place

at these three inter-connected levels, and can rarely be achieved by focusing on one level alone.

The challenge of agreeing across these levels can be approached by developing appropriate boundary objects that span the borders of the levels (Star and Griesemer 1989). For instance, a data exchange protocol developed for HIS that allowed *interoperability* at the syntactic level was also dependent on harmonization at the semantic level, spurring integration at both levels in West Africa (Sæbø, Braa et al. 2011). Interoperability is the "ability of a system to use and share information or functionality, of another system by adhering to common standards" (Braa and Sahay 2012 p. 59), and became a strategy in West Africa for integration at all three levels through becoming an attractor around which various actors engaged.

For both integration and interoperability, standards play an important role. Monteiro and Rolland (2002) examine a truly global effort to scale an II for a maritime classification company. While local adaptation of systems is backed by a considerable body of literature, they argue that for such large IIs, certain means of compatibility need to be fostered. A key issue, they write, "in realizing this ambition is to find a way to enforce some notion of control and coherence across the different contexts" (ibid p. 89). They thus see scaling of IIs also as scaling of certain standards. However, they conclude that to take height of the local context, there is a need to strike a balance between the local and the global, to scale up some standards, but also leave room for local adaptation.

Having worked extensively with HMIS, Braa and Hedberg (2002) come to the same conclusion, and find that inscribing flexible standards in the software used for an HMIS could solve a problem of the "hierarchy of standards", allowing each level of the health sector some leeway in defining their own health management indicators while adhering to the needs of the levels above. Scaling of national standards to lower levels had to be complemented with the ability of lower levels to define their own, additional, information standards. Later research on the same project proposes a flexible standards strategy to achieve scaling (Braa, Hanseth et al. 2007). They build on the notions of use and change flexibility by Hanseth, Monteiro et al. (1996), and show how a standard's flexibility is a sum of the two. Data standards, just like technical standards, should be modularised, and gateways should be created between them. They conclude:

"We need to develop infrastructures based on single, universal standards, but in countries like Ethiopia this is impossible. In most other cases, universal standards are beyond our capacity or will be totally inflexible if built. Establishing a fragmented infrastructure composed of a range of small ones which are not connected is not a viable option. An appropriate blend of standards and gateways allows infrastructures to evolve by maintaining order at the edge of chaos" (p. 18).

In sum, strategies for integration are diverse, and should address multiple levels and dimensions. Strategies should also be flexible, to accommodate the political and institutional reality in flux. Achieving integration through interoperability is an important strategy that also allows flexibility with existing systems. It provides a loose integration in that the various systems continue to exist on their own but can work as component of a larger, integrated system (Vernadat 2007). In relation to scaling, the frameworks and levels of integration presented above help understand the multidimensionality of scaling HIIs. Integration takes place at least at three different levels; the ability of technologies to be able to speak to each other (syntactic), the definitions and rules concerning the language through which they so do (semantic), and the organizational agreements, routines, strategies, and visions that make such integration desirable (pragmatic).

 Furthermore, the intention to integrate at only one level potentially leads to involvement also at the other levels, as they are connected. For example, integration through interoperability of software applications is not only dependent on a shared protocol for data exchange, but also on shared definitions of the data to be exchanged, and the organizational will to do this. Scaling through integration, in turn, runs the same risk of getting entangled with other levels. I will now turn to the second important mechanism of scaling, which deals more with the pragmatic level of Carlile's (2004) model; scaling and institutional change.

4.3.2   Scaling and institutional change

The motivation for this section is to look at some ways by which institutions shape and are shaped by the scaling of HIIs. I follow the understanding that institutions are formal or informal humanly devised structures that sanction behaviour (North 1990). Institutions take the form of written rules, codes of behaviour, taboos, and traditions (Jepperson 1991). They are different from organizations in that the latter are groups of people who share a

common purpose to reach objectives. North (1990) uses the analogy of sports, where institutions form the rules of the game, while organizations are the players.

Following the duality of structure as proposed by Giddens (1979), where actions both shape and are shaped by the structure, I conceptualize this section based on similar principles of duality of institutions and technology, to see how HIIs can both shape and be shaped by institutions. Specifically, I look at the role of technology in this change process, and how institutions sanction or not the use of the technology.

First of all, institutions are not static but evolve over time. The organizations working within the confines of an institution are, whatever their goal, trying to maximize results given the present situation. If they are of the impression that results could be higher given different rules, they would try to change them (North 1990). One recent and interesting strand of work within the domain of institutional theory is of institutional entrepreneurship (IE). IE concepts are geared towards understanding processes of change in institutions, and also how to "make change." Institutional entrepreneurship refers to "activities of actors who have an interest in particular institutional arrangements and who leverage resources to create new institutions or to transform existing ones" (Maguire, Hardy et al. 2004 p. 657). While IE does not focus on stability (Lawrence and Suddaby 2006), the same concepts used to explain change can also help to understand the status quo. For example, actors in position can also leverage resources to maintain the current institutional practices, resisting change. The same way as technology can be used to introduce change, as I will look at below, it can also be used to cement existing structures, like an HII.

Much has been written on the influence of institutions on technology (Orlikowski and Barley 2001), but less on potential of technology to influence institutions (Fountain 2001). One example is provided by Barley (1986), who shows through an impressive study how technologies can be an occasion "that trigger social dynamics which, in turn, modify or maintain an organization's contours" (p. 81). Influenced by IE, I now turn to the potential disruptive effect of technology on institutions, which one would expect whilst experiencing processes of scaling.

The introduction of technology can represent an exogenous shock en par with administrative, political or economic changes. Hayes (2008) argues that the relationship between ICT and institutions should be seen as conflicting and dialectical, thus providing space for change. Institutional Entrepreneurs can use this conflict to promote change, and

as a way of challenging the status quo. For example, the introduction of computerized HIS creates a technological disruption as it involves deinstitutionalizing (Oliver 1992) existing institutions of maintaining paper based records, manual compilation of monthly statistics, and the physical movement of data. Likewise, it can potentially change power relations as it necessitates different skills and knowledge amongst actors around the technology. The technology can empower different actors, and marginalize others. Thus, bringing technology into a "structure" of an organization can change the structure itself. However, the disruptive force of technology can be given too much importance. It has been noted that organizational practices seem to be more durable than technology when they are in opposition (Webster 1990).

Resistance to IE can be understood through the analysis of conflicting, and sometimes incompatible, institutional logics, or "socially constructed historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality" (Thornton and Ocasio 1999 p. 804). Institutional logics represent meta-rules, higher-order belief systems that shape the institutional change processes, such as political, economic, cultural traditions. In the case of HIIs, different institutional logics co-exist, such as logic of central vs. decentralized decision making, whose interplay shapes implementation processes.

There are different institutional logics at play within capitalist and socialist economic systems, within different forms of government, religion, and organizational structures. The essence is that actions may not be based on rational choice, as according to the traditional view of organizations (North 1990), but rather on what seems rational within the boundaries of the institutional logics (Thornton and Ocasio 2008), which are often tacit. As such, the scaling and use of HIIs can differ according to which institutional logics are at play (Hayes and Rajão 2011). The differences in institutional logics between designers and users can shed light on the conception-reality gaps behind many failures to sustain and scale health information systems (Heeks, Mundy et al. 1999). When scaling HIIs, such institutional logics will influence the direction of scaling and how successful this will be. For instance, an institutional logic of epidemiologic surveillance is to effectively identify and address outbreaks of communicable diseases. To do this, the respective HII must support the pinpointing of sick patients to a small geographic area, at least a facility, and within a short matter of time. To achieve this, scaling the HII to lower levels of the health

hierarchy may take precedence over scaling up in other dimensions, which may be seen as just as important following other, competing institutional logics.

Institutional logics are useful to understand scaling in that they shed light on the action of human actors. For instance, Feldman and March (1981) has shown how the symbolic value of information to signal efficiency in organizations contribute to the collection of excessive information. This can be explained as an institutional logic; where you collect and hoard otherwise useless data to show other actors that you are doing your job and have control of the situation. In the health sector, this tendency to excessively collect data has been called a "data-led" approach, where the data is seen as the end in itself (Sandiford, Annett et al. 1992). This data-led collection logic has a huge influence on scaling HIIs, as it shifts focus towards achieving large volumes of data. This is in contrast to the action-led logic, where the focus is not on the data itself, but on the use of it for decision-making (Braa and Hedberg 2002).

Another concept from institutional theory is useful to understand processes of scaling is that of isomorphism (DiMaggio and Powell 1983). Organizations that are linked together by competition in production of similar products or services constitute an organizational field (Avgerou 2002), which can also be seen to include ICTs and the formal and informal practices that surrounds them(Piotti, Chilundo et al. 2006). The organizational field also influences how organizations and institutions change. Organizations do not always act in a rational (profit-maximizing) way, but tend to imitate successful organizations in their field, regardless of matters of efficiency, contributing to a homogenization of organizations termed institutional isomorphism. As will be shown later, this resembles the generification concept (Pollock, Williams et al. 2007) applied to software development. Within the institutional field of health provision, organizations will tend to become more similar, also applied to their choice of ICTs and their emerging HIIs. Such institutional isomorphism are attributed to several factors; coercive, including political pressure and legislation; normative factors like the educational systems and influence of the professions; mimetic forces when faced with uncertainty (DiMaggio and Powell 1983); and evangelizing efforts by institutional entrepreneurs (Powell 2007).

 I have in the preceding two sections looked at what I argue are two main drivers of scaling; integration and institutional change. Integration drives scaling by being a necessary requirement from an end-user's perspective of getting access to data from

various sources, which are embedded within existing HIIs. Integration must take place at various levels simultaneously, namely the syntactic, semantic, and pragmatic. Scaling through integration thus means that efforts must be directed towards at least these three levels; technical interoperability, alignment of meta-data and definitions, and organizational negotiation between the owners, developers, and users of the HIIs. The second main driver for scaling identified was institutional change, and especially efforts by institutional entrepreneurs in using technology as a lever to promote this. Institutional logics, the underlying assumptions, traditions, values and beliefs behind behaviour and decisions, was identified as a main factor in such change efforts. Differences in institutional logics can explain both intention for and resistance to change, as well as unintended consequences of the promoted change. Having looked at these factors for scaling, and the dimensions involved, I now turn to the effects of scaling on the technology in a wider perspective. I do this by focusing on multi-site scaling, and the processes of generification and particularization.

4.4 Global scaling and the tension between the general and particular

In the previous sections, I set out to provide a background for approaching the multidimensional and multilateral nature of global scaling. By looking at literature concerning scaling, technology transfer and translation, and the mechanisms around integration and institutional change, the issues concerning multidimensionality have been addressed. However, multilateralism has not been given equal attention in this literature. In this section I will thus look at promising concepts to also establish an understanding of this phenomenon. As a point of departure, I do this by consulting research on generification.

4.4.1 Generification as a scaling strategy

Generification is a term describing the process of producing generic solutions, and has been identified as both a strategy for and implication of scaling (Johannessen and Ellingsen 2009). As a technology is developed at multiple sites, or scaled from one site to another, the variation between them will tend to drive development towards generic solutions that can be used across the sites. Generification is thus an interesting topic because it also considers feedback and feed forward mechanisms of HIIs; adoption in one place is not only influenced by the local context, but also by other contexts that feeds into the development of a shared technology.

Generification has been described mostly as an intended strategy to scale. In research on development of global Enterprise Resource Planning (ERP) systems, Pollock, Williams, and D'Adderio (2007) explain how different potential customers were included in the development process to negotiate common requirements. The aim was to avoid particularization, i.e. making the software too tied to a certain localization that it would not be useful to others.

"The software packages might be thought to have a promising future or 'career' ahead of them; promising because the effort to create a generic technology required moving towards maturity in order to escape particularization" (p. 270).

In order to escape particularization, the technology needs to be dismantled from its original implementation, like in an HII, and reconfigured in other settings. This, they argue, can happen through three different trajectories. First, as generification towards universally adaptable solutions. Second, by becoming poly-generic, where a few "generic" modes are needed to cover the needs of the user base. Thirdly, by what they call generification of the particular, where a particular customer does not at the moment share requirements with other customers, but are given attention in the hope that a generic solution to their problem will be attractive to others.

The study of the ERP package describes a situation where vendors set out from the start to create generic solutions. Johannessen and Ellingsen (2009) have in contrast looked at a single-site developed health system at a single health facility, and the ex post generification process. When first developed, this requires knowledge of the installed base that extends beyond the scope of the system itself. The locality then gets inscribed in the system, and the dismantling from this locality poses a different challenge than seeking generality from the onset. In the tension between the particular and the general, the particular is already entangled in a working HII where it was first developed. The first tension in the case described by Johannessen and Ellingsen came through integration with other departments at the same health facility, which had different technologies and work practices.

The two studies (Pollock, Williams et al. 2007, Johannessen and Ellingsen 2009) have two further commonalities. Firstly, they note that hierarchies of users develop, where some users are given more importance than others when it comes to inputs of user requirements. The hierarchy of users is guided towards potential to either earn money now, or in the

future by developing anticipated re-usable solutions. Users who are not seen as contributing to this are not prioritized.

The second is that both studies use the Biography of Artefact (BoA) perspective. The BoA perspective takes the full life history of an artefact into consideration, and is a response to the tendency of IS research to look at either design or use, and not the two in tandem, and to be too limited in scope of time and space (Pollock and Williams 2010):

"In articulating relevant aspects of the BoA perspective below, our work seeks instead to expand the focus of research longitudinally and across different social settings and scales, addressing multiple moments and sites of innovation, and encompassing different of what has been described as the systems development cycle (design, selection/procurement, implementation and use), and the multiple such cycles that constitute the product cycle for a particular artefact "(Pollock and Williams 2010 p. 3).

The BoA perspective thus focuses on the duality of design and use in many sites, over time. It is through this duality that generification happens, as the multi-site and longitudinal variation shapes the development. This is either done intentionally, as by a vendor seeking generification to reach larger markets, or unintentionally, as in many open source projects with distributed development. The embedding of the artefact in a time-space point produces the here-and-now translations (Johannessen and Ellingsen 2009), much like the single case studies known from the technology translation field (Akrich 1992). BoA, however, looks at the aggregate of such translations, over the life-time of the artefact.

4.4.2 Circulating references

Pollock and Williams (2010) refers to Latour's model of circulating references (Latour 1999) as an alternative way of describing generification and the BoA perspective. Latour uses this concept to analyse how there is a gradual transformation of data during a research project in the Brazilian Amazon. At first, there are gridlines strung out over the border between savannah and forest, and in the grids there are all kinds of living and non-living material, which are sampled. Put into boxes and labelled, the data is translated from a environment to samples and specimens. Through successive steps or translations, the data is codified and sorted, until it ends up in a research paper, far different from the mix of soils and worms and plants in the Amazon. The model, graphically presented in the figure

below, can be seen to represent a process of scaling across abstraction levels and technology described in the example from the Amazon.
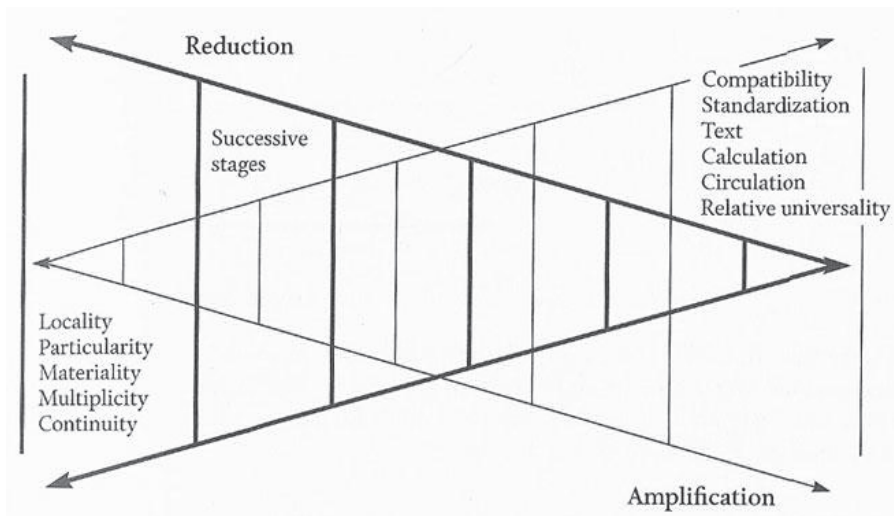
Figure 8 Loss/gain dichotomy of successive translation (Latour 1999)

The model shows how there is a gain and loss with movement along the horizontal axis. For each successive step from left to right, there is a movement from the local and particular towards universality and standardization, and vice versa for movements from right to left. Generification is a strategy intending to amplify universality, and reducing the local, which can be seen as taking steps to the right in this model. At each step, there is a translation taking place. However, there has been some critique of this model, in that it may indicate that the particularities are deleted, erased, as one move towards generality (Pollock, Williams et al. 2007). Rather, influenced by Turnbull (2000), generification should be seen as the aggregation of particularities. Hence, rather than seeing two different users offered one generic solution that prescribes the same behaviour, the one generic solution should also be flexible, allowing the different users to use it as if it was particular. In an example of developing a software package for universities, Pollock, Williams, and D'Adderio (2007) show how the functionality for managing students' payments were made generic in this way. Rather than settling on a single generic way to do this, generification meant that increasingly diverse and flexible ways of handling this was incorporated. Students could pay fees up-front, or in equal instalments, or in unequal instalments defined by the user, etc. Functionality around this kept being added as more universities voiced their different requirements.

While there are good reasons to see generification as an aggregate of particularities, there is also an ongoing process of loss and gain. In the same ERP and university system examples, a hierarchy of users would develop, and there would be a marginalization of certain group of users deemed less profitable. While the functionalities become generic because they allow more particularities, they also become more complex and in need of initial configuration.

The above arguments are relevant for global scaling of HIIs, and contrast the diffusion argument by Rogers (1962) brought up earlier. The circulating reference model is not only useful to understand that there is an ongoing technology translation through scaling, but also what such translation leads to. In general, there will be a tendency towards generification as an aggregate of particularities. However, there will still be loss and gain involved. For instance, participatory development will be increasingly challenging with larger scale (Monteiro, Pollock et al. 2012). This is very relevant for the case this thesis builds upon, with an foundation on participation that has now become challenging as over 30 countries are using the software DHIS (Braa and Sahay 2012). To engage in multi-level on-site participatory development in all countries, a vast number of people would have to be employed, and the core software development model would have to be changed to accommodate the increased participation.

4.4.3   Characteristics of circulation

Having seen how the generification process can lead to an amplification of the general, through aggregated particularities, it remains to be explained how this takes place. What moves, between space and time, to become translated and circulated among the localities that contribute to this process? In Latour's example, it was originally soil samples from the Amazon, but then later codified notes, which is represented with the reduction of particularity (the living soil) towards amplification of generality (codes). So there is a translation taking place. There is a translation into other objects, such as books, models, and presentations. In the case of ERP systems described earlier, it was a software that circulated between designers and users from many localities.

With this software, also come the ideas, routines, institutional logics that have been inscribed in it: "What is being transferred from one setting to another is not an idea or a practice as such, but rather accounts and materializations of a certain idea or practice" (Sahlin and Wedlin 2008 p. 225). Latour has earlier himself described how such

translations take place, as "the spread in time and space of anything – claims, orders, artefacts, goods – is in the hands of people; each of these people may act in different ways, letting the token drop, or modifying it, or deflecting it, or betraying it, or adding to it, or appropriating it" (Latour 1986 p. 267).

The circulation of translations that drives generification thus takes the shape of materialized artefacts. However, there is a distinction between physical hardware, which circulate slowly, and electronic information, which can circulate much faster. The latter, by being circulated much easier, speeds up the rate of translation: "Translation is speeded up, made continuous and magnified by technology: more specifically, by mass storage, mass reproduction, and mass media technologies" (Czarniawska-Joerges and Sevón 1996 p. 24). Importantly, "information flows have been dematerialized from place. With digitization, information adopts patterns and modes of mobility substantially separate from material form or presence" (Urry 2003 p. 84). There are thus substantial differences in the speed of circulation, and attachment to space, between material and digital technology. In addition, digital technologies can also be argued to hold more interpretive flexibility (Orlikowski 1992), in that they can more easily be modified, or translated, than more physical machines, as the equipment for this itself is detached from place. Software can be modified with knowledge and tools which are also available in digital form.

4.5 Summary and proposed view of global scaling

From the literature on IS scaling, there emerge a range of dimensions through which this takes place. Technological capacity, amount and types of users, user maturity, geographical width and depth, and functional scope can all be the focus for scaling. Scaling is thus multidimensional, and scaling can be seen to scale up complexity.

From the field of technology transfer an important insight is that technologies are learned, adapted, and modified in different ways, depending on the local context. This, known as technology translation, is a useful concept to describe unanticipated use of technology in a new setting. However, the literature is quite insufficient when looking at global scaling, as it treats translation as a unilateral process, in one place.

Two mechanisms have been identified as overarching in shaping scaling; integration and institutional change. Integration is a primary result of HIIs being embedded in other (H)IIs, and is also often a reason for scaling itself. A global consensus on the need for integrated

health information systems drive such developments in many countries, and has also been a powerful force in the projects of my empirical material. This also leads to institutional change, which can be promoted by certain actors, called institutional entrepreneurs (IE). IEs can see the introduction and scaling of new HIIs as a way to change institutions. This interaction between institutions and technology can be seen as conflicting, with potential for change, but is not necessarily a recipe for success. An important reason why this is so is that existing institutional logics become "victorious" in resisting this, or making the change processes deviate in unforeseen directions.

The concept of generification brings in the multi-site dimension of global scaling by explaining how HIIs will increasingly become more generic as a variety of users and context come into play. This can be intentional, as a scaling strategy by for instance vendors seeking to expand their market, or unintentional as a matter of accumulation of technology translations. If such translations circulate and are re-translated by others, there will potentially be a drift towards generic solutions. As technology has become increasingly dematerialized and more digital, coupled with increased ease of transmitting such digital material, circulation and translation of technology have become easier and faster. The process of translation has been sped up, in turn increasing the speed of generification.

I conclude this chapter by proposing a view of global scaling of HIIs as one of "circulation of translations", where generification is the result of aggregated particularities. The questions remains, however, through what mechanisms does global scaling take place. That is an empirical question which my field work will focus on.

5 Research findings

In this chapter, I will present findings from six research papers included as part of this thesis. The first five papers have looked at scaling in more designated geographical areas, while the last, which is also the most recent, has developed a more theoretically informed perspective on global scaling, including interactions between materiality and global scaling processes. The papers all come from work with the HISP network, on strengthening health information systems in African and Asian countries.

I begin by presenting the six papers and their main findings. Then I continue with a discussion on how they together contribute to the understanding of global scaling of HIIs, and help answer my research questions. This discussion helps to provide the foundations for my contributions presented in the following chapter.

The papers are ordered by date of publication. In the cases the papers concern health information systems, HIS, I have in this thesis used health information infrastructures, HII. The two terms are, related to the aspects discussed in this thesis, interchangeable.

Paper 1: A Flexible Approach to Integrating Health Information Systems – The Case of Data Warehouse as Integrator in Botswana

Sæbø ,J; Braa, J; Chandna, O, Proceedings of the IFIP WG 9.4 Conference on Social Implications of Computers in Developing Countries, Sao Paulo, 2007

This paper looks at work done with HII strengthening in Botswana 2005-2007. Using a complex adaptive system (CAS) framework, the implementation of a data warehouse for the health information system is explained through the notion of an *attractor* (Plsek and Wilson 2001, Braa, Hanseth et al. 2007).

The original situation in Botswana was one of outdated data, duplication of data collection efforts, little local use of data, and differences in resources among the various actors involved in the HII. The main problem, though, was one of fragmentation. The organizational complexity of the Botswana HII was fairly high, with many actors involved. Four ministries were responsible for various aspects of the HII, and with also the various health programs in charge of their own data, many independent subsystems had been created. The situation was summed up by a senior official in the Ministry of Health; "there is no way to access or get overview of the essential information from across the various

health programs and sectors. The only way to get an overview is to visit the individual offices one by one and thereby compile your own data, and that is not good enough". The paper is thus fundamentally about scaling the HII through integration, and how fragmentation impedes scaling efforts.

The intervention the paper describes was one of setting up DHIS version 1.4 as a central data repository in four pilot districts and the national level, to have a base from which to work on harmonization of data collection forms and a reduction of the fragmentation of information streams. Using the data warehouse as an attractor, all actors were given the chance of participating in the new integrated HII without additional costs, i.e. gaining without risking losing anything. This was done by allowing them to get their data on their preferred format, either in the new data warehouse or exporting it from that to another software. The data warehouse became a focal point towards which the various actors' actions were aligned. The concepts of *gateways* and *border objects* (Hanseth 2001)were important to understand how actors are aligned around the attractor. Having a flexible data warehouse that allows customization of the user interface to the various actors' needs and wishes was important as a gateway to the single, integrated platform. As such, generification, which was not explicitly dealt with in the paper, was an important process. The allowance of multiple, customized user interfaces were a generic solution to allow the many particularities to co-exist. As a result, a certain degree of integration was achieved.

In terms of scaling, the process described in this paper is one of functional, or programmatic, scaling , through integration. While the geographical uptake of the data warehouse was slow, the uptake by various health programs was an important scaling process to achieve the integration of their information systems on a common platform. The approach became attractive in a resource scarce environment because it offered gateways that would ensure the continuation of the health programs' independence, while at the same time offering a data collection and analysis tool that is maintained jointly by the other health programs.

Paper 2: Interplay of Institutional Logics and Implications for Deinstitutionalization: Case Study of HMIS Implementation in Tajikistan
Sahay, S; Sæbø, J; Mekonnen, S; Gizaw, A, Information Technologies & International Development, Volume 6, Number 3, Fall 2010, pp 19-32

The second paper looks at HII implementation in Tajikistan, covering events of 2007-2008. The authors were involved in proposing and piloting a computerized health management information system based on a proposed complete overhaul of the current data collection tools, as well as in planning for the scaling up of the system. The overall objective was the same as in Botswana above; strengthened routines and opportunities for information use at local levels through the establishment of district and national data warehouses. Contrary to Botswana, though, it was not fragmentation that was the main challenge, but the enormous amount of data the existing system was designed to capture and process at the national level. Also, in contrast to Botswana, the work was focused on the national rather than district level. The software used for the data warehouses was DHIS2, which was still quite immature in many aspects.

The paper focuses on the interplay of two main paradigms; that of Soviet central planning and that of decentralized health management, that the authors were promoting. These paradigms encompass several *institutional logics* (Thornton and Ocasio 2008), which govern human and organizational action. The institutional logics found in Tajikistan were those relating to centralism, statistical analysis, "gigantomania" in terms of using information collection to signal seriousness and scientific vigour, coupled with a rigidity of paper-based technologies. The proposed solution, on the other hand, was based on the logics of decentralism, action-led analysis, and the flexibility of computer-based information systems. The interplay of these opposing institutional logics revealed that the political domain of the HII had a great influence over the functional domain, so much that a complete deinstitutionalization of the current practices, tantamount to a paradigm shift, would be necessary to initiate and scale the proposed solution. This would not take place within the scope of the described project, but a seed had been sown, and other organizations, like the Asian Development Bank, would continue to exert pressure to change the ruling logics.

At the same time, this study took place when the DHIS2 software was relatively young. The forces at play in Tajikistan very much contributed to the development of functionalities to accommodate large data collection requirements, through the multidimensionality of data elements and data entry screen in the software. While you earlier had to define separate instances of for example "Malaria, Male < 5 years", and so on for both sexes and all age groups, you could now define once, and reuse, the age groups, sex, and any other dimension of the data. This made it much easier to set up and

manage large tabular data reporting forms, which had previously been discouraged as it typically put emphasis on data collection instead of information use. This had other implications in other countries, and was not discussed further in this particular paper. In hindsight though, this is an example of generification and translation that is evident in all the papers included in this thesis. The added functionality in DHIS2 was the result of a process to both accommodate the large scope of the existing data requirements, and a strategy to be able to scale within the political context of Tajikistan which did not permit any change at that time. Without this support, the legitimacy locally of DHIS2 would evaporate. The generification around DHIS2 in Tajikistan can be seen as coming out of the interplay of institutional logics, between the Soviet logic of a strong statistical focus in a centralized system, and the "HISP" logic of decentralized decision making through collection of essential data only. In this interplay, the Soviet logic can be seen as the dominating one in the short run, and the generification of the software as the accommodation of HISP to still be able to scale. As of 2013, Tajikistan is implementing DHIS2 nationwide and reforming their HII, with a renewed focus more in line with traditional HISP logic supporting local information use.

Paper 3: Comparing strategies to integrate health information systems following a data warehouse approach in four countries

Sæbø, J; Kossi, E; Titlestad, O; Tohouri, R; Braa, J; In Elaine Byrne; Brian Nicholson & Fadi Salem (ed.), *Assessing the Contribution of ICT to Development Goals,* Special Issue of Information Technology for Development, Volume 17, Issue 1, 2011

Comparing South Africa, Zanzibar, Botswana, and Sierra Leone, this paper looks at four models of approaching integration of vertical health information systems. Projects in these countries opted for harmonization of health data reporting forms to be collected from facilities with a common software; DHIS versions 1 and 2. The strategies opted for were a) agreeing on a common essential list of indicators for DHIS while not tackling the overlap and inconsistencies of existing systems (South Africa), b) duplicate the existing system directly in DHIS without any harmonization (Botswana), c) solving the inconsistencies before implementing DHIS (Zanzibar), and d) solving the inconsistencies in the database, but leave them in the paper forms used at facilities (Sierra Leone). A key finding in all countries was that the strategy for integration needs to be rooted at the institutional and organizational level. While this was the case from the beginning in South Africa and Zanzibar, it was also used in Sierra Leone through the "shortcut" of integrating

only at the technical level in the database first. Here, the DHIS became a boundary object where the various actors could engage in the integration process. The relative lack of success in Botswana can be analysed as the failure to create such a boundary object, as the software for the HII was maintained by the IT department in the Ministry of Health, which created a professional gap between the users and administrators of DHIS.

A relevant aspect of this comparison to the wider theme of scaling is that of path dependencies and lock-in effects. While Sierra Leone took all existing forms "as is" into the DHIS, without any efforts towards rationalization beforehand, this did not preclude later harmonization; on the other hand, the "integrated" system served as a vehicle for harmonization later. In Sierra Leone, the technology was thus used to prepare the environment for institutional change. Again the notion of attractors is used, to show how the key tool towards integration is to provide some common ground for the various actors involved. Being able to span the boundaries of sub-systems within the wider HII, and provide a technical platform that allows each actor to continue with the routines of their sub-systems as they please, a first step towards integration was achieved. How this was done varied between the countries, as illustrated in the figure below.

While South Africa had first agreed on an essential dataset with no overlaps, the other three countries had an initial situation of some overlap between the different datasets before integration. As the illustration shows, Zanzibar sorted this out beforehand, so that the integration in a single data warehouse could be implemented without further ado. In Botswana and Sierra Leone, the current political environment at the start of the projects did not allow for such harmonization prior to integration. While the solution in Botswana was to carry on the duplication into the integrated system, in Sierra Leone, partly based on the learning from the Botswana experience, the integration was sorted out in the database but kept in the paper forms still used at facility level.
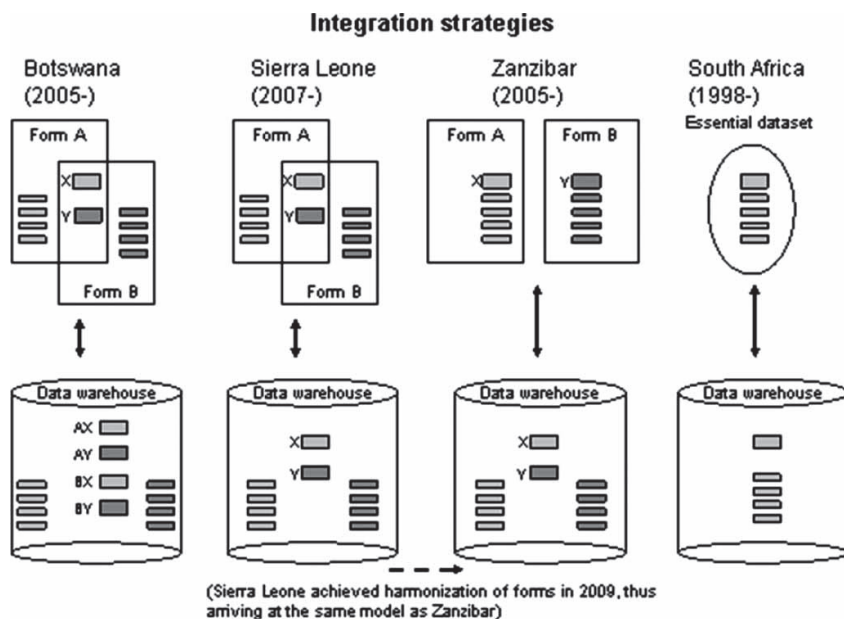
Figure 9 Four strategies of integration

The paper presents the outcome of similar efforts in four countries, and contributes to the theme of this thesis by showing how an idea circulates between, and is translated in, different contexts. While only Sierra Leone used DHIS2, and the others used DHIS1.4, the differences in the software did not really matter for this issue. What we see is that the idea of integration that has circulated between the countries, or more appropriately out of South Africa, via Botswana and Zanzibar, to Sierra Leone, has been translated in each country based on two criteria. The first is the local context and possibilities and challenges around integration, and the second is the experience with such efforts in other countries. The four different strategies for integration discussed are thus based on both the local and the global.

Paper 4: Networks of networks – collaborative efforts to develop Health Information Systems across developing countries

Sæbø, J; Braa, J; Sahay, S; Kossi, E; Settle, D; Proceedings of the IFIP WG 9.4 Conference on Social Implications of Computers in Developing Countries, Kathmandu, 2011

This paper looks at scaling of health information systems in two directions not covered by the other papers; scaling of an HII architecture through interoperability, and international scaling throughout the West African region.

Initiated as a pilot in Sierra Leone, interoperability between two open source applications for health, DHIS2 for aggregate data and OpenMRS for medical records, became an attractor for a group behind a third application, iHRIS for human resource management. Basing the interoperability on the WHO-led SDMX-HD standard for data exchange, the proof of concept from Sierra Leone was an answer to what many countries in the region struggle with; various applications in use with no sharing of data. The exchange standard is of secondary importance in this story, more importantly is how it works as an attractor to bring the various development communities and users together. The "Networks of Networks" concept describes how interoperability between the open source applications not only bring these applications together, but also the networks around them. This comes with important synergies. For instance, the Health Metrics Network and University of Oslo, responsible for the DHIS2 implementation in Sierra Leone, have certain legitimacies and capacities, while the groups associated with the other software applications have others. Complementary legitimacies made the interoperable architecture extremely potent, leading the West African Health Organization (WAHO) to promote this solution for it's member countries.

The second aspect of the case relates to the potential for WAHO to play an important role for scaling of HIIs across the region. Cross-country standardization needs international brokering, and WAHO represent a "middle-layer" between the more global WHO, and the "local" ministries of health and their project partners. The strengths of WAHO is that it holds this international role while being close to the countries; it consists of the 15 West African states as a health division of the ECOWAS (Economic Community of West African States).

At the time of writing, WAHO has developed common HII policies for the region, as well as helping countries implement HII reforms according to these policies. The triggering events for this large-scale implementation were the proof of concept of interoperability using open standards, and the architecture-enabled network of networks of interest groups.

Related to sustainability, the regional collaboration is also a potential remedy in a context of weak national institutions and capacity in the area of HII. By developing a community

of practice at the regional level, the countries can benefit from an extended pool of expertise, funding, and development.

With WAHO providing regional legitimacy, the concept of interoperable architectures for HIIs gained momentum across West Africa. While a few countries had already begun piloting DHIS2 or one of the other applications, there are now only a few that are not using DHIS2 at all, and in several it is the national data warehouse for most health data. Related to regional scaling, we see a few artefacts circulating between the countries; the software, the WAHO policy document, and reports and flyers made by groups such as HMN. The paper thus also describes how ideas around HIIs circulate between the countries, opening up for local translations. For example, the ideas of interoperable architectures, of decentralization of information use, and a national data warehouse spread through the sharing of the above mentioned artefacts, being interpreted and adapted across the region.

Paper 5: Developing decentralised health information systems in developing countries –cases from Sierra Leone and Kenya

Sæbø, J; Braa, J; Kossi, E; Jalloh, M; Manya, A; Journal of Community Informatics, Volume 9, No. 2, 2013

This paper looks at how community participation in both the development and use of health information systems has led to a situation where communities themselves are taking active part in improving their health status. It touches on several issues; participatory design, effects of transparency, and the appropriateness of internet technologies in developing countries.

Using cases from Sierra Leone and Kenya, this study shows how country health information systems, producing simple information products such as quarterly bulletins and league tables being distributed widely, have enabled the communities to engage to improve the health status of the population. An environment of transparency of health data, fostering a culture of community competition around key health indicators, was integral to the results, and shows that the communities are as dependent on data from others as they are on their own data. Three main contributors to success in this regard have been identified. The first is involving the communities in the development and use of the HII. Then, sharing data among communities in a transparent and mildly competitive manner. Finally, as the case from Kenya shows, using a mix of cloud computing and offline support

to further facilitate the above points, also for communities not regularly connected to the Internet.

It is clear from the case that communities are not just users of the information system, but they are also participating in its development and shaping the way information is handled and used at the community level. Conceptualising information systems as social systems, cultivation is used as a metaphor to understand how culturally appropriate information systems may be developed through local commitment and bottom-up participatory processes. At the technical level, the cases demonstrates how modern ICT and Internet technologies are becoming "appropriate" even for rural communities in Africa.

This case from Sierra Leone shows that while the HII needs to be based on local ownership and freedom to define its requirements, the system must also include the national standards in order to be useful in a wider national comparative perspective. This implies that community HII need to be connected in a larger, national HII and that routines for feedback and dissemination are in place. The case shows how communities are leveraging the national integrated data warehouse in Sierra Leone to make local decisions, which would not be possible without the wider system.

Related to scaling, two issues are worth highlighting. The first stems from the differences in infrastructure between Sierra Leone and Kenya. In the former, each district needed a local installation of DHIS2, since internet connection was not available. With only 13 districts, this was just about manageable with regards to keeping the software updated and the 13 district databases in synch with the national database. In Kenya, with an order of magnitude of more districts, this distributed model would have become extremely resource consuming. Luckily, modems using the cellular network managed, with some extra functionality developed for robustness, to keep an online implementation a viable option. In both countries, using the same software, the resulting HIIs thus became very different. The infrastructure directly influenced how the software could be used, what practices and routines could be developed, and what ideas for information use could be pursued.

The second issue is that of national diffusion of practices, like the league table in Sierra Leone which ranked the districts according to a few key indicators. Some districts picked up this idea, and on their own initiative started ranking chiefdoms (sub-districts) in the same way. There were some adaptations to this practice at the district level though. The paper presents the case of one district who also started producing diplomas for the best

chiefdoms, and made a ceremony of awarding these at the monthly review meetings. This created a stronger sense of competition, and the paramount chiefs became more involved in the priorities of the health administration.

Paper 6: Scaling of Health Information Systems in a Global Context: Same, same, but different

Sahay, S; Sæbø, J; Braa, J; Invited paper, in review, Information and Organization

This paper presents the story of scaling of the DHIS software and associated practices and principles across the globe, and in particular in India, Kenya, and Sierra Leone. Empirically, the story of DHIS is told from its birth in the mid-nineties in South Africa developed on a Microsoft platform to its transformation to a web-based platform, built using Java based open-source frameworks, and now moving through multiple countries. Both domestic and international scaling is tracked, and the key contribution is to conceptualize scaling as a process of translation. Informed by theories around technology transfer and translation, a framework is developed that sees scaling as incremental steps of circulating translations. Informed by the concept of circulating references by Latour (1999), each such step can be seen as a dialectic process of loss and gain, and not as a linear process of expansion. We contribute to the technology transfer literature in arguing that the process of transfer is not about a "parachuting" from point A to B, or a "design from nowhere", but it occurs in a series of small steps, where with each step new socio-technical configurations are created. These configurations not only shape subsequent steps, but also redefine the content of the artifact. Compared to the work by Latour and Akrich (Latour 1986, Akrich 1992, Latour 1999) that motivated this paper, we have dealt with a very different technology in terms of it's "virtual immateriality". The artifact, a software, can easily be circulated from one context to another, increasing it's potential for translation. Also, there are less physical restrictions to modifying and changing it, if not proprietary. Coupled with the growth of web-based and mobile infrastructure, this allows ease of circulation across contexts, where it gets redefined and embedded at the same time at the interconnected levels of the global and local – a process we conceptualize as global scaling being "same, same, but different".

We discuss both the characteristics of this process of global scaling, and the channels and mechanisms through which it takes place. Four overlapping conditions that shape this process include the software itself, the infrastructure, institutional practices, and ideas –

this forms the basis for a general framework to understand global scaling of health information systems.

5.1 Summary of papers

The following table summarizes the papers in terms of the trajectories of scaling taking place, and main theoretical concepts used to analyze this.

Paper	Location and dimensions of scaling	Key concepts
A Flexible Approach to Integrating Health Information Systems – The Case of Data Warehouse as Integrator in Botswana	Inclusion of health programs in data warehouse. These actors were enrolled in an integrated data warehouse project by offering a flexible solution that would bring benefits without compromising current activities and ownership	Attractor Gateways
Interplay of Institutional Logics and Implications for Deinstitutionalization: Case Study of HMIS Implementation in Tajikistan	Scaling taking place in the functional domain of the software, but not in the political domain of practices and ideas. Various dimensions of HII "locked" in present status.	Institutional logics Deinstitutionalization
Comparing strategies to integrate health information systems following a data warehouse approach in four countries	Integration of health information subsystems in a single data warehouse. Various strategies and successes in doing this in 4 countries	Attractor Boundary objects.
Networks of Networks – Collaborative Efforts to Develop Health Information Systems Across Developing Countries	Interoperability: scaling functionally through interoperable software in a growing architecture Collaboration and legitimacy: building "networks of networks", complementing legitimacy of various HII-related groups and software to gain political acceptance	Networks of action. Attractor Interoperability and integration
Developing decentralised health information systems in developing countries – cases from Sierra Leone and	Scaling up practices and ideas of information use. Maturation of use and users.	Cultivation Participatory design

Kenya		
Scaling of Health Information Systems in a Global Context: same, same but different.	Scaling of geographical reach and practices towards information use within three countries; India, Sierra Leone, Kenya At the global level: scaling of software, practices, and ideas across many countries, over time.	Translations Circulating references

Table 7 Summary of the included research papers

5.1.1   Dimensions of scaling

In preparation for next chapter, I here provide a short summary of some of the key dimensions along which scaling has taken place in the cases covered by the papers. Common for all of them has been a thrust to achieve some kind of geographic scale, both horizontally across regions, and vertically down from the national level to districts, chiefdoms, facilities, and the like. This geographic scaling has at least two implications; first, that the amount of users and types of users increase, and second, that such scaling spans different infrastructural contexts.

In the case of types and amounts of users, the scaling process in Sierra Leone introduced the HII to around 10 people at the national level, who were either HIS Officers or heads of health programs. For the 13 districts in Sierra Leone, the core team of users would be the two health information officers, and the district medical officer (DMO), who is the manager of the district. While the national level health program officers would be more interested in a subset of the information, regarding their area (such as immunization, or morbidity, or HIV/AIDS), the DMOs would need a broader picture of the whole district transcending all programs. While the national level held a yearly planning meeting, the district organized monthly review meetings, with actors outside the health system present, such as paramount chiefs. So when scaling occurs across geography, various users with different needs become part of the system.

The geographic scaling also meant that the system would be exposed to different infrastructures. In Botswana and Sierra Leone, as well as in other countries covered by the papers, there are big differences in infrastructure and communications across the country.

This had practical implications in Sierra Leone, where low-voltage computers were applied initially, to deal with lack of reliable electricity in the districts. It also led to the adoption of local area networks, as DHIS2 could then be put on a dedicated Linux server in each district, to prevent breakdowns related to computer virus and the lack of connection to update anti-virus software. At the national level, this was not necessary to the same degree, as the Ministry of Health and Sanitation HQ had a central power generator and more reliable grid electricity supply in the first place. Comparing Botswana and Sierra Leone, however, reveals a larger difference when it comes to power supply and the availability of hardware at the district level. While Botswana is a much larger country than Sierra Leone, highways connect the country, and there are regular flights to the far-away cities. For support visits, I could rely on daily buses reaching all cities, while in Sierra Leone a 4WD car was necessary, and some roads would become unusable in the rainy season. So distance from periphery to centre was more than the geographical space between them, and support mechanisms for the HII had to take this into account.

An important dimension of HII is the functional, or programmatic, scope it covers. All the papers on Botswana and Sierra Leone show a process of integrating various health programs into a single data warehouse, either directly in one software, or more loosely with interoperability between different software. Here we can also see a difference between various "types" of data. For example, in Botswana only aggregate data was part of the system, which was covered by the DHIS software. In Sierra Leone, this was also the case in the early period. Later, however, with the preliminary work on interoperability, the overall system came to include also patient data, through the medical record system OpenMRS. Looking at the national data warehouse in isolation (only DHIS), this still has implications as more actors will be involved to make the interoperability work. The scaling of interoperability through an HII architecture, as described in the paper on "networks of networks", can have an exponential effect on the scale of the system as a whole. On the other side, it is also a way to isolating and "black-boxing" functional domains, where the alternative could have been to develop the desired functionality within the already used software.

Related to the functional scope of health programs, there is also a dimension of granularity and detail of data. The paper from Tajikistan provides an example of extreme granularity, where the full ICD-10 coding system for medical classification was part of the regular data collection process, often further subdivided into narrow intervals of age groups, and

gender. In such a way, even a single health program like mortality statistics may be expanded to cover thousands of potential data elements. The reason for this in Tajikistan was an institutional logic based on the central level use of such detailed medical data, to be discussed later in this chapter.

One often overlooked dimension is that which can be termed usage, or user maturity (Sahay and Walsham 2006, Shaw, Mengiste et al. 2007), which again has important, wider, spill-over effects. As the paper on community use of information shows, the use matured through the development of integrated league tables in districts in Sierra Leone. While the availability of data from various sources through integration was an early achievement, it took some time before the league tables were developed and modified at the district level. This followed the increased maturity of users both in relation to getting the desired data from the data warehouse and in relation to using and acting upon such information products. Furthermore, as a spill-over effect, the league tables contributed to increase transparency and accountability, two cornerstones of efficient public management.

In sum then, at least the following dimensions of scaling have been identified; geography, both vertical and horizontal, amount of users and different types of users, across different levels of infrastructure, scope in terms of data covered, types of data, and details of data, and user maturity and governance. In addition, there are technical characteristics relating to data processing and network loads.

5.1.2 Content of scaling

The dimensions of scaling visited in the papers say something about the directions or routes, but there is also a *what* in these stories. The dimensions are the containers of scaling, but it is the various parts of the HII that is the content. What is scaled across geography, infrastructural contexts, organizations and among a multitude of various users? I propose four concepts to describe this; infrastructure, software, practices, and ideas.

The first concept is that of infrastructure, encompassing physical hardware like computers, power grids, batteries and other sources of electric power, cellular network towers, cables, air conditioned rooms, etc. In Sierra Leone, improving and extending the infrastructure was a key focus area in the districts, and low voltage computers were installed there in the early phase of the project. In another example, internet connectivity was scaled up in Kenya by using mobile modems, which could work over the cellular network.

All papers are about scaling the software DHIS, with version 1.4 in Botswana and version 2 in the other countries. Accompanying this were auxiliary applications like appropriate operating systems and web browsers. The software was both scaled geographically, reaching new computers in new offices with new users, but also functionally. Adding more functionality to handle patient data, to increase variability of charts and reports, and to continue functioning as an online service even when internet connectivity was lost, represent scaling of the software.

In addition to the infrastructure and software, all papers visit the theme of scaling practices. This encompass all routines and ways of doing things, such as how health data is collected, processed, analyzed, disseminated and used, as well as supporting practices that take place in the society at large. In this sense, institutions, being "rules of the game" (North 1990) are treated as practices. As an example, a common way of organizing vaccination of children around the world is to organize it through local health facilities. However, in some countries this is complemented by vaccination campaigns where trained staff visits villages and communities since the facility-based vaccination does not cover all children, which again has implications for the HII. In Botswana, Sierra Leone, and Tajikistan, most health-related data was collected routinely from the health facilities, a practice that is shared with also other countries. However, the content of what is collected, and the interval, differs. Sierra Leone and Botswana collects most data on a monthly basis all the way from facilities to national level, while in Tajikistan it is mostly reported on an annual basis

The differences between the annual and monthly reporting of Tajikistan and Botswana/Sierra Leone can be traced back to different ideas, in this case ideas about the role of information. This is the last concept on content I have included. This includes institutional logics (Thornton and Ocasio 2008), but also ideas of organizations and technology. For example, ideas differ in relation the role of information, the virtues of an integrated data warehouse, and if decision-making should be centralized or decentralized. In Sierra Leone, the idea of a central integrated data warehouse was more refined than in Botswana, coinciding with a rising global tide of this as a preferred solution to the many challenges of health information systems. The idea of an integrated data warehouse have led to different manifestations, as shown in the paper on comparative solutions in South Africa, Zanzibar, Botswana and Sierra Leone (Sæbø, Kossi et al. 2011). This idea has gone through a maturation process, and it has a wider scope now than when first applied in

South Africa in the beginning of the HISP project. As such, the idea has both been scaled to new countries, but also changed itself over time.

What we see is that these four concepts of content, represent different levels of materiality. Infrastructure is the most material, consisting of physical artefacts. Software, being digital information, is not as material. However, it has a strong material connection in that it needs computers, networks and a power source to function. It is thus unable to be of any use without the supporting infrastructure. Practices, representing how work is organized, are not material, but linked to material artefacts such as tally sheets, monthly summary forms, computers, and other tools of collecting and reporting data. Ideas are the least material of the four. Again, it's manifestations are often material, but less so than the other three dimensions. For example, a vision of a decentralized HII, with a focus on a small geographic area like a district for health management, can exist irrespective of the infrastructure, hardware, software etc, in place. I sum up the four concepts in the table below, which cover the content of the scaling, and their associated materiality.

Concept	Level of materiality	Example
Infrastructure	High, physical objects	Hardware, electricity, buildings, networks, support structures
Software	Medium, dependent on infrastructure	Digital information, but need some computing device and electricity, local support
Practices	Low, prescribed by physical objects	Often linked to using and producing "material" objects, like vaccination, reporting, evaluation.
Ideas	Immaterial	"Information for action", vision of data warehouse

Table 8 Summary of four conceptual dimensions along which scaling takes place.

The content and materiality of the identified concepts have important and varying implications on scaling. Infrastructure, being the most material, naturally is difficult to move from one location to another because of the physical elements involved. Software, which is relatively less material, can circulate more easily through the medium of the Internet. However, for that to happen, they require the supporting material infrastructure of computers, internet, etc to be in place. This makes it relatively more difficult to circulate

than practices and ideas, which move through movement of people, best practices, presentations, documents, and the like.

These different elements, with their varying degrees of materiality, interact with each other in different contexts in specific ways. There may be certain contexts where introducing new ideas is difficult as existing ones are strongly rooted. Strong existing legacy systems may make it difficult in certain contexts to introduce new software and infrastructure. The manner in which these four concepts interact with each other and shape scaling processes is termed as "interaction effects." Across multiple contexts, where each have their own interaction effects, there are different forms of influences, which are further termed as "constellation effects." Both these effects are further elaborated in the next chapter, providing the foundation to propose a theoretical model on global scaling of HII.

6 Implications

The main research aim of this thesis is to develop a theoretically informed model of scaling of HIIs in a global context. I earlier outlined some particular aspects I would look at to help build such a model, such as dimensions of scaling, and their varying levels of materiality. From the dimensions and concepts identified in the previous chapter, I in this section abstract from this analysis to develop broader theoretical implications. I include also in this chapter implications for practice and policies, and also for methodology of doing research on global scaling.

6.1 Implications for theory

I will in this section look at implications of my analysis for theory, leading to a model for analyzing global scaling of HII. I take as a point of departure the identification of four concepts relating to the content being scaled, and especially their differing levels of materiality. Since levels of materiality have implications on the ease or not of how HIIs are circulated across contexts, they have implications on the levels of "interpretive flexibility" they are susceptible to. In the first section, I expand the concept of interpretive flexibility (Orlikowski 1992) to show how the content of scaling lends itself to different levels and types of translations (Latour 1986, Akrich 1992). In the following section, I explore two contextual effects that contribute to these translations , one at intra-contextual level and the other at the inter-contextual, and I present some key mechanisms that drive them. This leads to the formulation of a model of global scaling, and its theoretical contributions in relation to the reference disciplines of technology transfer and information systems scaling. Next, I discuss implications for policy, practice and methods.

6.1.1   Materiality and implications for scaling

The differences in materiality of the four concepts have implications for what is scaled, how that scaling takes place, and the interactions between the existing systems and practices, and the new. These implications can be formulated as:

- The less material something is, the more interpretive flexibility it holds

- The less material something is, the faster and with lesser effort it can be moved across contexts

Interpretive flexibility, as used by Orlikowski (1992), applies to the scope for users of technology to change it, physically or socially. In other words, it is a measure of how easy or not it is for users to change the technology itself, or use it differently than anticipated by the designers, also labeled as change-flexibility and use-flexibility by Hanseth (2001). Orlikowski differs between more or less rigid technology, focusing on the software and infrastructural aspects of it. I have argued for also practices and ideas to be considered while analyzing scaling. Thus, it is not only infrastructure and software that holds interpretive flexibility, but also practices and ideas. As the two latter are less material, and so easier to move around, they arguably hold more potential for interpretive flexibility. Practices and ideas are less tied to physical objects, and can be changed and tweaked considerably without being forced "back in line" by physical limitations. As an example, from Tajikistan, the hardware and software used to collect health information could do so in a limited way. Though the DHIS2 software could be adapted to focus on large-scale, yearly, data collection, it could at the time of implementation only collect aggregate data statistics, not individual patient data. It's use-flexibility was high in the aspects of periodicity and amount of data to be collected, but low when it came to including the different types of data. For the idea and associated practices related to a central data warehouse and decentralized decision-making, the interpretive flexibility was higher. The idea of a central data warehouse was readily adopted, but the aspects relating to decentralization were not, as they conflicted with the earlier existing central structure.

The second implication is based on the ease of transmitting digital information as compared to physical objects (Czarniawska-Joerges and Sevón 1996, Urry 2003). While a distinction can be made between the digital and the non-digital, all four concepts are linked to material objects in different ways and degrees. This relates both to how they are actually communicated, and the objects they are dependent upon to be put into use. For communication, even practices and ideas move through the use of written documents, presentations, and the like (Sahlin and Wedlin 2008). Then, all concepts are more or less tied to artefacts; Infrastructure requires the physical installation of material goods, like buildings and hardware. Software can be digitally transmitted, for instance over the internet, but still needs a computing device, internet, and electric supply. Practices are even less tied to physical objects than software, but not detached from it. For example, a data reporting form can be filled out using a pencil, a pen, or filled out electronically on a computer or mobile phone. While the practice of data reporting would be the same, the

flexibility in terms of physical object would be high. It would still depend on some "material" recording and means of communication, so while the practice itself can easily be communicated and scaled up, it still needs some physical object to accompany it.

What these two implications show, is that the levels of materiality significantly influence the potential for scaling, and the translation of the HII across contexts. What is less material moves with greater ease, is exposed to a variety of social groups and thus holds greater interpretive flexibility. However, as the example from Tajikistan shows, movement is a necessary, but not a sufficient condition for scaling. The sheer circulation of artefacts from one place to another does not imply it is accepted in the new setting. This is because there are different sets of ideas and practices existing in the old and new contexts, which may resist the introduction of new ideas. That was why the ideas and practices associated with decentralization and an action-led information system were rejected in Tajikistan. Linked to this is the fact that the more material something is which is scaled , for example a computer or a power-backup, the more irreversible it is to change, because of the effort required to bring in something different. Materiality is seen to have a greater delay in circulation compared to the less material, such as ideas.

However, regardless of actual acceptance, interpretive flexibility and rapid, digital, circulation creates a *potential* for scale, and local translation. How this potential gets realized, will depend on how these concepts interact with other such concepts in other settings, and translation takes place. Some key mechanisms for such translations are now explored.

6.1.2 Translations as interaction of infrastructure, software, practices, and ideas

In this section, the relationships between the four concepts of content are discussed. As a start, I revisit the table from the methodological framework chapter, where I showed the process of abstraction from my empirical material, through concepts to constructs. l now elaborate more on this process, including the concepts and constructs, and argue that the interaction between these four dimensions is what determines scaling, by shaping the outcomes of interpretive flexibility of what is scaled (Akrich 1992).

Construct	Concept	Example of empirical data
Interaction effects:	Infrastructural influences;	Offline implementation in Sierra Leone and Botswana due to lack of connection
The four	The	Low voltage computers employed to function off car

dimensions, of diminishing materiality, exert force upon each other	infrastructure influences the system	batteries in Sierra Leone
		Unqualified local support would re-install windows and overwrite DHIS software in Botswana
	Software influences; The software influences the system	Integration of duplicate reporting structures in DHIS led to agreement among actors to harmonize reporting forms
		Interoperability between DHIS and other applications increased legitimacy, interest, and resources for system
		Functionality on data completeness led to increased focus on this issue
		Multidimensionality in DHIS allowed continuation of massive tabular forms in Tajikistan
		Online implementation change the way people report data
	Practices influences; New and existing practices influence the system	Perverse incentives lead to low reporting on logistics data
		League tables increased data completeness
		IT department in charge of DHIS led to less involvement in the project from the health professionals
		District supervision in Sierra Leone offered an opportunity for offline electronic data collection
	Idea influences; Ideas influence the system	Integrated data warehousing and integrated architectures shift focus (towards interoperability) and legitimacy
		Annual reporting of large datasets for central statistics in Tajikistan, and dimensionality in DHIS2
		Difference of the meaning of "0" and "blank" in reporting??
		Logic on access to data drives restriction functionalities in DHIS
		Logic of data ownership determines outsourcing of server or not
		Open source software, software as a public good

Table 9 Examples of interaction effects working through the influences of four dimensions.

As earlier stated, the four concepts influence the HII as exemplified in the table above. Infrastructure, software, practices and ideas shape how HIIs are developed, used, and

scaled. One way is that these influences change what is scaled, over one or more dimensions. Another way is that this in turn shapes scaling trajectories, as shown by the examples of infrastructure determining how DHIS2 is deployed as stand-alone local data warehouses, like in Sierra Leone, or with a central server solution as in Kenya.

I have labelled these influences as infrastructural, software, practice, and idea-based. Working together in one single setting, they together produce *interaction effects* on the scaling of an HII, representing the push and pull factors, creating both expansion and not. While it for analytic purposes can be useful to think of a constellation of the four dimensions as given, the dimensions are not static. Rather, they change over time, for instance by the introduction of new technology which changes the constellation (Barley 1986). In the figure below, this is illustrated by two snapshots of constellations; the second representing the change through the redefining of the constellation. The change, for example through the adoption of the HMN-inspired model of a central data warehouse to integrate previously disparate health program information systems in Sierra Leone, exerts influences on the HII, exemplified as the constellation of the four concepts. In turn, the change of ideas influence practices, software, and infrastructure. In Sierra Leone, this new idea led to the adoption of DHIS2 as a software platform to integrate the various subsystems (Sæbø, Kossi et al. 2011), changing practices through the reduction of data collection forms, development of new information products, and a focus on peer review of health data (Sæbø, Braa et al. 2013). This also led to a push to set up local area networks in the districts (Jolliffe, Braa et al. 2010). At the same time, the infrastructure did not allow the deployment of a web-based solution, since there were no reliable network connection in the districts. In this way, the infrastructure also contributed to modifying the software, practices, and ideas, leading to a hybrid of local-area networked solutions based on routines of physically sending the data to the national level with memory sticks.
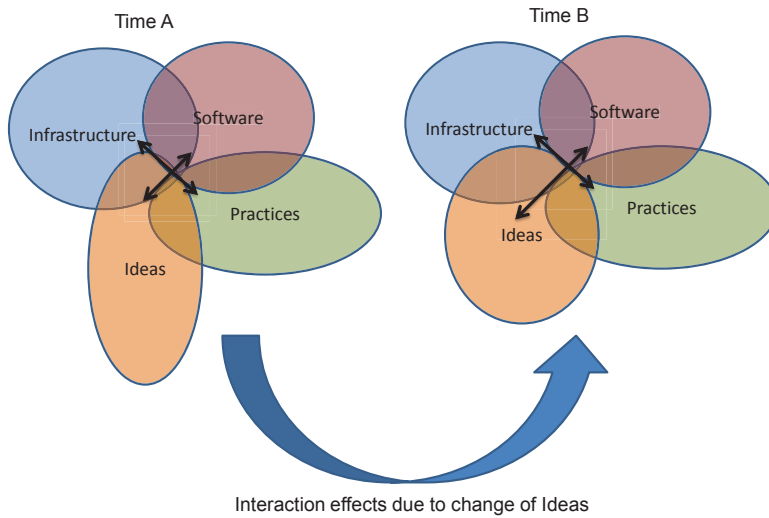
Figure 10 The change in the dimension of ideas leads to a new constellation of the four dimensions, and hence a change of the HII

So the change in one dimension leads to spill-over effects on the others, representing interaction effects, which help to shape the constellation of dimensions continuously. This supports the notion of HIIs not being developed from scratch, but evolving through a dialectical process (Nielsen 2006) involving a context of complex pressures (Edwards, Jackson et al. 2007). When one action can have unintended re-actions, as the interaction effects reverberate back and forth, one single actor does not have control over the whole network, and the development is not predetermined. While this argument has also been made by the other II researchers, I have gone further in terms of identifying some of the mechanisms driving change. Following the example above from Sierra Leone, the change of ideas at the Ministry of Health and Sanitation about integration led to the involvement of University of Oslo, and thus me, supporting the implementation of DHIS2 and the associated process of data harmonization (Sæbø, Kossi et al. 2011). Success of this harmonization process has contributed to a practice of ongoing form revision based on negotiations between stakeholders and continued changes to the database.

Through these interaction effects, translation takes place. As several researchers have pointed out, cultural, institutional, and infrastructural differences makes replication of technology in a new setting difficult (Lind 1990, Akrich 1992, Braa, Monteiro et al. 1995,

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Sahay and Walsham 1999, Heeks 2002, Nhampossa 2005), but involves a process of translation and appropriation to the local context. The theoretical model posits the interaction between these four concepts to contribute to these translations. Even in the same geographical context, there will be actors with different practices and ideas, involving varying institutional logics, contributing to different types of interaction effects and scaling trajectories (Barley 1986, Sahay and Robey 1992, Hayes and Rajão 2011).

Scaling will typically introduce changes in one of more of these four content-dimensions, and further creating interaction effects back and forth that will be hard to predict. Translations can take place both to what is scaled, and the context it is scaled to.

6.1.3   Inter-contextual influences: constellation effects

The above interaction effects describe how these various dimensions exert influences on each other, leading to translations. Scaling in these dimensions are further influenced not only by the local, there is also a strong inter-context influence, that even work at the global level. Even with the great geographic distance between, say India and Sierra Leone, and even though the HII in each country are primarily national, they evolve in the similar directions, representing a form of institutional isomorphism (DiMaggio and Powell 1983). A constellation of dimensions in one context exerts influences on other contexts through the circulation of people, material, and stories, in what I term constellation effects. Some examples of constellation effects are shown in the table below.

Construct	Concept	Example of empirical data
Constellation effects: The sum of interaction effects in one context exerts a force upon other contexts	Best practices;	Mobile modems used for online implementation in Kenya led to same approach in Ghana League tables at national level in Sierra Leone influenced practices at district level Success of integrated data warehouse in Sierra Leone led to similar efforts across West Africa Implementers (including myself) draws upon a pool of experiences from other context, consciously and unconsciously influencing new contexts
	Inscriptions	DHIS "tracker" functionality developed for Indian needs adopted for anonymous patient registry in Ghana Multidimensionality of data entry forms developed to suit Tajikistan needs applied in Sierra Leone

		Training material originally developed in and for South Africa used in other countries

Table 10 Examples of constellation effects working through best practices and inscribed material.

Two important mechanisms for shaping constellation effects are best practices and design which go into the application. The first denotes objects that tell a story, to be accepted or not, while the latter are built-in characteristics that promote certain behaviour. These mechanisms are first depicted in the figure below, and then discussed.
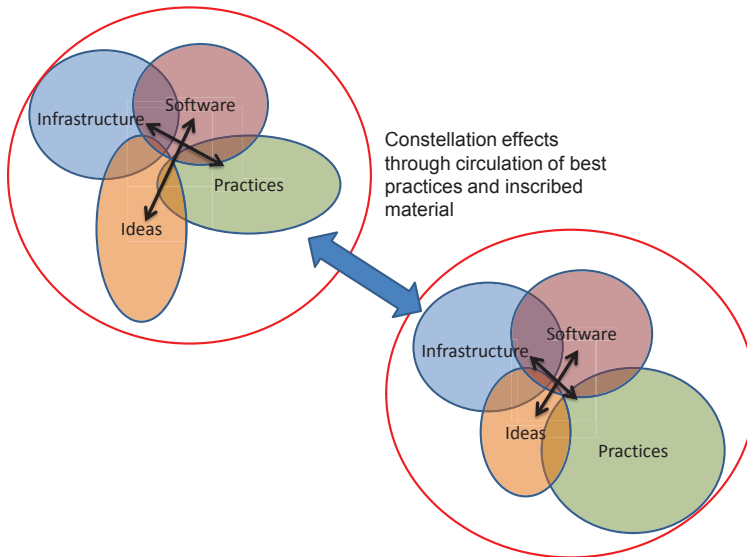
Figure 11 The blue arrow signifies the mutual influences between two different contexts, each with their own constellation of the four dimensions: Infrastructure, Software, Practices, and Ideas.

The "best practices"-mechanism denotes the sharing of experiences and solutions across contexts. Maybe needless to point out, the best practices don't travel themselves. However, they are translated into text, presentations or other objects (Czarniawska-Joerges and Sevón 1996), separated from their original context, which are then circulated. This detachment from context, translation into objects, circulation, and interpretation by new actors, makes these best practices open for translations in their new context (Latour 1986, Nicolini 2010). The concept of best practices is wide in scope, it should also include the circulation of people, money and resources (Braa, Monteiro et al. 2004). A typical example

is of international consultants frequently being engaged in similar efforts in different countries.

For instance, the relative success in using DHIS2 in Sierra Leone was communicated widely by WHO and HMN, leading other countries, like Kenya, to adopt the software and also similar implementation strategies. The success of the software and strategies in Sierra Leone, however, was tightly linked to the constellation of the four dimensions there, and translated into written material and presentations, re-interpreted by consultants, and translated into different contexts. For example, in Kenya, the infrastructure was better developed and the districts were larger in number, in the end leading to a central server deployment of DHIS2 where all district offices access the same database over the mobile network. A chain of translations can be identified; first, HMN would detach what they wanted to communicate from Sierra Leone by representing it in their publications, which were then read and interpreted in Kenya, together with other accounts of DHIS2 and similar work in other countries. There were then local translations taking place in Kenya stemming from the interaction effects there. The availability of mobile coverage meant that an online solution based on this was feasible. The amount of districts meant that the logistical challenge of maintaining hundreds of synchronized offline databases was overwhelming. Together, this led to a translation; a fully online HII. With this came new requirements for the software, for not always could online connection be relied upon. Support for offline data entry and analysis was developed in DHIS2, to cope with the occasional "downtime".

Still later, Ghana learned from both the Kenya and Sierra Leone cases, and implemented DHIS2 on a central server like in Kenya. The interaction effects that produced a viable central server deployment in Kenya thus came to influence the deployment in Ghana. Yet new translations took place in Ghana, notably the use of the "tracker module", originally developed in India to track pregnant women and their newborns, to function as simple birth and death registries (Poppe 2012). When Sierra Leone subsequently developed new plans for their HII, online deployment and registries of tuberculosis patients became important. Unfortunately, political changes have put these new plans on hold; they never got further than being translated into implementation plans, nevertheless a potential for future scaling efforts exists.

What we can see from this "Biography of Artefact"-storyline (Pollock and Williams 2010) is that the common artefact, DHIS2, "circulates translations" within and between the countries. That is, at each point it is used, it is translated through the interaction effects at play there. The way this takes place is particularly evident by a second mechanism of constellation effects, namely inscriptions that promote certain practices (Akrich 1992), and redefine the interpretive flexibility. As Callon notes, a translation "involves a translator, something that is translated, and a medium in which that translation is inscribed"(Callon 1991 p. 143), so that the translation can move across time and space and reach other contexts. Such inscriptions are thus an important mechanism for the circulation of translations, through for example the software DHIS2, the accompanying documentation, and the various training material accumulated over the years. One example of how such inscriptions work follows below.

The DHIS2 development, in the start heavily influenced by only one implementation of the software, in India, had come to be shaped by the interaction effects there. When it was subsequently implemented in Sierra Leone, it brought with it the footprints of these interaction effects in India. It inscribed behaviour by being designed in a particular way. Shaped by the development, trial, and feedback from users in India, it also incorporated many aspects of DHIS version 1.4, which had been developed in South Africa and subsequently used in neighbouring countries like Botswana. The obvious reference to the implementation in India, and other countries, is of course that DHIS2 is an application made to support data collection, processing and analysis, which are tasks shared by the HIIs in all countries. But there are also more specific functionalities that constrain or promote various solutions. For example, the early DHIS2 only supported representation of "whole" data definitions, without the possibility to re-use dimensions of disaggregation. So one needed to define "Malaria, male" and "Malaria, female" as two separate meta-data instances. However, since disaggregation by sex and age groups is very common for a lot of statistical health data, the eventual incorporation of better support for this grew out of Ethiopia and was finally developed in conjunction with implementation in Tajikistan (Sahay, Sæbø et al. 2010).

While early users of DHIS, like Botswana (using DHIS version 1.4), had previously managed without the ability to define such categories as sex and age groups and re-use them for various data definitions, institutional logics in Tajikistan made these categories essential to be able to manage the database there. Given that nearly all data they collected

was disaggregated by sex and several age groups, the work on setting up and maintaining the database would increase tremendously without the new functionality. The more modular approach to defining the meta-data in DHIS2 became extremely important there, especially as the revision of the many data collection tools in Tajikistan was out of the question. So the practices and ideas ingrained in the Tajikistan HII changed the DHIS2, with a set of interaction effects. Now, Sierra Leone, Kenya, Ghana, etc, all use the new functionality, even though they could have easily implemented their relatively small data collection forms with the older versions of DHIS2. The constellation of the four content-dimensions in Tajikistan, which led to the development of the categories for meta-data, has inscribed a different way of doing meta-data management in DHIS2. While earlier, DHIS2 promoted some thinking about rationalizing your meta-data to avoid a lot of definition work, in line with an institutional logic of collecting only essential data, it does now not promote this. It instead promotes rationalizing disaggregation categories, like age-groups, but does not "care" about the total amount of data collected, as the categories can be (and very often are) re-used to create huge tables, more in line with an institutional logic of "the more data, and the more detailed, the better" (Braa 1997, Lewis 2011). This gain and loss dichotomy points to how the constellation of dimensions in Tajikistan produced different inscriptions in the DHIS2, which also influenced the HIIs in other countries.

The circulation of translations, or constellation effects, does not only take place between countries, but in general between contexts. One intra-national example is from Sierra Leone, where the league tables propagated from the national level to districts (Sæbø, Braa et al. 2013). The contexts do not differ significantly, but there are slight variations between the national level and the districts, and between the various districts. Such differences relate to weaker infrastructure in certain districts, less technical experience in DHIS2, practices around monthly reviews, and ideas around particular needs and priorities locally. The league table "template" that had been made at the national level was thus adapted to suit the local needs in the districts. The chiefdom league table then made there was a result of both constellation effects (the "template" that suited the national level), and of local interaction effects (small changes to be more suitable for district needs).

6.1.4 Global Scaling as Circulating Translations

I have up to now presented several examples of translations and re-translations stemming from differences in contexts, related to both geography and time. For instance, a paradigm shift in infrastructure where internet has become fast and robust running over the mobile

phone network has changed the situation in most countries over the last few years. This change of infrastructure has translated the HII in Kenya, related to the software, practices, and ideas of system design and decentralization, from a stand-alone based implementation to a central server implementation. The scaling up of mobile coverage has thus led to further spreading of the HII, both with new functionality of the software and of it's geographic reach.

All scaling has the potential for creating such translations, big or small. The potential for translations come from differences in the local context, be it infrastructure, climate and disease patterns, practices, institutional logics, culture, existing software, resources, and people. These differences are typically larger between one country and another, than between two localities within a country, though examples of these latter are also easy to point to. For instance, special "emergency forms" in districts in Tajikistan represent completely different ideas and practices at the district level than at the national, and the infrastructural challenges in rural districts in Botswana and Sierra Leone are a world apart from the capitals in those countries.

I have also shown how these translations manifest themselves in objects than allow for circulation to other contexts (Sahlin and Wedlin 2008). These objects circulate both between and within countries, and through multiple channels. The multidimensionality of data entry forms developed in DHIS2 for Tajikistan was used later in Sierra Leone, brought there in the software. Training material I developed in Botswana, based on my interpretations of material from South Africa, were re-used in Sierra Leone, at each step being slightly modified based on earlier experiences and new expectations. The district league tables developed at the national level in Sierra Leone were used as blueprints for chiefdom league tables in some of the districts. These examples show, in a simplified way, three objects that circulate; the software, presentations and written exercises related to information use, and the printed health bulletin and league tables in Sierra Leone. An important point is that the software and other electronic material circulate much more freely than physical machines and books (Czarniawska-Joerges and Sevón 1996, Urry 2003). It is less material than the technologies typically discussed in the early days of technology transfer literature (Rogers 1962, Akrich 1992), and any new version of DHIS2 can be globally downloaded the day it is released. Training material is circulated constantly among trainers and implementers in several continents. These adaptations, which have

become embodied as software and written material, are then again subject to local translations in other places.

Based on the above mentioned observations, I argue that global scaling of HIIs can be seen as circulating translations. Scaling an HII in a particular locality produces translations, based on the local context, the interpretive flexibility of what is scaled, and the acceptance or not of parts or the whole of the introduced change. The mechanism for such translations are *interaction effects*; the push and pull of the local context within the space for interpretation and modification.

These translations are materialized as documents, software, objects, interpreted and re-told by people, becoming susceptible to reach other contexts. This movement can take place much faster and at less cost when the objects are digital, and hence software, practices, and ideas have a greater potential to scale to new areas. In a new context, the translations are susceptible to yet new interaction effects. But being products of earlier interaction effects, they carry with them the foot-prints of other contexts. These *constellation effects* work through the stories the objects and people tell, and the inscribed functionality of technology and tools.

The interaction effects and constellation effects together help me to formulate a model of global scaling which I term as "circulating translations." After depicting this in the figure below, I discuss the theoretical and practical implications of the model in the following section.
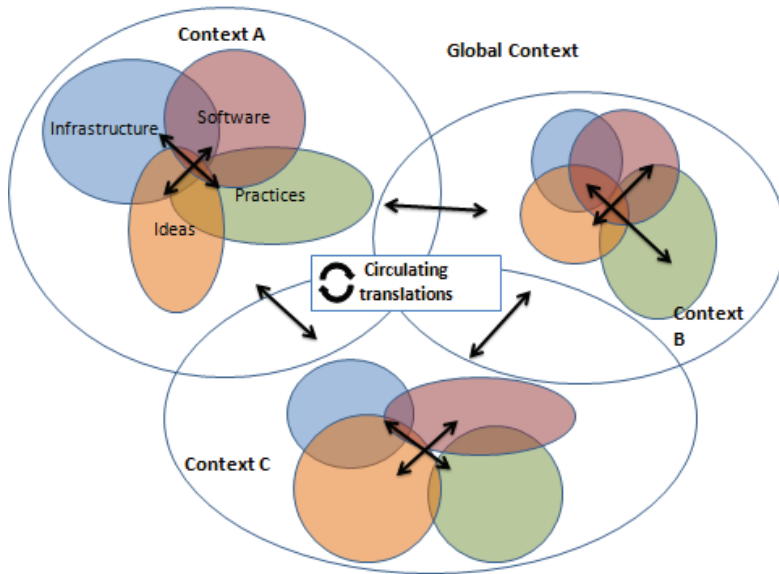
Figure 12 The Global Scaling of HII: Model of Circulating Translations

Key characteristics of the model of circulating translations
Interaction effects: The interplay of influences from infrastructure, software, practices and ideas contribute to translations in a particular context, producing scaling effects and a unique HII.
Constellation effects: These translations circulate between contexts through media like consultants, reports, documents, software with inscribed functionalities, and the like. So translations from one context influence scaling in other contexts.
These effects, both interaction and constellation, are not linear, but move back and forth, often circulating and return back in a different form, taking place in small steps.

6.1.5   Implications of the model of "scaling as circulation translations"

The model of circulating translations has some implications for our understanding of IS phenomena. Primarily, it contributes to understanding aspects of scaling of IS and technology transfer. The current debates around these topics are re-visited in this section, whereupon I provide some remarks based on the model.

The model of circulating translations derives from empirical material in many countries, over many years. It is thus an answer to the call from Pollock and Williams (2010) to base studies of IS on more than single-site ethnography, and to follow longitudinally the biography of the artefact. The model of circulating translations does that, looking at the biography of not just DHIS, but also related practices and ideas, in their history of embedding in various contexts. Through the longitudinal and multi-site empirical material, new insights to the debates can be drawn. This is in contrast to the reviewed literature on scaling and technology transfer, which, with a few exceptions, have looked at single cases and over a short time-span. The added perspective of scaling over time and multiple contexts complements this literature.

6.1.5.1 Circulating translations and scaling

Scaling of IS has been seen as a challenge of replication (Eoyang 1996), or at least in taking a working solution and make it spread to other sites (Braa, Monteiro et al. 2004). It has generally been seen as linear process, of outwards expansion. However, the circulating translations model shows that scaling is not linear, and is not a process of replication. Contrasting a view of scaling as continuous expansion, scaling in the circulating translations model is rather seen as a process that can stop, recede, and go forward again, based on the four inter-dependent dimensions. Interaction and constellation effects will shape the direction of scaling, which has also been earlier acknowledged (see for example Shaw, Mengiste et al. 2007), and paradigm shifts may create unanticipated bursts of scaling, like the decision to use mobile modems to connect to the Internet in Kenya. Furthermore, parts or the whole of what is sought scaled may be rejected, leading only to partial scaling. The example of Tajikistan shows the scaling of software only, while ideas and practices did not scale due to resistance arising from the particularities of the local context.

A second implication is that scaling always involves a process of loss and gain. When something is scaled, it is also in many cases replacing something. A translation can be a diversion from original intent, and an exclusion of other potentials. One part of this comes from generification, even though it should be seen as the accumulation, rather than elimination, of particularities. As a start, almost by definition a generic solution will require more customization, increasing the skills and time it takes to "particularize" it. The DHIS2 can handle a wide range of use cases, but needs to be properly set up and maintained. It is a trade-off between flexibility and ease of use. Gains for one of these

subjects very often leads to a deterioration of the other. Furthermore, as it becomes more generic, the inscriptions also change. DHIS2 is now much easier to adapt to support centralized decision making than earlier, even though it is also more powerful to support decentralized decision making, which HISP has been promoting. With this expansion of software functionality, DHIS2 has become more interpretively flexible, for better or worse.

Another part of the gain/loss dichotomy is the change inherent in the scaling process. When DHIS2 started to be implemented as an online solution, the scope for participatory design changed (Braa and Sahay 2012), as use and communication was increasingly detached from localities and moved to an online mode. Supporting visits to districts for installation and trouble-shooting were no longer needed, and were prioritized less than earlier. With this also disappeared an arena for engaging the district staff in development of the HII.

6.1.5.2 Circulating translations and technology transfer

Literature on technology transfer has traditionally been focused on the movement of some technology from one country (primarily a "rich" country) to another (primarily a "poor" country) (Rogers 1962, Akrich 1992, Heeks 2002). As such, it has, like literature on scaling, been seen as a linear process. Further, while there has been acknowledgement of both the need for, and actual materialization of, local adaptations, this has been examined only from the perspective of the receiving country. Technology X has been moved from country A to country B, where some translation takes place.

The model of circulating translations complements such views in two ways. First, the movement of infrastructure, software, practices, and ideas, is not linear, but can go back and forth, even circulate, between many contexts. Second, the impact of a translation of any of these four dimensions is not only felt in the receiving context, as the translations have the potential to circulate to other contexts, even back to where the "original" came from. These two aspects together contrast a centre-periphery view of technology transfer, both in that there is not necessarily a linear movement from "developed" to "developing" countries, from near to far away, and in that the originating context is not the only provider of a finalized product. The DHIS2 was first deployed in India, it's development was coordinated from Norway, it was transferred to and translated in Sierra Leone, whereupon it again traveled to Kenya, Ghana, and back to Sierra Leone, all the while providing translations back to India. The constellation effects across contexts mean that there are no

fixed centre-periphery direction of technology transfer, but a back and forth movement of translations. Technology transfer, as a research subject, should then not assume a linear direction, especially since digital information so effortlessly travel between contexts.

6.1.5.3   Implications on generification

So far I have described scaling as involving intra-contextual interaction effects, which leads to local translations, and the circulation of these translations leading to what I have termed constellation effects. In essence, scaling of an HII in one context thus depends on both the local context, and potentially multiple other contexts. Global scaling contributes further to the rate of translation, as more contexts provide fertile soil for both interaction effects and constellation effects. The circulation of local translations between contexts which takes place through scaling, has a further implication; it drives generification.

Generification, the process towards generic solutions through scaling (Johannessen and Ellingsen 2009), can be seen throughout the empirical material. It is important to keep in mind that generification should not be seen as making HIIs, or any particular part of it, alike, or that there will be a reduction of the scope to be particular or unique. Rather, generification can be seen as accumulation of particularities, meaning that it is a process which allows increasing heterogeneity of use (Turnbull 2000, Pollock, Williams et al. 2007). As such, the interpretive flexibility increases as generification enlarges the scope of use. In this respect, the *circulating reference* model of Latour (1999) is appropriate; while there are translations that tend to drive development towards generality, there are always some reference back to certain particularities. Second, generification is not only about the software, but can be applied also to infrastructure, practices, and ideas.

I will point out a couple of examples from both the software DHIS2, which is the shared software in all implementation sites, and other objects, emphasizing that generification is not only taking place in the software. For DHIS2, most of the functionalities have been developed based on requirements from a single implementation, and then refined and redeveloped to accommodate others wanting to use them in their locally relevant ways. The starting reference was DHIS version 1.4, which was primarily shaped by it's use in South Africa, but had also brief development phases based on use in Botswana, Namibia, Zanzibar and earlier with DHIS 1.3 in Mozambique, India, and Cuba.

Two examples show how generification has been at work in DHIS2. The first is data collection, or more specifically, functionalities for setting up how users enter data into the

database. Originally, all data to be collected could only be done so through an auto-generated vertical column of cells. This worked well for the short list of data to be collected in South Africa. However, different health programs typically have their own data collection tools, like a single A4 sheet of paper with a table. The first change took place in DHIS version 1.4 that allowed several such sheets to be replicated in the software, called data sets. Now you could have different "pages", and not all data entered in the same page. A further requirement was often that the digital data entry screen looks similar to the paper data collection tools, so it's easier to get the data into the right cells when doing data entry. This was accommodated by allowing customized layouts, in effect introducing a text editor to allow creation of tables, changing fonts and colours, adding headings etc, to the electronic data entry screen.

Another example is functionality to measure data completeness. This is a common data quality indicator, and is used to both identify health facilities not reporting, and to help estimate the validity of data analysis. However, there are different ways of measuring this, and DHIS2 has incorporated several of them over the last years. The first was a through self-reporting of completeness by those entering data. Since not all diseases and events take place each month, facilities typically leave a lot of empty cells in their reporting forms. To indicate that the forms have been completely filled out, even if there are empty cells, DHIS2 has a "complete-button" to mark the form as complete. One way to measure data completeness, which was developed based on requirements from Sierra Leone, is then to make statistics on this self-reporting of completeness. Many countries now use this. But some don't, as they have different criteria for measuring this. So DHIS2 has also incorporated functionality for compulsory data. For example, a few key indicators can be set as compulsory, and data completeness for reporting facilities can be calculated based on this compulsory sub-set being filled out or not. For the two ways of measuring completeness, there is some room for customization, like setting the compulsory indicators, or which facilities are expected to report on this or that data or not. DHIS2 has thus become poly-generic (Pollock, Williams et al. 2007), with a few, generic, ways of measuring completeness.

Two other examples other than the software show that generification also applies to less material aspects. The first is the practice and idea of data harmonization, which is about sorting out duplications and inconsistencies in data definition across smaller parts of the HII. For instance, it is very common to see health programs such as Mother and Child

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Health, Communicable Diseases, and HIV/AIDS collect the same data related to new cases of HIV. Through harmonization, the aim is to reduce the instances of this data being collected to one, make all involved health programs to use a common definition, and through this reduce the workload for all involved in collection and processing this data and improve data quality. Various approaches to this is the main focus of the paper comparing how this was done in South Africa, Zanzibar, Botswana, and Sierra Leone (Sæbø, Kossi et al. 2011). These cases show how the focus, over the years, move away from the process, to the goal. In other words, data harmonization as promoted by the HISP network becomes more generic through exploring and "incorporating" several approaches toward the goal of harmonized sub-systems within the HII. Just like generification of the functionality to charge students tuition in a university management system (Pollock, Williams et al. 2007), the "toolbox" of data harmonization has come to include several options, depending on the needs and possibilities in each context.

One other example not explicitly part of the software itself is the documentation and training material that goes with it. While of course tied to the increasingly generic functionality in DHIS2, the training material have gone through it's own cycles of generification. Initially developed for a specific workshop, for instance, examples and exercises have been re-used in other countries and in different settings, along the way shedding the particularities of it's original context. For example, exercises made for a three-week training course in Sierra Leone, using the local data definition and form layout, have been re-used in a generic way in later DHIS2 Academies, and circulated through the Internet, mailing lists, etc.

One implication of more generic solutions adds to the loss/gain dichotomies discussed earlier. With a more generic DHIS2, the initial work to customize it has become more complex. As new functionality allows increasing particularization of a national DHIS2 instance, more work has to be put into designing it, and filling it with meta-data. This also needs a more skilled intervention. For instance, while the ability to set up an online data warehouse is a massive gain in both usability and related to database maintenance, the original setup depends on skills with servers, security, proper back-up routines, and stricter user-control.

6.2 Implications for policy and practice

Implications for policy and practice are presented together, as there is a strong relationship between HII policies and implementation (Braa and Sahay 2012, Braa, Sahay et al. 2012). Effective policies affect the success of implementation, the efficiency and effectiveness of the HII, and the eventual outcomes, which again makes for better policies. This relationship is shown in the figure below, which treats policy as an input to the HII, that should cover development and implementation, standards, integration, data quality improvement, and information processing and use. Policies thus apply to all aspects of the HII, and are again influenced by them. The following implications are thus relevant both for policy makers, such as national governments, regional bodies, and international organizations such as the WHO, and HII implementers.
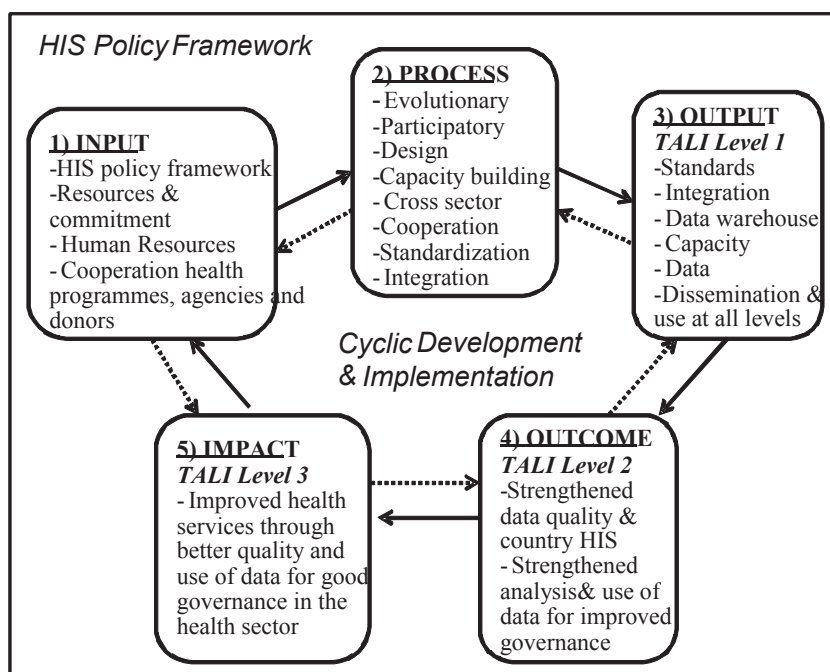

Figure 13 Relationship between policies, development, implementation, and use of HIIs (Braa, Sahay et al. 2012)

A key concern for policies should be to plan for scale. Too many HII projects end as pilots, never being able to scale or not being sustainable if larger scale is achieved. A common reason for that is an over-emphasis on technology, ignoring the other aspects of the HII.

An implication from this thesis is that by strengthening the policy-practice relationship could help to plan for scale. This relation can support a holistic view of HII, enabling local translations through the scaling process. A key objective would be then to provide for an enabling environment where interaction and constellation effects can take place, as they potentially support scaling process. However, at the same time this requires coordinating the translations so that standards and interoperability are maintained, requiring some form of central coordinating unit at the right level. For example, WAHO is taking this role in West Africa, to develop standards that both allow each of the 15 member countries to particularize their HII and at the same time achieve region wide standards related to health indicator definitions and use(Braa, Sahay et al. 2012). Another role of a coordinating agency is to function as a centre of excellence, providing expert advice and assist in capacity building based on cutting edge knowledge and technologies. For WAHO, this is a way to also harness economies of scale, as the smaller member countries typically with limited resources, can leverage constellation effects from the region and further their local interaction effects.

Central to translations, and hence interaction and constellation effects, is the interpretive flexibility to change the software by that being open source. If not having the capacity to change the code themselves, organizations will still be able to harness these effects if other users have the potential to make changes. Open source software thus has a larger potential, with their interpretive flexibility being greater for it's users, than proprietary software. For instance, South Africa has made it official government policy to use open source software unless there is a substantial benefit of proprietary software (Office of the Government CIO 2006). Similar policy directives are seen also in Brazil and the state of Kerala in India. However, setting up policy is one issue, but to make that work on the ground, there needs to be implementing mechanisms in place, such as the WAHO example provided above.

Four implications for practice can be derived from the above discussions that can help contribute to strengthen scaling effects of HIIs:

6.2.1 How to harness network externalities

The model of circulating translations can not only help to understand processes of scaling, but also build on the practical aspects of the notion of networks of action (Braa, Monteiro et al. 2004). If possible, the implementation of pilot projects in more instances increases the chance of translations that can benefit a larger set of implementations. There are thus

network externalities that can be potentially harnessed, and increasing scale can itself improve the scalability. In any case, feedback mechanisms of such translations should be encouraged, through communication and building of networks. Small incremental steps in one location can lead to a breakthrough in another. This is also an argument for the use of open source software and open standards, as it has the potential to trigger more translation processes than proprietary software.

A strategy employed in HISP to manage the scale of projects in multiple countries has been to enable the circulation of people, material, and best practices between the implementations. That includes the pool of international researchers and consultants, that travel between the countries, but also the DHIS2 Academies where practitioners participate together with the implementers. These academies are not only training workshops, but offer the opportunity to share experiences. The academies are held yearly for each region of East and West Africa, Asia, and Latin America, and both contribute to manage large scale implementation by centralizing training, and to enable the participants to share best practices. Such regional academies have thus been instrumental as the number of implementing countries has increased.

6.2.2 Enable the strengthening of networks of networks

An architectural design, with openness towards other systems, can support significantly the formation of "networks of networks". One example is the network around DHIS2, traditionally focused around statistical health software, and the network around the software iHRIS for human resource management. Such networks of the second order can lead to synergetic effects, such as complimentary legitimacies. In the example of DHIS2 and iHRIS, this joint legitimacy led WAHO to initiate collaboration to promote such interoperable architectures across the region of West Africa.

An important exercise is to draw the boundaries between what different software applications should support. While there are many other applications, even open source like OpenMRS and iHRIS that cater for patient management and human resource management, respectively there are also requests for covering these areas with DHIS2. This is natural as scale and maturity of use increase, but at one point a line has to be drawn. The balance has to be found between the users' need for one, single, system, and the complexity for developers without domain knowledge. In real life, there are no such clear cut boundaries. One example is logistics data, where the aim is to manage the efficient

distribution of health commodities. In DHIS2, simple inventory management can be, and is, implemented with the existing functionality. However, there is a drift towards responding to the more "advanced" use cases, such as forecasting, procuring, and tracking shipments. The "networks of networks" argument calls for collaborating with those with domain knowledge of this, close off applications to single domains, and provide opportunities for interoperability using open standards.

6.2.3 Strategies for integration

The comparative study on strategies for integration shows that there are many roads leading to the same goal (Sæbø, Kossi et al. 2011). Technology can usefully be leveraged to integrate HIIs also at the semantic and organizational level, and obtain political legitimacy in an otherwise locked situation. In Sierra Leone, the implementation of the fragmented health data sets in one single database, solving the inconsistencies at the database level, was instrumental in highlighting at the organizational level the degree of duplication and the need for harmonization. As such, the introduction of technology was used as an occasion to initiate change (Barley 1986). In general, introducing change to any of the four dimensions of HII can lead to change in the others. This is what happens in several of the countries using DHIS2 now, with the change in infrastructure related to a shift from cable-based to mobile-based internet.

Interoperability as a strategy for integration has not been applied frequently in HISP. However, an early attempt was part of the project in Botswana, where a third software was developed to manage sharing of data between DHIS and CRIS, a software for HIV/AIDS monitoring (Sæbø, Gill et al. 2008). While an appealing idea, interoperability between these two applications, which do not differ in functionality and the type of data handled, instead increased complexity. DHIS could have been used instead of CRIS, but since the latter was supported by UNAIDS, it's use had to be continued, and the approach was then to "integrate" the two by making a third software to manage this integration.

In other cases, interoperability between two applications who do not overlap in functional scope makes more sense. However, this is not without challenges, for instance related to different data models, lack of data sharing protocols that are appropriate for both applications, and the willingness and capacity to support it. While the technical hurdles were sorted out between OpenMRS, iHRIS, and DHIS2 in relation to work with WAHO, none of these have actually been implemented as interoperable solutions in any of the

countries in West Africa. The technical interoperability was not followed up by organizational integration in those countries who had any two of them in use. In India, however, interoperability between OpenMRS and DHIS2 has been established.

6.2.4   Visibility a strategy to strengthen accountability

Lastly, transparency and accountability through simple information products can have a great impact on use of information and create an environment of competition. The league tables in Sierra Leone had the effect of sensitizing the districts and chiefdoms about their *relative* performance, which had not earlier been easy due to the lack of a) access to different health data from one source, and b) access to peer data. The potential of online data warehouses, like in Kenya, holds great promises for the development of informed decision making at local level based not only on their own data, but on a comprehensive picture drawn by the access to data for comparison.

A key learning from the work on improving information access and use, is that there is a strong relationship between data quality and use, and that it is important to push information use even if the data is of dubious quality and mistrusted. Without data being used, the quality will inevitably deteriorate. With no-one having an interest in it, less work will go into assuring it's quality and completeness. It is thus very hard to improve quality without using it, and at the same time one will often find reluctance to use the data precisely because it's perceived quality is low. A strategy to counter this is to start the information use with a focus on data quality assessment. The league tables in Sierra Leone combined health indicators with data quality indicators, and while the first few issues revealed that the quality was low, this analysis itself increased the attention on this area.

6.3 Implications for methodology

Some implications for methodology can be drawn both based on the experiences of this thesis, and also from the model of circulating translations. These concern the balance between action and research, trade offs in practical action research, and strategies for doing research on global scaling.

First, a common argument against action research is that action can easily take predominance over research, in which the researcher becomes a mere consultant (Davison, Martinsons et al. 2004). Strict adherence to the cycles of action research has been promoted as a solution, but rather than pointing to the action part of AR as potentially

disturbing and dominating, it is important to see the scope of action necessary to do research on global scaling. The biography of artefact-perspective calls for following the evolution of the technology over long time and many sites. A fair amount of practical work is required, and immersion over time, in different settings, is hard to discourage if the aim is to understand how global scaling takes place. The "networks of action" strategy was formulated to both increase the richness of empirical material and the robustness in face of uncertain political environments (Braa, Monteiro et al. 2004). This thesis supports these two arguments in the following way. First, the ability to draw on multiple sites of implementation research has been crucial to identify the phenomena of circulating translations and the mechanisms driving it. Second, HII strengthening processes are often time-bound exercises, funded for a certain (limited) time, which in any case risks being shortened for various reasons. The project in Botswana got partly stuck in organizational complexities, and the EU-funding driving it came to an end without much success having been achieved. At that time, the efforts in Sierra Leone had just started, but new priorities at the global level led to the external funding not being renewed at the very same time the first promising results towards improved efficiency of the HII started to show. At the same time, the ability to be engaged in both countries for extended periods, and in other countries for shorter time, also helped to identify the peculiarities of the local HII. As such, multi-site research is not only useful for complementary experiences, but to be able to discern what is general and what is particular at any one site, a crucial aspect in tracking the mechanisms of translation.

Related to the practical work of action research, doing this on global scaling is extremely resource demanding. I have been based a few months in both Botswana and Sierra Leone, as well as shorter trips to a range of other countries. In addition, I have also been closely communicating with colleagues in the countries when I have not been physically there. However, even this have been limited to the work in the countries themselves, over the years. A key challenge has been how to engage with the local level (communities, district offices) as a national HII has scaled. Even the relatively few 13 districts in Sierra Leone have been too many to be able to visit all, not to mention to spend enough time to learn about their practices. As a natural consequence of increasing scale, an action researcher is constantly pulled by new challenges arising, which diverts attention from areas previously focused on.

A strategy towards this has been to engage in centralized training and capacity building. In Sierra Leone, the training courses run at the national level presented an opportunity to engage district medical officers and district IT officers from all districts. At the regional level, the DHIS2 Academies presented an opportunity to engage with key stakeholders from many countries. The training sessions, conferences, and academies have thus enabled me to engage with more people than I would have if doing research only in one setting. Such events have also presented an opportunity to learn about the circulation of translations (and contribute to it).

To engage in research at different levels, from communities to the global level, I have also had many roles. To engage in research at both global and local level, this is inevitable to gain access to the perspectives needed, and it remains a big challenge to balance these roles. However, this challenge, if managed, can give legitimacy that opens new doors. For instance, being perceived as a "field worker" can give added access at the global level, while being perceived as a "global level expert" can give access at the national and local levels. An implication of doing action research on all levels, in several countries, thus involves a potential to gain the necessary access and legitimacy, which may not be gained by working in only one site.

A clear implication of the model of circulation translations is that I as an action researcher contribute extensively to the circulation. In all my empirical settings, I have been integral in introducing the software DHIS, practices around health data collection, processing, analysis, and use, and ideas of how to organize the HII. In the absence of a researcher spanning the various countries, would there be a circulation of translations? Yes, but perhaps not as fast and frequent as in the countries I have been involved in. The role of boundary-object, or more literally boundary-crosser, is not limited to researchers, but any person being involved in several contexts. In fact, for two years I worked as a representative of HMN and WHO, functioning as a carrier of translations without being directly involved in research. The role of a courier of translations is thus not limited to researchers, but it is important to acknowledge that one also holds this role as a researcher, and that this will be a channel for the circulation.

7 Conclusions

This thesis has addressed the topic of scaling of HIS, and developed a theoretical model to understand the same. I conclude by discussing how the challenge of scaling is going to be enhanced in the future, and how useful the theoretical model may be in the light of some of these new trends. Three trends are highlighted. The first relates to the growing importance of Civil Registration and Vital Statistics (CRVS) system, the second on the upcoming agenda of Universal Health Coverage, and the third concerns the use of DHIS2 in domains outside health. These trends are indeed global in nature, and are relevant in the context of the work within the HISP network.

The first trend concerns CRVS systems, and the increasing global attention to its strengthening. One of the key recommendations of the Commission on Information and Accountability on Women's and Children's Health (COIA)[14] is to strengthen the CRVS systems. This strengthening inevitably will involve building linkages of interoperability with HII, which is a key source of data for births and deaths. Historically, these systems have operated largely as independent and standalone systems. The HII naturally then has to functionally scale to be able to make effective linkages with the CRVS. How effectively this will take place can be broadly understood through the concepts of interaction and constellation effects. While there will be the combination of software, infrastructure, practices and ideas shaping the interaction effects, there will be differences arising from the fact that practices come from different ministries of health and justice or home. Furthermore, CRVS systems are typically strongly paper-based, the paper on its own will shape particular kinds of interaction effects, for example with the need for particular forms of infrastructure. Constellation effects will arise from other sources, such as the global urgency to build CRVS systems, and how agencies like the WHO and HMN are trying to identify new kinds of systems.

The idea of Universal Health Coverage (UHC) has received increasing attention at both global and national levels, and has wide ranging implications on both how health services are managed, and how HIIs will develop over time. Post-MDG, the UHC is expected to become the single most important global health agenda, and is being hotly debated on its meaning and content in many countries. Primarily, the UHC aims at extending health

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[14] http://www.who.int/woman_child_accountability/progress_information/recommendation1/en/index.html

services to all, without the financial hardship associated with paying for them. As many of the world's poorest are excluded from formal health services due to out-of-pocket payments they can hardly afford, the UHC as promoted by WHO seeks to address this with national insurance schemes and redistributive taxing. This implies that qualitatively different types of information becomes more important, such as linked to insurance, social security numbers, and first and foremost a stronger focus on individual patient data. Needless to say, this information is linked to individual and name based data as contrasted with aggregate data that have been the focus of many HIIs. Being able to manage such data, aggregate data systems need to scale in granularity to capture the name based data, and also to deal with qualitatively different data, such as related to finance and insurance. Similar to the CRVS example discussed earlier, the lens of interaction and constellation effects provides us with useful insights on the potential of scaling, although the source and nature of these effects may be different as contrasted with the conditions discussed in this thesis. For example, an insurance supported UHC system that requires data on every patient-health system encounter is different in ideology than a state based primary health care system that focused on aggregate population based data.

A third set of scaling effects arise as the DHIS2 starts to get applied to domains outside health. One striking example of this comes from the ongoing HISP India work in Bangladesh where they are customizing the DHIS2 for a Food Security and Nutrition Information System (FSNIS) for the Ministry of Food and Disaster Management. The domains of food security and health, although with some overlaps, are fundamentally different with respect to the kind of data they deal with and the underlying logic for data processing. For example, the health sector deals primarily with the logic of aggregation where data from facilities are aggregated to the districts, and then provinces and national levels respectively. In food security systems, there are naturally in-built statistical functions of means, medians, correlations and regressions. This leads to important questions on what are the functions that need to be incorporated in the DHIS2, and what are those that should be linked with external packages. Constellation effects, for example related to the availability of such open source packages, become an important determining factor in the effectiveness of scaling. This scaling can of course lead to other circulating effects where the statistical functions incorporated for food security can then be used in the health domain for epidemiological analysis.

These trends and challenges do point to some interesting potential new research questions. For instance, what new mechanisms may come into play for the interaction and constellation effects, and how will these play out for instance between information systems in different domains? These, and other themes, will become relevant for future research on global scaling.

References

Akrich, M. (1992). The De-Scription of Technical Objects. <u>Shaping Technology, Building Society: Studies in Sociotechnical Change</u>. W. Bijker and J. Law. Cambridge, Massachussetts, MIT Press**: 205-224.**

Anadach Group (2012). Nairobi conference on eHealth sees high-level participants discuss rapidly growing African eHealth platforms and say no to "pilotitis".

Archer, S. (1988). 'Qualitative' research and the epistemological problems of the management disciplines. <u>Competitiveness and the Management Process</u>. A. Pettigrew. Oxford, Basil Blackwell**: 265-302.**

Avgerou, C. (2002). <u>Information systems and global diversity</u>. Oxford, Oxford University Press.

Avison, D., F. Lau, M. D. Myers and P. A. Nielsen (1999). "Action Research." <u>Communications of the ACM</u> **42**(1): 94-97.

Barley, S. R. (1986). "Technology as an Occasion for Structuring: Evidence from Observations of CT Scanners and the Social Order of Radiology Departments." <u>Administrative Science Quarterly</u> **31**: 78-108.

Baskerville, R. L. (1997). "Distinguishing action research from participative case studies." <u>Journal of Systems and Information Technology</u> **1**(1): 24-43.

Baskerville, R. L. (1999). "Investigating information systems with action research." <u>Communications of the AIS</u> **2**(3es): 4.

Baskerville, R. L. and M. D. Myers (2004). "Special Issue on Action Research In Informaton Systems: Making IS Research relevant to practice foreword." <u>MIS Q.</u> **28**(3).

Baskerville, R. L. and A. T. Wood-Harper (2002). A Critical Perspective on Action Research as a Method for Information Systems Research <u>Qualitative Research in Information Systems</u>. M. D. Myers and D. Avison, Sage Publications**: 129-145.**

Bogers, M., A. Afuah and B. Bastian (2010). "Users as Innovators: A Review, Critique, and Future Research Directions." <u>Journal of Management</u> **36**(4): 857-875.

Bondi, A. B. (2000). <u>Characteristics of Scalability and Their Impact on Performance</u>. WOSP 2000.

Braa, J. (1997). <u>Use and Design of Information Technology in Third World Contexts with a focus on the Health Sector, Case Studies from Mongolia and South Africa</u>. PhD, University of Oslo.

Braa, J. (2005). "A data warehouse approach can manage multiple data sets." <u>Bulletin of the World Health Organization</u> **83**: 638-639.

Braa, J., O. Hanseth, A. Heywood, W. Mohammed and V. Shaw (2007). "Developing health information systems in developing countries: The flexible standards strategy." <u>MIS Quarterly</u> **31**(2): 381-402.

Braa, J. and C. Hedberg (2002). "The Struggle for District-Based Health Information Systems in South Africa." <u>The Information Society</u> **18**: 113-127.

Braa, J., E. Monteiro and E. Reinert (1995). "Technology transfer vs. technological learning: IT-infrastructure and health care in developing countries." <u>IT for Development</u> **6**(1): 15-23.

Braa, J., E. Monteiro and S. Sahay (2004). "Networks of Action: Sustainable Health Information Systems Across Developing Countries." <u>MIS Quarterly</u> **28**(3): 337-362.

Braa, J. and S. Sahay (2012). Health Information Systems Program: Participatory design within the HISP network. <u>Routledge international handbook of participatory design</u>. J. Simonsen and T. Robertson. London, Routledge**:** 235 - 257.

Braa, J. and S. Sahay (2012). <u>Integrated Health Information Architecture: Power to the Users</u>. New Delhi, Matrix Publishers.

Braa, J., S. Sahay, E. K. Kossi and P. Mbondji (2012). ECOWAS Health Information Systems Policy and Strategy Document: West African Health Organization 56.

Braa, J., O. H. Titlestad and J. Sæbø (2004). Participatory health information systems development in Cuba: the challenge of addressing multiple levels in a centralized setting. <u>Proceedings of the eighth conference on Participatory design: Artful integration: interweaving media, materials and practices - Volume 1</u>. Toronto, Ontario, Canada, ACM**:** 53-64.

Bødker, S., P. Ehn, J. L. Knudsen, M. Kyng and K. Madsen (1988). Computer support for cooperative design (invited paper). <u>Proceedings of the 1988 ACM conference on Computer-supported cooperative work</u>. Portland, Oregon, United States, ACM**:** 377-394.

Callon, M. (1991). Techno-economic networks and irreversibility. <u>A sociology of monsters. Essays on power, technology and domination</u>. J. Law, Routledge**:** 132-161.

Carlile, P. R. (2004). "Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge across Boundaries." <u>Organization Science</u> **15**(5): 555-568.

Chan, M. (2012). Report by the Director-General to the Executive Board at its 130th Session, World Health Organization.

Checkland, P. and S. Holwell (1998). "Action Research: Its Nature and Validity." <u>Systemic Practice and Action Research</u> **11**(1): 9-21.

Chua, W. F. (1986). "Radical Developments in Accounting Thought." <u>The Accounting Review</u> **61**: 601-632.

Ciborra, C. U., K. Braa, A. Cordella, B. Dahlbom, A. Failla, O. Hanseth, V. Hepsø, J. Ljungberg, E. Monteiro and K. A. Simon (2000). From Control to Drift: the Dynamics of Corporate Information Infrastructures. Oxford, Oxford University Press.

Czarniawska-Joerges, B. and G. Sevón (1996). Translating Organizational Change, Walter de Gruyter.

Damtew, Z. A., G. Miscione, S. Mekonnen, E. Østmo, K. Staring, J. I. Sæbø and V. Sun (2010). "Globetrotting health information systems." Journal of Health Informatics in Developing Countries 4(1): 27-38.

Davis, F. D. (1989). "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology." MIS Quarterly 13(3): 319-340.

Davison, R., M. Martinsons and N. Kock (2004). "Principles of canonical action research." Information systems journal 14(1): 65-86.

de Kadt, E. (1989). "Making health policy management intersectoral: Issues of information analysis and use in less developed countries." Social Science & Medicine 29(4): 503-514.

de Laet, M. and A. Mol (2000). "The Zimbabwe Bush Pump: Mechanics of a Fluid Technology." Social Studies of Science 30(2): 225-263.

DiMaggio, P. J. and W. W. Powell (1983). "The Iron Cage revisited: Institutional isomorphism and collective rationality in organizational fields." American Sociological Review 48(April): 147-160.

Easterly, W. (2006). The white man's burden: why the West's efforts to aid the rest have done so much ill and so little good, Penguin Books.

Edwards, M. and D. Hulme (1992). Making a difference: NGOs and Development in a Changing World. London, Earthscan.

Edwards, P., S. Jackson, G. Bowker and C. Knobel (2007). Understanding Infrastructure: Dynamics, Tensions, and Design. D. Blue.

Engelstad, P. H. and B. Gustavsen (1993). "Swedish Network Development for Implementing National Work Reform Strategy." Human Relations 46(2): 219-248.

Eoyang, G. H. (1996). "Complex? Yes! Adaptive? Well, Maybe..." Interactions 3: 31.

Feldman, M. and J. March (1981). "Information in Organizations as Signal and Symbol." Administrative Science Quarterly 26(2): 171-186.

Fountain, J. E. (2001). Building the Virtual State: Information Technology and Institutional Change, Brookings Institution Press.

Germann, S., A. Jabry, J. Njogu and R. Osumba (2012). The Illness of "Pilotitis" In mHealth – Early Lessons from the KimMNCHip Partnerships in Kenya. Geneva Health Forum. Geneva, Switzerland.

Giddens, A. (1979). Central Problems in Social Theory. Berkeley, University of California Press.

Giddens, A. (1984). The Constitution of Society. Cambridge, Polity Press.

Glaser, B. G. and A. L. Strauss (1967). The Discovery of Grounded Theory: Strategies for Qualitative Research. London, Weidenfield and Nicholson.

Greenwood, D. J. and W. F. Whyte (1993). "Participatory Action Research as a Process and as a Goal." Human Relations 46(2): 175-192.

Grimson, J., W. Grimson and W. Hasselbring (2000). "The SI challenge in health care." Communications of the ACM 43(6): 49-55.

Gulledge, T. R. (2006). Industrial Management & Data Systems 106: 5.

Hanseth, O. (2000). The Economics of Standards. From control to drift: The dynamics of corporate information infrastructures. C. Ciborra. Oxford, Oxford University Press.

Hanseth, O. (2001). "Gateways - just as important as standards. How the Internet won the "religious" war about standards in Scandinavia." Knowledge, Technology and Policy 14(3): 71-89.

Hanseth, O. and K. Lyytinen (2010). "Design theory for dynamic complexity in information infrastructures: the case of building internet." Journal of Information Technology 25: 1-19.

Hanseth, O., E. Monteiro and M. Hatling (1996). "Developing information infrastructure: the tension between standardisation and flexibility." Science, Technology and Human Values 11(4): 407-426.

Hasselbring, W. (2000). "Information system integration." Communications of the ACM 43(6): 33-38.

Hayes, N. (2008). "Institutionalizing change in a high-technology optronics company: The role of information and communication technologies." Human Relations 61(2): 243-269.

Hayes, N. and R. Rajão (2011). " Competing institutional logics and sustainable development:the case of geographic information systems in Brazil's Amazon region." Information Technology for Development 17(1): 4-23.

Health Metrics Network (2006). Everyone counts. WHO.

Health Metrics Network (2008). Framework and standards for Country Health Information Systems, World Health Organization.

Health Metrics Network (2010). Results Report June 2010 - Building momentum and saving lives. Geneva, Health Metrics Network.

Heeks, R. (2002). "Information Systems and Developing Countries: Failure, Success, and Local Improvisation." The Information Society **18**: 101-112.

Heeks, R., D. Mundy and A. Salazar (1999). Why Health Care Information Systems Succeed or Fail. Information Systems for Public Sector Management. Manchester, Institute for Development Policy and Management.

Heywood, A. and J. Rohde (undated). Using information for action: a manual for health workers at facility level. South Africa, EQUITY Project.

Jepperson, R. L. (1991). Institutions, institutional effects, and institutionalism. The New institutionalism in organizational analysis. W. W. Powell and P. DiMaggio. Chicago, University of Chicago Press**: 143-163.

Johannessen, L. K. and G. Ellingsen (2009). "Integration and Generification - Agile Software Development in the Healthcare Market." Computer Supported Cooperative Work (CSCW) **18**: 607-634.

Jolliffe, B., J. Braa, E. K. Kossi, A. Kanter, N. Lesh, R. Crichton, C. J. Seebregts and J. Sæbø (2010). Comprehensive Yet Scalable Health Information Systems for Low Resource Settings: A Collaborative Effort in Sierra Leone. AMIA Annual Symposium, American Medical Informatics Association.

Klein, H. K. and M. D. Myers (1999). "A set of principles for conducting and evaluating interpretive field studies in information systems." MIS Quarterly **23**(1): 67-93.

Kuipers, P., J. Humphreys, J. Wakerman, R. Wells, J. Jones and P. Entwistle (2008). "Collaborative review of pilot projects to inform policy: A methodological remedy for pilotitis?" Australia and New Zealand Health Policy **5**(1): 17.

Latour, B. (1986). The powers of association. Power, Action and Belief. J. Law. London, Routledge and Kegan Paul**: 264-280.

Latour, B. (1999). Pandora's Hope, Essays on the Reality of Science Studies. Cambridge, Massachusetts, Harvard University Press.

Law, J. (1996) "Traduction/Trahison: Notes on ANT."

Lawrence, T. and R. Suddaby (2006). Institutions and institutional work. Handbook of Organizational Studies, . S. R. Clegg, C. Hardy, T. Lawrence and W. R. Nord. London, Sage.

Lemley, M. and L. Lessig (2001). The End of End-to-End: Preserving the Architecture of the Internet in the Broadband Era, Stanford Law School, John M. Olin Program in Law and Economics.

Lewin, K. (1945). "The Research Center for Group Dynamics at Massachusetts Institute of Technology." Sociometry **8**(2): 126-136.

Lewin, K. (1946). "Action research and minority problems." <u>Journal of Social Issues</u> **2**: 34-46.

Lewis, J. (2011). <u>From technology for information to information for local action: the role of participatory networks from case studies in India</u>. PhD, University of Oslo.

Lind, P. (1990). <u>Computerization in Developing Countries: Model and Reality</u>, Routledge.

Lindgren, R., O. Henfridsson and U. Schultze (2004). "Design Principles for Competence Management Systems: A Synthesis of an Action Research Study." <u>MIS Q.</u> **28**(3): 435-472.

Maguire, S., C. Hardy and T. Lawrence (2004). "Institutional Entrepreneurship in emerging fields: HIV/AIDS treatment advocacy in Canada." <u>Academy of Management Journal</u> **47**(5): 657-679.

McKay, J. and P. Marshall (2000). <u>Quality and Rigour of Action Research in Information Systems</u>. ECIS 2000.

Mell, P. and T. Grance (2011). The NIST Definition of Cloud Computing. <u>NIST Special Publication 800-145</u>. Gaithersburg, National Institute of Standards and Technology.

Mingers, J. (2001). "Combining IS Research Methods: Towards a Pluralist Methodology." <u>Information Systems Research</u> **12**(3): 240-259.

Monteiro, E. (2000). Actor-Network Theory and Information Infrastructure. <u>From Control To Drift, The Dynamics of Corporate Information Infrastructures</u>. C. U. Ciborra. Oxford, Oxford**:** 71-83.

Monteiro, E., N. Pollock, O. Hanseth and R. Williams (2012). "From Artefacts to Infrastructures." <u>Computer Supported Cooperative Work (CSCW)</u>: 1-33.

Monteiro, E. and K. H. Rolland (2002). "Balancing the Local and the Global in Infrastructural Information Systems." <u>The Information Society</u> **18**: 87-100.

Moyo, D. (2009). <u>Dead aid : why aid is not working and how there is a better way for Africa</u>. New York, Farrar, Straus and Giroux.

Mumford, E. (2001). "Advice for an action researcher." <u>Information Technology & People</u> **14**(1): 12-27.

Myers, M. D. (1997) "Qualitative Research in Information Systems." <u>MISQ Discovery</u>.

Nhampossa, J. L. (2005). <u>RE-THINKING TECHNOLOGY TRANSFER AS TECHNOLOGY TRANSLATION: A CASE STUDY OF HEALTH INFORMATION SYSTEMS IN MOZAMBIQUE</u>. Doctor Scientarum, University of Oslo.

Nicolini, D. (2010). "Medical Innovation as a Process of Translation: a Case from the Field of Telemedicine." <u>British Journal of Management</u> **21**(4): 1011-1026.

Nielsen, P. (2006). <u>A Conceptual Framework of Information Infrastructure Building, A Case study of the Development of a Content Service Platform for Mobile Phones in Norway</u>. Doctor Scientarium, University of Oslo.

Norad Evaluation Department (2012). Hunting for Per Diem: The Uses and Abuses of Travel Compensation in Three Developing Countries.

Norris, A. C. (2002). "Current trends and challenges in health informatics." <u>Health Informatics Journal</u> **8**(4): 205-213.

North, D. (1990). <u>Institutions, institutional change, and economic performance</u>. Cambridge, Cambridge University Press.

Office of the Government CIO (2006). Policy on free and open source software use for South African Government. D. o. P. S. Administration.

Oliver, C. (1992). "The antecedents of deinstitutionalization." <u>Organization Studies</u> **13**: 563-588.

Orlikowski, W. (1992). "The Duality of Technology: Rethinking the Concept of Technology in Organizations." <u>Organization Science</u> **3**(3): 398-427.

Orlikowski, W. and J. J. Baroudi (1991). "Studying Information Technology in Organizations: Research Approaches and Assumptions." <u>Information Systems Research</u> **2**(1).

Orlikowski, W. J. and S. R. Barley (2001). "Technology and institutions: what can research on information technology and research on organizations learn from each other?" <u>MIS Quarterly</u> **25**(2): 145-165.

Piotti, B., B. Chilundo and S. Sahay (2006). "An Institutional Perspective on Health Sector Reforms and the Process of Reframing Health Information Systems." <u>The Journal of Applied Behavioral Science</u> **42**: 91-109.

Plsek, P. E. and T. Wilson (2001). "Complexity science: Complexity, leadership, and management in healthcare organisations." <u>BMJ</u> **323**: 746-749.

Pollock, N. and R. Williams (2010). "e-Infrastructures: How Do We Know and Understand Them? Strategic Ethnography and the Biography of Artefacts." <u>Comput. Supported Coop. Work</u> **19**(6): 521-556.

Pollock, N., R. Williams and L. D'Adderio (2007). "Global Software and its Provenance: Generification Work in the Production of Organizational Software Packages." <u>Social Studies of Science</u> **37**(2): 254-280.

Poppe, O. (2012). <u>Health Information Systems in West Africa - Implementing DHIS2 in Ghana</u>. Master, University of Oslo.

Powell, W. W. (2007). The New Institutionalism. <u>The International Encyclopedia of Organization Studies</u>, Sage Publishers.

Reinert, E. (2007). How Rich Countries Got Rich ... and Why Poor Countries Stay Poor. London, Constable.

Ribes, D. and T. Finholt (2009). "The Long Now of Technology Infrastructure: Articulating Tensions in Development." Journal of the Association for Information Systems **10**(5).

Rogers, E. M. (1962). Diffusion of innovations, Free Press of Glencoe.

Rose, J., M. Jones and D. Truex (2005). "Socio-Theoretic Accounts of IS: The Problem of Agency." Scandinavian Journal of Information Systems **17**(1): 133-152.

Sahay, S., E. Monteiro and M. Aanestad (2009). "Configurable Politics and Asymmetric Integration: Health e-Infrastructures in India." Journal of the Association for Information Systems **10**(5): 399-414.

Sahay, S. and D. Robey (1992). Social Construction of Geographic Information Systems: Some Preliminary Impressions. ICIS.

Sahay, S., J. Sæbø and J. Braa (accepted with revisions). "Scaling of Health Information Systems in a Global Context: Same, same, but different." Information & Organization.

Sahay, S., J. I. Sæbø, S. Mekonnen and A. Gizaw (2010). "Interplay of Institutional Logics and Implications for Deinstitutionalization: Case Study of HMIS Implementation in Tajikistan." Information Technologies and International Development **6**(3).

Sahay, S. and G. Walsham (1999). "GIS for district-level administration in India: Problems and Opportunities." MIS Quarterly **23**: 39-65.

Sahay, S. and G. Walsham (2006). "Scaling of health information systems in India: Challenges and approaches." Information Technology for Development **12**(3): 185-200.

Sahlin, K. and L. Wedlin (2008). Circulating Ideas: Imitation, Translation and Editing. The SAGE Handbook of Organizational Institutionalism. R. Greenwood, C. Oliver, K. Sahlin and R. Suddaby. London, Sage Publications Ltd**:** 218-242.

Sandiford, P., H. Annett and R. Cibulskis (1992). "What can information systems do for primary health care? An international perspective." Social science & medicine **34**(10): 1077-1087.

Senn, J. (1998). The Challenge of Relating IS Research to Practice, IGI Global**:** 23-28.

Shaw, V. (2005). "Health information systems reform in South Africa: developing and essential data set." Bulletin of the World Health Organization **83**(8).

Shaw, V. (2009). A Complexity Inspired Approach to Co-Evolutionary Hospital Management Information Systems Development: Case studies from the "South". PhD, University of Oslo.

Shaw, V., S. Mengiste and J. Braa (2007). Scaling of Health Information Systems in Nigeria and Ethiopia: Considering the options. IFIP 9.4, Sao Paulo.

Shaw, V., S. A. Mengiste and J. Braa (2007). <u>Scaling of Health Information Systems in Nigeria and Ethiopia - Considering the Options</u>. IFIP WG 9.4, São Paulo.

Silverman, D. (1998). "Qualitative research: meanings or practices?" <u>Information systems journal</u> **8**: 3-20.

Stansfield, S., N. Orobaton, D. Lubinski, S. Uggowitzer and H. Mwanyika (2008). The Case for a National Health Information System Architecture; a Missing Link to Guiding National Development and Implementation. <u>Bellagio Series</u>. Bellagio, Italy.

Star, S. L. and J. R. Griesemer (1989). "INSTITUTIONAL ECOLOGY, TRANSLATIONS AND BOUNDARY OBJECTS - AMATEURS AND PROFESSIONALS IN BERKELEYS-MUSEUM-OF-VERTEBRATE-ZOOLOGY, 1907-39." <u>Social Studies of Science</u> **19**(3): 387-420.

Stiglitz, J. E. and C. E. Walsh (2002). <u>Principles of microeconomics</u>. New York, W.W. Norton.

Suchman, L. (2002). "Located accountabilities in technology production." <u>Scandinavian Journal of Information Systems</u> **14**(2).

Suchman, L. (2007). <u>Human and Machine Reconfigurations : Plans and Situated Actions</u>. Cambridge, Cambridge University Press.

Susman, G. and R. Evered (1978). "An Assessment of the Scientific Merits of Action Research." <u>Administrative Science Quarterly</u> **23**(4): 582-603.

Swanson, E. B. and N. C. Ramiller (2004). "Innovating mindfully with technology." <u>MIS Quarterly</u> **28**(4): 553-583.

Sæbø, J., J. Braa, E. K. Kossi, M. Jalloh and A. Manya (2013). "Developing decentralised health information systems in developing countries –cases from Sierra Leone and Kenya." <u>Journal of Community Informatics</u> **9**(2).

Sæbø, J. and O. Titlestad (2004). <u>Evaluation of a Bottom-Up Action Research Project in a Centralised Setting: HISP in Cuba</u>. 37th Hawaii International Conference on System Sciences, Hawaii.

Sæbø, J. I., J. Braa and O. Chadna (2007). A Flexible Approach to Integrating Health Information Systems: The case of Data Warehouse as Integrator in Botswana, Proceedings of IFIP WG 9.4 9th international conference "Taking Stock of E-Development".

Sæbø, J. I., J. Braa, S. Sahay, E. K. Kossi and D. Settle (2011). <u>Networks of Networks - Collaborative Efforts to Develop Health Information Systems Across Developing Countries</u>. Ifip WG 9.4 Social Implications of Computers in Developing Countries, Kathmandu, Nepal.

Sæbø, J. I., W. Gill and B. Ngatia (2008). Integrating Software to Monitor HIV/AIDS: The Case of eBHRIMS in Botswana. <u>IST Africa</u>.

Sæbø, J. I., E. K. Kossi, O. H. Titlestad, R. R. Tohouri and J. Braa (2011). "Comparing strategies to integrate health information systems following a data warehouse approach in four countries." Information Technology for Development **17**(1): 42-60.

Thornton, P. and W. Ocasio (1999). "Institutional Logics and the Historical Contingency of Power in Organizations: Executive Succession in the Higher Education Publishing Industry, 1958-1990." American Journal of Sociology **105**(3): 801-843.

Thornton, P. and W. Ocasio (2008). Institutional Logics. The SAGE Handbook of Organizational Institutionalism. R. Greenwood, C. Oliver, K. Sahlin and R. Suddaby. London, Sage Publications Ltd**:** 99-129.

Thorseng, A. (2008). Managing complexity through flexible scaling - a case study of the expansion of a health information system in Botswana. Master, University of Oslo.

Turnbull, D. (2000). Masons, tricksters and cartographers. London & New York, Routledge.

United Nations (2000). United Nations Millenium Declaration.

Urry, J. (2003). Global Complexity. Cambridge, Blackwell Publishing Ltd.

USAID (2009). Pay for Performance (P4P) to Improve Maternal and Child Health in Developing Countries: Findings from an Online Survey.

Vaast, E. and G. Walsham (2009). "Trans-Situated Learning: Supporting a Network of Practice with an Information Infrastructure." Information Systems Research **20**(4): 547-564.

Van Maanen, J. (1979). "The fact of fiction in organizational ethnography." Administrative Science Quarterly **24**(4): 539-550.

Vernadat, F. B. (2007). "Interoperable enterprise systems: Principles, concepts, and methods." Annual Reviews in Control **31**(1): 137-145.

Wainwright, D. and T. Waring (2004). "Three domains for implementing integrated information systems: Redressing the balance between technology, strategic, and organizational analysis." International Journal of Information Management **24**: 329-346.

Walsham, G. (1995). "Interpretive case studies in IS research: nature and method." European Journal of Information Systems(4): 74-81.

Walsham, G. (1997). Actor-network theory and IS research: current status and future prospects. Information Systems and Qualitative Research. A. Lee, J. Liebenau and J. I. DeGross.

Webster, J. (1990). Office Automation: the labour process and women's work in Britain. Hemel Hempsted, Harvester Wheatsheaf.

Weisz, G. (2003). "The Emergence of Medical Specialization in the Nineteenth Century." Bulletin of the History of Medicine **77**(3): 536-574.

WHO (1978). Declaration of Alma-Ata.

WHO (2009). <u>Systems thinking for health systems strengthening</u>, World Health Organization.

WHO (2011). Keeping promises, measuring results: Commission on information and accountability for Women's and Children's Health.

Williams, R. and N. Pollock (2012). "Research Commentary—Moving Beyond the Single Site Implementation Study: How (and Why) We Should Study the Biography of Packaged Enterprise Solutions." <u>Information Systems Research</u> **23**(1): 1-22.

Winner, L. (1978). <u>Autonomous Technology: Technics-Out-Of-Control as a Theme in Political Thought</u>, Mit Press.

Winner, L. (1993). "Upon Opening the Black Box and Finding it Empty." <u>Science, Technology and Human Values</u> **18**(3): 362-378.

Zittrain, J. (2006) "The Generative Internet." <u>University of Oxford Faculty of Law Legal Studies Research Paper Series</u>, 1974-2040.

Zittrain, J. (2008). <u>The Future of the Internet And How to Stop It</u>, Allen Lane.

Appendices

Paper 1: *A Flexible Approach to Integrating Health Information Systems – The Case of Data Warehouse as Integrator in Botswana*, Sæbø ,J; Braa, J; Chandna, O, Proceedings of the IFIP WG 9.4 Conference on Social Implications of Computers in Developing Countries, Sao Paulo, 2007

Paper 2: *Interplay of Institutional Logics and Implications for Deinstitutionalization: Case Study of HMIS Implementation in Tajikistan*, Sahay, S; Sæbø, J; Mekonnen, S; Gizaw, A, Information Technologies & International Development, Volume 6, Number 3, Fall 2010, pp 19-32

Paper 3: *Comparing strategies to integrate health information systems following a data warehouse approach in four countries*, Sæbø, J; Kossi, E; Titlestad, O; Tohouri, R; Braa, J; In Elaine Byrne; Brian Nicholson & Fadi Salem (ed.), Assessing the Contribution of ICT to Development Goals, Special Issue of Information Technology for Development, Volume 17, Issue 1, 2011

Paper 4: *Networks of networks – collaborative efforts to develop Health Information Systems across developing countries*, Sæbø, J; Braa, J; Sahay, S; Kossi, E; Settle, D; Proceedings of the IFIP WG 9.4 Conference on Social Implications of Computers in Developing Countries, Kathmandu, 2011

Paper 5: *Developing decentralised health information systems in developing countries – cases from Sierra Leone and Kenya*, Sæbø, J; Braa, J; Kossi, E; Jalloh, M; Manya, A; Journal of Community Informatics, Volume 9, No. 2, 2013

Paper 6: *Scaling of Health Information Systems in a Global Context: Same, same, but different*, Sahay, S; Sæbø, J; Braa, J; Invited paper, in review, Information and Organization

I

A FLEXIBLE APPROACH TO INTEGRATING HEALTH INFORMATION SYSTEMS – THE CASE OF DATA WAREHOUSE AS INTEGRATOR IN BOTSWANA

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Abstract: The organizational complexity of health service provision is fairly high, given the many actors and the rapid evolution of both treatment methods and disease picture. Due to a dysfunctional health information system, the various actors in Botswana had created their own, independent information systems, leading to duplication of work and inaccessibility of data. This paper describes how the various actors of the Botswana health sector were brought together to work on health information systems integration through the development of a single, computer-based tool for collecting, processing, and analyzing data. This software, together with a set of shared routines that would save resources for the individual actor, became an *attractor*, an option that would create no losers, while all could win. Thus, for the first time, the fragmented network of health service providers could come together, an important first step in health information standardization.

Keywords: data warehouse, standardization, health information system, Botswana

A FLEXIBLE APPROACH TO INTEGRATING HEALTH INFORMATION SYSTEMS – THE CASE OF DATA WAREHOUSE AS INTEGRATOR IN BOTSWANA

1. INTRODUCTION

The main aim of this paper is to advance the understanding of theoretical concepts relating to complexity, derived from a study of the development of an integrated health information system in Botswana. Taking the existing fragmented health information systems as a point of departure, this study shows the complexity of the health services in the country. Complexity has been loosely defined as a product of the amount of different actors, the relationship between them, and the speed of change. In Botswana there are four ministries involved in providing health information systems, with sub-divisions of these also involved, each with different agendas. In addition, international organizations, such as UNAIDS, are present both as independent actors and partners of local initiatives. On top of this, the HIV/AIDS pandemic has turned the health situation in the country upside down over the last ten years.

Due to a dysfunctional original information system, each health program within the Minsitry of Health, such as Mother and Child Health or Home Based Care, has over the years created its own systems to accommodate its information needs. The underlying cause of this is the organizational complexity mentioned above, with several ministries involved in the process of gathering, analyzing, and utilizing data. The health programs themselves are also organized vertically, creating a fragmented environment within the Ministry of Health (MoH). Thus, the lack of coordination among these has led to a multitude of different information systems, of varying quality. Those health programs which have had more resources have developed well-working, isolated systems, some which are supported by computers. The less-resourceful health programs still rely on paper reporting up to the national level, where simple spreadsheets function as both data reports and data repository. The results are; overlap among the systems, duplication of work in supporting the various systems, but above all, less accessibility to data, that in turn hampers information use both at the district and national level. A project has been established to address these issues, in which the authors have been main participants.

The other aim of the project is to strengthen the district level, to increase the abilities of the local level to effectively manage preventive primary health care. Botswana consist of 26 health districts, varying greatly in size, population density, climate, and geography, and the motivation has been to enable the districts to better utilize their local expertise and knowledge through access to relevant and updated information.

The proposed approach was thus to integrate the various information systems within the framework of a district data warehouse. This would enable the health programs to maintain their independence, while at the same time benefit by getting access to relevant information and pool their resources. As a next step, this would be used to address overlaps, gaps and inconsistencies between the data sets collected and processed by the various information systems. This approach to standardization of health data take the constantly changing health sector into account and emphasizes flexibility and negotiations between actors through an evolutionary process (Braa et al, 2007). The bureaucratic models of standardization (agreements before implementation) are too slow and static to cope with the rapid organizational and technological changes, such as seen in the health sector, and more flexible approaches are needed (Egyedi, 2002; Hanseth, Monteiro, & Hatling, 1996).

An open source software was to be the vehicle for integration, what we see as an attractor for change. All health information systems in use would be implemented in the software, creating one single system for collecting, processing, and analyzing health information. This system would make new and historical data easily accessible to all program managers and district health specialists. In addition, it would form a base from which to align the various programs' data reports, starting the long road towards standardization and an information system geared towards information for action and "need-to-know" information. It may be an appropriate way of working towards this standardization "in a situation increasingly dominated by strong programmes and multiple uncoordinated data sets and software applications"(Braa, 2006)

This article will proceed as follows. First, we present relevant theory, before we look at the Health Information Systems Programme HISP project and experiences from other countries. Then we present the case of Botswana, and discuss the experiences there. Lastly we look at implications for other similar projects, and the way forward in Botswana.

2. Conceptual framework

Complexity Science has been increasingly used to describe health systems (Tan, Wen, & Awad, 2005). Complex Adaptive Systems (CAS) is especially useful when dealing with changing environment and many actors. A CAS has been defined as "a collection of individual agents with freedom to act in ways that are not always totally predictable, and whose actions are interconnected so that one agent's actions changes the context for other agents" (Plsek & Greenhalgh, 2001). This changed context will lead to new actions, reflexively influencing the first acting agent. Order is not designed in CAS, but rather emerges over time. Central to this are attractors, "a limited range of possible states within which the system stabilizes" (Braa, Hanseth, Mohammed, Heywood, & Shaw, forthcoming). These attractors are focal points for the constant evolution of complex systems; technical or social constructions that attract agents to change behaviour in a certain direction. They have proven very useful to describe how complex systems can be formed. Attractors for change are preferred over battling resistance through strong leadership. Those who seek change should "harness the natural creativity and organising ability of its staff and stakeholders through […] the positive use of attractors for change, and a constructive approach to variation in areas of practice where there is only moderate certainty and agreement" (Plsek & Wilson, 2001).

An inherent property of CASs is its non-linearity. Even small changes in initial variables can lead to very different outcomes (Plsek & Greenhalgh, 2001). Attractors implemented at early stages do thus achieve even greater potential for changing the direction of the system's evolution.

Scaling and scalability is also important in complexity science. Here scaling is seen as the reproduction of the same structure as appears in other parts of the system (Eoyang, 1996). (Braa, Hanseth, Mohammed, Heywood, & Shaw, forthcoming) show how scaling can also involve flexibility to deviate from the original template or structure. Encouraging diversity and experimentation may in fact support the scaling process. When it comes to scaling of health information systems, little research has been done (Sahay & Walsham, 2006). One peculiar characteristic of Health Information Systems (HIS) is the "all or nothing" dilemma. Given the nature of health administration, data is only useful when you have "full" coverage. Health districts cannot be administered properly based on data from only half the clinics, or only half the health programs. An HIS's usefulness is thus closely related to its *completeness*. An integrating strategy seeks to address this dilemma by offering a complete set of data collection forms adapted to the software. This in turns enables a rapid geographic expansion since the various collection forms are already known and used at district offices and clinics.

A related set of analytic notions are found in Actor Network Theory (ANT). Put simply, ANT describes a given context as interactions between heterogeneous actors, both technical and social

(Monteiro, 2000). Each actor is itself an actor network, consisting of yet more actors. Because of the reflexivity of such networks, we "blackbox" networks and look at them as individual actors where this is useful for the analysis. Embedded in each actor are inscriptions, representing a force of influence these actors exert on other actors. Inscriptions can be strong or weak, and they can change. Studying these inscriptions is useful to see how actors influence each other and align themselves among other actors.

Combining CAS and ANT leads to an important insight. Attractors for change are communicated through the various actors' inscriptions. Making change attractive can be inscribed in technical and social artefacts (such as organizations). The flexibility of the District Health Information System (DHIS) software, inscribed through easy database editing and compatibility between variously defined databases, has been an important attractor for change in South Africa (see for example Braa, Hedberg 2002). This does not mean all inscriptions are attractors, as many inscriptions are focused on deterrence. In Latour's classic example of the hotel manager (Latour, 1991), the weight of the keys is a strong inscription to return the key when leaving the hotel, but the inscription is negatively formulated. It is not an attractor to change behaviour, but a penalty for not. Inscriptions can also be seen as weak/flexible or strong/inflexible. For example, a hammer has a weak inscription of action; it can easily be used for other purposes than the intended one. An assembly line has a strong inscription; it is not easily modified into other uses (Monteiro, 2000).

When dealing with different standards or different technologies, gateways emerge as a key concept (Hanseth, 2001). Gateways function as a pragmatic, and necessary, solution for complex, evolving settings. Standardization is not always possible, or desirable, and gateways can link these different standardized entities in a common network. In terms of ANT, gateways become border objects, being something two actor networks have in common linking them together. In the case of health information systems, gateways are typically needed between patient information system and systems only dealing with aggregated data. A gateway here would typically be a piece of software extracting aggregated data from the patient information system and presenting them in a readable format for the latter system. Other gateways are needed between a paper based system and a computer based.

3. The Health Information System Programme

While this paper focuses on Botswana, the work there is based on experiences from a larger ongoing international project, the Health Information System Programme (HISP). It was established in South Africa in 1996 (Braa, Hedberg 2002), as a combined research and development project based in Western Cape. While the software DHIS has since been piloted and implemented in a range of countries, from India and Vietnam in Asia, Ethiopia, Tanzania, and Mozambique among others in Africa, to Cuba in the Americas, it has only become a national standard in South Africa. The success of the approach in South Africa led to similar strategies being adopted for other countries as well. The strategy there was to define an essential data set, a collection of the most important data for management, while simultaneously prototype a software in a participatory process. The approach proved successful in reducing the amount of data collected and improving the data quality. However, conditions special to South Africa that made this approach successful has not been present in other countries (Braa, 2006). Among these are the political will for change, the failure of competing systems, the long time frame, and the political attractiveness of HISP's philosophical foundation (Braa & Hedberg, 2002)((Braa, Hanseth, Mohammed, Heywood, & Shaw, forthcoming). An essential data set approach was less feasible in for example Cuba, where the extensiveness of data collected carried an important political message (Sæbø & Titlestad, 2004).

An important aspect of the HISP processes is what has been termed the hierarchy of standards (Braa & Hedberg, 2002). Each administrative level is free to define its own standards and information needs, given that it provides the information asked for by the "superior" level. Such a

decentralization of information ownership has been essential in the development of streamlined information systems based on collecting information for action. The essential dataset could be expanded at each level if that was necessary for local management.

Botswana is part of the "HISP network", i.e. a wide network of health professionals and researchers who work along the same principles in many developing countries. Developing local expertise is essential to ensure sustainability, and the project seeks to create a south-south network, where developing countries can help other developing countries. Botswana has both received from and contributed to this growing network.

4. Methodology

The research has followed an interventionist approach. Following principles of Action Research (AR), the goal for the researchers has been to change the HIS in Botswana while simultaneously creating knowledge. Adhering to a Scandinavian strand of AR, with a political agenda and a focus on sustainability, this method has been the preferred one for most HISP related projects (Braa, Monteiro, & Sahay, 2004). One important lesson from this strand has been to base the action in networks rather than on singular units (Elden & Chisholm, 1993). The work in Botswana is thus part of a wider action research project, with the researchers being involved in similar processes in other countries.

Interpretive research methods (Walsham, 1993) have guided the analysis of the observations and experiences made by the researchers.

The authors have all been involved in the process of piloting DHIS in Botswana. One holds a resident position as IT Manager at the MoH, while the two others are external researchers that have spend considerable time working with the project in Botswana, as well as in other countries, including South Africa. Together, the external researchers have spent six months in Botswana, engaging in implementation, training, and adaptation, over a period spanning 18 months. In participating extensively in the project, the authors gained empirical experience and data from both formal and informal meetings and unstructured interviews, document analysis, and observation.

5. The Case of Botswana

Botswana is a Southern African country largely consisting of dry savanna and semi-desert. It is extremely sparsely populated, with the majority of the inhabitants living in and around a few urban centers. During 40 years of independence, Botswana has developed a mature democracy, and social and infrastructural development has been fuelled by exploitation of rich diamond fields. Compared to the region, and sub-Saharan Africa as a whole, Botswana is a prosperous and stable country. This has positive implications on any IS project, as the education level is relatively high, computer knowledge is good, and the telecommunication infrastructure is well developed, and expanding. Though relatively rich and politically stable, Botswana has been especially hard hit by the AIDS pandemic, with an estimated prevalence of over 30 percent of the adult population. The result is the second lowest life expectancy at birth in the world, at 34.9 years (United Nations Development Programme, 2006).

5.1. The Botswana Health Service

Botswana has, due to its small population, a relatively shallow organizational structure. 26 Health Districts are organized directly under the Ministry of Health (MoH). Health facilities, including hospitals, clinics, mobile clinics etc, are organized under the districts. The MoH is responsible for policy and strategic development of health services in Botswana in line with general government policy. It is also responsible for health service delivery at the primary, district and referral hospitals. The district health services and primary health care services at clinic level is the

responsibility of the Ministry of Local Government (MLG). Thus two ministries are involved in the day-to-day running of the health ministries.

Within the MoH, there are health programs that are responsible for various fields, such as Extended Program on Immunization, Tuberculosis, Home based care etc. Some of these programs have their own representatives at district level, but most are pooled under a District Health Team (DHT).

5.2. The Health Information System

The main provider of health statistics in Botswana is the Central Statistics Office (CSO) in the Ministry of Finance and Development Planning. Based on data collected by the Health Statistics Unit (HSU), an arm of CSO within the MoH, produces a yearly publication on health information. The latest published volume by the time of writing was from 2004, containing three years old data. The CSO was involved in an international project to improve its routines, but the focus was one defining reports rather than on implementing them in efficient routines. Due to this delay, the various health programs at the MoH have developed their own reporting structures. For all practical purposes, data that is three years old is not useful in health management. To monitor policies and take rapid action at disease outbreaks, the health programs have been forced to install their own routines and tools to collect data. This has several implications on the overall health information system.

First, there is a duplication of work. The Integrated Disease Surveillance Report program collects data on communicable diseases. They collect much of the same data as the HSU. Data that come from the same source at facilities are split into two information systems. In addition, this data is not always identical when it reaches the national level, indicating bad data quality.

Another example is the Prevention of Mother To Child Transmission (PMTCT) program and the Mother and Child Health (MCH) program, both of which collect data on antenatal visits and births. This duplication takes place in a setting with limited resources. The duplication of work also applies to the development and maintenance of information systems.

Second, the information systems developed by the different health programs are vertical and isolated from the other systems. Data from another health program than your own becomes more inaccessible. A multitude of parallel systems are handled by different people, at different levels.

Thirdly, the quality and technological level of the information systems vary greatly. Some programs have more resources, both financial and human, and have developed computer based reporting structures, while other programs still rely on legacy paper systems. For example, the PMTCT program has invested in computers for all of its 26 districts officers. These computers are used to collect PMTCT specific data only. In one of the pilot districts, the district PMTCT officer, together with her computer, was located in a clinic separate from the rest of the District Health Team.
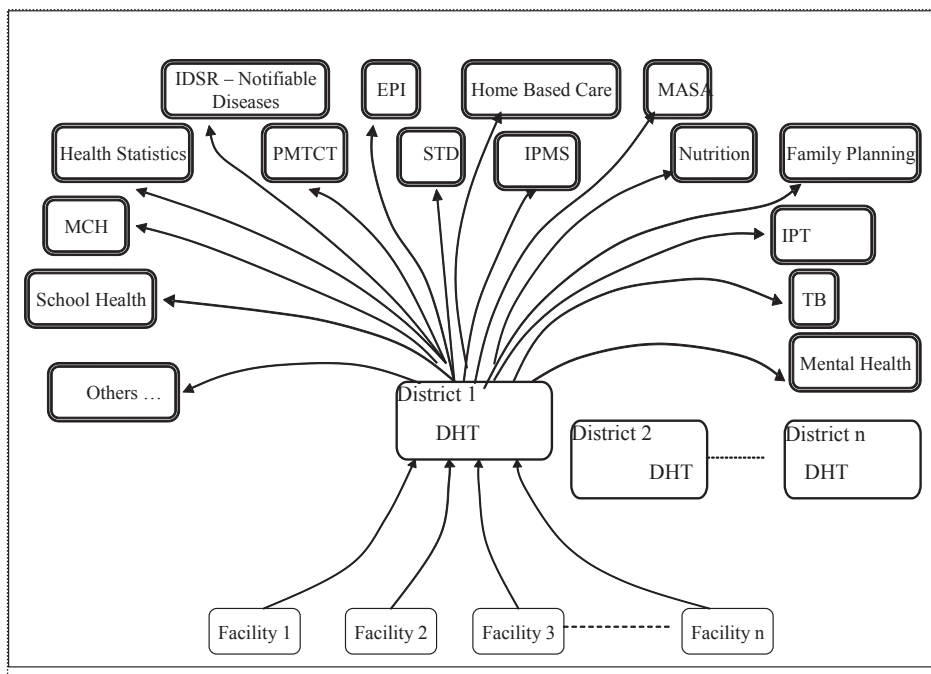
Figure 1: The current fragmented health information system

The figure above shows the information flow at the start of the project (Chandna & Hedberg, 2005). Data is collected at facilities, and reported to the DHT, which is here showed as one entity. However, even though a majority of the data is processed by one or two persons at the district level, some programs are handled by other nurses, who might even work at a different location. From the DHT the data is reported to the respective health programs. There is no national database containing all data, this is stored at each health program either electronically or on paper. A multitude of computer systems are used by the stronger health programs, such as PMTCT and TB, but mostly at the national level.

Information use at the districts is fairly developed, but the amount of data collected indicates that most is never used. Around 1500 data elements, that is, aggregated figures of diseases and conditions, are collected on a regular basis at the districts. Very little of this data is used to construct indicators (rates and ratios), most remains as raw data (pure figures).

5.3. Organizational Complexity in the health service delivery

As we have seen, there are several actors involved in the delivery of health services. The major chasm is that between the national and district level, run by two different ministries. The main recipient of health data is however the Central Statistics Office, who is responsible for preparing a yearly reports from different sectors. The MoH is further divided in different health programs, from which the current fragmentation of information systems stems. The differences between them are exacerbated by their different resources. Some health programs are also supported by international NGO's, especially those related to HIV/AIDS. These programs have fared better in developing their own information systems.

The table below shows the four ministries involved in the health information systems in Botswana, and their respective role. The Ministry of Science, Technology and Communication is responsible for supporting the MoH regarding IT solutions, including various HIS software.

Table 1: Ministries and their role in the Health Sector

Ministry	Active departments	Responsibility	Level Active
Ministry of Health (MoH)	All health programs	Implement policies at national level	National, Hospitals
Ministry of Finance and Development Planning	Central Statistics Office (CSO)	Produce yearly health statistics publication	National
Ministry of Local Government		Execute policies from MoH, run clinics. Resource allocation and human resource management at districts and facilities.	Districts, Clinics
Ministry of Science, Technology and Communication	Department of Information Technology	Develop, maintain, and evaluate IT solutions for the MoH	National

A sample of health programs is shown below. Note that the PMTCT and MCH data have the same source. They have however very different information systems for the parallel reporting.

Table 2: A sample of Health Programs and their responsibilities

Health Program	Responsibility	Status
Health Statistics Unit (HSU)	Collect and prepare routine statistical health data	Statistical system at national level, which is very slow with 2 years of data not yet captured. Is formally responsible for all health data.
Extended Program on Immunization (EPI)	Monitor immunization	Have resources, independent IS, use EPI-Info software package
Prevention of Mother To Child Transmission (PMTCT)	Implement policies to reduce the rate of transmission of HIV from mothers to their children. Antenatal care	Have resources, donor funded, developed independent information system. Overlapping data collection with MCH.
Integrated Disease Surveillance and Response (IDSR)	Collect and analyse data on particular important communicable diseases and provide responses	Initiated as a response to the "slowness" of the official health statistical system, with which it has overlapping data collection. Has resources and independent IS, using Epi-Info.
Mother and Child Health (MCH)	Antenatal care	Little resources, collect data from same source as PMTCT, paper based information system of very poor quality

5.4. HISP in Botswana

The aim of HISP in Botswana was to strengthen the district level and reform the current health information system. Instead of various health information systems going through the DHTs, the DHIS would serve as a data warehouse both at the district and national levels. All data would be collected electronically at the districts, and be exported with e-mail to a national database. Figure 2 shows the future information structure. Extensive training would be given in information use at the districts.
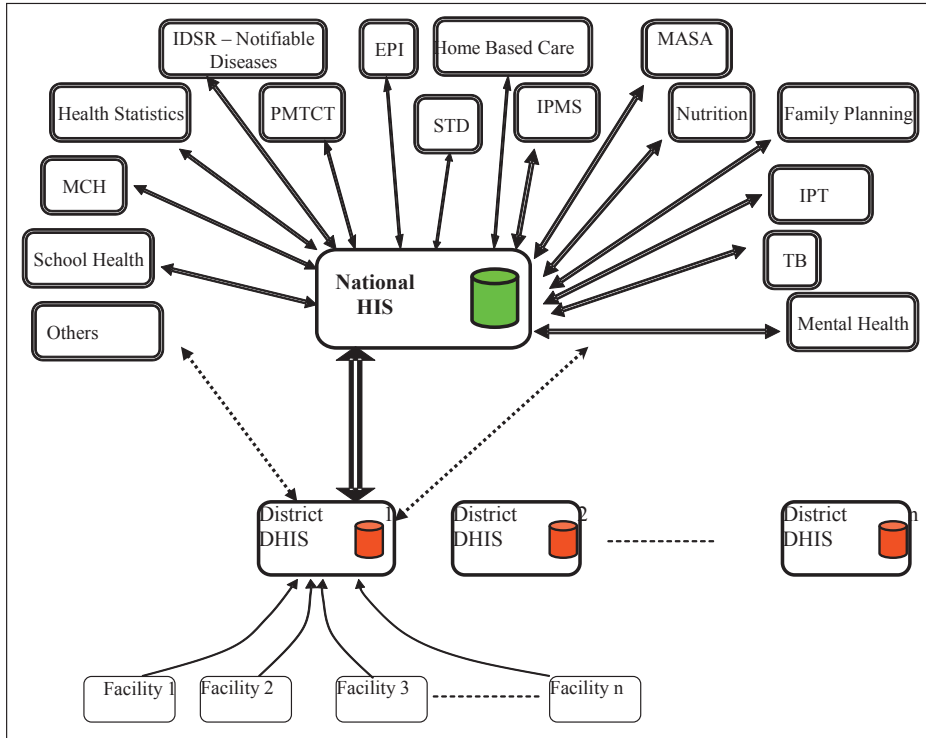
Figure 2: The proposed District Data Warehouse structure

The HISP project was initiated early in 2005, and four (out of 26) districts were selected for a pilot implementation. All existing paper forms were collected from most health programs, and adapted to the DHIS. An effort was made to make the graphical user interface of the DHIS look just like the existing paper forms. Training was conducted mainly for community health nurses and district health managers from the pilot districts, but also representatives from the national level health programs attended. The DHIS database was populated with data from 2004 onwards, to be used as a historical base for analysis of new data.

The project was set up as belonging to the MoH, but also the Ministry of Communication, Science, and Technology was involved, as well as the Ministry of Local Government. All major health programs participated in the initial phase, providing their reporting tools to be adapted to the DHIS. Over the summer of 2005, data was entered in the pilot districts and inconsistencies between the paper forms and DHIS was sorted out. Several different versions of the paper forms exist in the districts. Descriptive of the situation, the project even encountered paper forms in the districts from the same release which were different.

The project has run into several problems related to the poor state of information technology knowledge in the health services. Computers have been in disuse due to hardware failure, virus

attacks, reinstallation of operating systems, and a general lack of problem-solving expertise in far-away districts. Data exporting to the national level has taken place on flash disks, since proper internet connection is not yet available at all sites.

At the time of writing, HISP Botswana is planning a national roll-out to all districts, based on the experiences from the pilot district. Interfacing with existing software is an important part of this, to achieve full data coverage and present a possibility for program managers to continue old, established reporting routines while still being able to keep their data in the district and national data warehouse for analysis and storing.

Interfacing with patient data systems is also essential to build an integrated database. This requires gateways between DHIS and existing paper and electronic patient records to extract aggregated data. There is currently a multi-million dollar project ongoing, piloting the Integrated Patient Management System. This would be a main supplier of patient-based data, but at the time of writing there are several existing systems in use.

6. Discussion

We have so far described the fragmented and uncoordinated nature of the Botswana health information system. The problem arising from this situation is as seen by a senior official in the Ministry of Health that "there is no way to access or get overview of the essential information from across the various health programs and sectors. The only way to get an overview is to visit the individual offices one by one and thereby compile your own data, and that is not good enough". Lack of data standards and consistency between the data collected by the different health programs add to this problem. It has proven difficult to get all stakeholders to agree on shared standards for both what data to collect and procedures and technologies for their collection, processing and use. Consequently a more flexible approach to standardization has been selected (Egyedi, 2002, Braa et al, 2007). In an effort to balance the individual stakeholder need for independence and flexibility with the district and central managements' need for coordination and a certain level of control, a relatively loose integration and standardization strategy has been implemented; the data warehouse approach.

6.1. Creating an attractor – The Data Warehouse

The main challenges in Botswana were related to having the various actors coming together to address the problem of a fragmented health information system. Only when all actors are involved could one start to coordinate and standardize the system. Facing several ministries, and a range of uncoordinated health programs, a "shared" data warehouse was selected as the preferred approach. Each health program could continue to collect their own data on paper forms in the health facilities, get support for capturing this data in the database at the district level and get the data transferred to the central level. If the program had their own computerized system, the data would be made available for them electronically in the required format.

The creation of a data warehouse can be seen as having two immediate results. It would make it easier to kick start the project by having a well known data collection structure and layout for both the national and district level, and it would serve as a vehicle for bringing the various health programs together. Once the system started to produce results and the actors learned about it, an attractor had been created.

Using ANT and CAS, we can highlight the effect of such an attractor. The DHIS is now itself an actor in the health system in Botswana. Its design and technical solutions carry certain inscriptions. Strong support for analysis is an inscription to use the data for health management. Easy maintenance of the database is a deliberate inscription encouraging local development of standards by people with less technical skills. In the case of Botswana, these and other inscriptions are supplemented with a complete set of health programs mirroring the existing paper forms. Each

health program could be presented their own reporting forms, now computerized, and populated with historical data. As several of the major health programs had joined the project from the start, such as PMTCT, HSU, and IDSR, the project gained momentum. The software has assumed the function of an attractor for integration making "attractive" for other actors to join forces, and at the same time a starting point for local analysis of data.

While the project so far has had limited success in improving data quality and use, the attractor has been successful in, for the first time, bringing the various stakeholders together. There is now a strong consensus among the health programs and the ministries involved that an integration of the information systems following the data warehouse approach is necessary and the project has been given a mandate to work towards such a goal.

So far the system has been implemented only for four health programs in four districts. Nevertheless, as a prototype it has served the function of showing the actors that, indeed, a data ware house may serve the purpose of a "shared resource" for handling data, and for providing access to all data across health programs. However, it has also demonstrated inconsistencies in the current system of data standards and procedures; when same or similar data is collected by different health programs (e.g. MCH and PMTCT) the totals do not necessarily match. In this way inconsistencies in the current system has been made transparent and some first efforts to address them have been initiated. This example illustrates that the data warehouse approach has the potential to become a "vehicle" for standardization of data and procedures for their collection which allows for flexibility and an evolutionary process. Changes that are resulting from negotiations between individual partners, such as between MCH and PMTCT regarding data on deliveries and ANC, may be implemented in a piecemeal fashion without affecting other actors.

An important precondition for such a consensus is that all actors will "win" something, none will lose. Gateways between DHIS and existing software enables programs to continue using their own software if they so desire. No legacy systems are removed, but incorporated into a software where they can easily be modified by the respective health programs.

The data warehouse has also the effect of saving resources. A fragmented information system requires duplicate efforts to create and maintain collection and reporting routines, software, and paper forms. A common set of routines for all health programs, executed by a few specially trained nurses, using one software, will save considerable amounts of time and money in a resource scarce environment.

6.2. Emerging order versus design

A central theme in CAS is that order is not designed, but emerges over time. However, one has a certain degree of leverage, and one way to cultivate, or nurture, a certain "design" is through the implementation of attractors. The attractor is an actor in itself, influencing other actors in the network. The success of using DHIS as a data warehouse (as opposed to an essential dataset approach) to form an attractor to align the interests of a range of actors, highlights our ability to steer the seemingly autonomous life of health information systems towards a desired state.

7. Conclusion

The health service in Botswana is a very complex organization, involving four ministries and many health programs. Due to a lack of coordination between these actors, the health information system has become extremely fragmented, with several parallel systems run by the various health programs. This fragmentation results in duplication of work, low data quality, and a lack of accessibility of data.

This paper has used the notion of inscriptions from Actor Network Theory to show how the software introduced in Botswana carries regulations and opportunities that makes it attractive for the various stakeholders. Seeing the health sector as a Complex Adaptive System, the creation of

such an attractor has been a successful strategy to create a focal point, a force of gravity, and an arena, for the continuing efforts to standardize the various health information systems.

This attractor needs to be supported by gateways that can link it to the actors' interests. The data warehouse in Botswana has succeeded as an integrator precisely because it offers all actors a way of joining without risking losing. The approach became attractive in a resource scarce environment because it offered gateways that would ensure the continuation of the health programs' independence, while at the same time offering a data collection and analysis tool that is maintained jointly by the other health programs.

At the time of writing, a gateway between the software and a UNAIDS-run HIV/AIDS monitoring system is under development, aligning the interests of a strong and resourceful actor in a specific sector with that of the wider health sector. The attractiveness of DHIS has gained momentum for the integration efforts.

This paper is the product of on ongoing effort to reform the health information system in Botswana, and forms the basis for further studies on complexity in, and scaling of, health information systems.

8. REFERENCES AND CITATIONS

Braa, J. (2006). A data warehouse approach can manage multiple data sets. *Bulletin of the World Health Organization, 83*(8), 638-639.

Braa, J., Hanseth, O., Mohammed, W., Heywood, A., & Shaw, V. (forthcoming). Developing Health Information Systems in Developing Countries. The "Flexible Standards" Strategy. *MIS Quarterly*.

Braa, J., & Hedberg, C. (2002). The Struggle for District-Based Health Information Systems in South Africa. *The Information Society, 18*, 113-127.

Braa, J., Monteiro, E., & Sahay, S. (2004). Networks of Action: Sustainable Health Information Systems Across Developing Countries. *MIS Quarterly, 28*(3), 337-362.

Chandna, O., & Hedberg, C. (2005). *Project Initiation Document Botswana*.

Egyedi, T. M. (2002). *Standards Enhance System Flexibility? Mapping Compatibility Strategies Onto Flexibility Objectives*. Paper presented at the EASST, University of York, UK.

Elden, M., & Chisholm, R. F. (1993). Emerging Varieties of Action Research: Introduction to the Special Issue. *Human Relations, 45*(2), 121-142.

Eoyang, G. H. (1996). Complex? Yes! Adaptive? Well, maybe... *Interactions, 3*(1), 31-37.

Hanseth, O. (2001). Gateways - just as important as standards. How the Internet won the "religious" war about standards in Scandinavia. *Knowledge, Technology and Policy, 14*(3), 71-89.

Hanseth, O., Monteiro, E., & Hatling, M. (1996). Developing information infrastructure: the tension between standardisation and flexibility. *Science, Technology and Human Values, 11*(4), 407-426.

Latour, B. (1991). Technology is Society Made Durable. In J. Law (Ed.), *A Sociology of Monsters: Essays on Power, Technology and Domination*. London: Routledge.

Monteiro, E. (2000). Actor-Network Theory and Information Infrastructure. In C. U. Ciborra (Ed.), *From Control To Drift, The Dynamics of Corporate Information Infrastructures* (pp. 71-83). Oxford: Oxford.

Plsek, P. E., & Greenhalgh, T. (2001). Complexity science: The challenge of complexity in health care. *BMJ, 328*, 625-628.

Plsek, P. E., & Wilson, T. (2001). Complexity science: Complexity, leadership, and management in healthcare organisations. *BMJ, 323*, 746-749.

Sahay, S., & Walsham, G. (2006). Scaling of health information systems in India: Challenges and approaches. *Information Technology for Development, 12*(3), 185-200.

Sæbø, J., & Titlestad, O. (2004). *Evaluation of a Bottom-Up Action Research Project in a Centralised Setting: HISP in Cuba*. Paper presented at the 37th Hawaii International Conference on System Sciences, Hawaii.

Tan, J., Wen, H. J., & Awad, N. (2005). Health Care and Services Delivery Systems As Complex Adaptive Systems. *Communications of the ACM, 48*(5), 36-44.

United Nations Development Programme. (2006). *Human Development Report 2006*: United Nations Development Programme.

Walsham, G. (1993). *Interpreting Information Systems in Organisations*. Chester: Wiley.

II

Research Article

Interplay of Institutional Logics and Implications for Deinstitutionalization: Case Study of HMIS Implementation in Tajikistan

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Abstract

This article describes the efforts to reform the Health Management Information System (HMIS) of Tajikistan. The authors were involved in proposing and piloting a computerized HMIS based on a complete overhaul of the current data collection tools, as well as in planning for the scaling up of the system. One of the recommendations was to support local decision-making through a flexible, decentralized system to collect, process, and analyze essential primary healthcare data. The institutional logics underlying the current HMIS in Tajikistan were heavily influenced by the tenets of central planning from a deeply embedded Soviet system that was alien to the ideas proposed. This article explores the different institutional logics arising from what already existed and from our proposals, as well as the interplay among them over the course of the project. Clearly, a complete deinstitutionalization—amounting to a paradigm shift—is necessary to overcome the differences in institutional logics. However, this is a remarkable challenge, given a centralized control context. This study makes interesting contributions to the domain of IS/HMIS research in two ways: (a) by reporting from a country that until now has been almost invisible to the IS community, and (b) by adding to the debate around IS and organizational change through the lens of institutional logics and deinstitutionalization.

1. Introduction

Tajikistan is a Central Asian country about which little, if anything, has been published in the mainstream information systems (IS) and development communities. Gaining independence after the downfall of the Soviet Union in 1991, Tajikistan has experienced an extremely rocky period, with a prolonged civil war and the loss of the supporting Soviet financial and social infrastructure. The country faces further challenges that include an extreme climate, a long and porous border with war-ravaged Afghanistan, a recent food and energy crisis of gargantuan proportion (Antelava, 2008), and the exodus of many trained people due to weak employment and decreasing social opportunities at home.

As do other Central Asian countries, Tajikistan confronts urgent public health problems. The demise of the Soviet economic base, followed by civil war, has led to a surge in various communicable diseases in the last two decades. According to the World Health Organization, life expectancy

has decreased through poor nutrition, polluted water, and increased incidence of diseases (WHO, 2008).

Acknowledging the key role that ICTs can play in development and public health management, the Asian Development Bank (ADB) established the Health Sector Reform Project (HSRP) in 2005, with the aim of creating various reform initiatives, including those relating to Health Management Information Systems (HMIS). One of the four authors of this article was invited by the ADB to participate in the HMIS-related reform efforts. He enrolled the three other authors to create a joint team responsible for the design, development, and pilot implementation of the national HMIS. However, carrying out these tasks was fraught with immense challenges, most of which were related to countering the policies of the existing institutions left behind by the Soviet legacy, which favored a large manual system based on a centralized planning model. The research team's key efforts revolved around understanding and addressing these historical conditions and trying to create new institutions that were based on a computer-based HMIS and favored local analysis and use of information. These efforts resulted in two key research questions:

- What are the key institutions that challenge the introduction of ICT-based HMIS reforms in the context of a post-Soviet economy?

- What theoretical concepts inspired by institutional theory could help us to understand deeply the nature of these challenges, and how may these be addressed?

The remainder of the article is organized as follows: In section 2, we propose key theoretical concepts from institutional theory that help to develop our analysis; section 3 provides a brief summary of the research methods used; section 4 discusses the details of the case study; and section 5 presents the case analysis, based on institutional theory. That is followed by a concluding section on discussions and contributions.

2. Theoretical Perspective: Institutional Logics and Deinstitutionalization

The theoretical aim of the article is to develop concepts that can identify existing institutions that

shape the deployment of computer-based HMIS and their associated processes. The concepts of institutional logics and deinstitutionalization provide a framework for this by helping us to categorize actions and artifacts as belonging to underlying themes that represent the various forces in play, as well as to analyze the interplay among them. First, though, we present an overview of institutions and institutional theory, as applied to the information systems field.

The basic building block of institutional theory is the concept of *institutions,* which has been diversely defined within the domains of economics, political science, and sociology. For example, economic historian Douglas North defines institutions as human-devised rules in a society that shape human interactions, or the "rules of the game" (1990, p. 3). While formal rules include political rules, economic rules, and contracts, informal rules include taboos, customs, and traditions (Jepperson, 1991). Both formal and informal institutions help to give pattern to human or organizational behavior by enabling and constraining their activities.

In the context of sociology of organizational studies, the definition of institution has been expanded by DiMaggio and Powell to include the unintentional activities of human beings, an aspect not covered in the definition of North. "While institutions are certainly the result of human activity, they are not necessarily the products of conscious design" (1991, p. 8). From a sociological perspective, Jepperson elaborates on institutions as follows:

> [I]nstitution represents a social order or pattern that has attained a certain state or property; institutionalization denotes the process of such attainment. . . . [O]rder or pattern . . . is conventional to standardized interaction sequences. . . . [W]hen departures from the pattern are counteracted in a regulated fashion, we refer to a pattern as institutionalized. (1991, p. 145)

In trying to reconcile the multiplicity of definitions given by various researchers, Scott defines institutions "as multifaceted, durable social structures, made up of symbolic elements, social activities, and material resources" (2001, p. 49). In a subsequent publication, Scott elaborates on the distinctive properties of institutions, as they are resistant to change and tend to be transmitted across generations through different mechanisms, by argu-

ing that "institutions are comprised of regulative, normative and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life" (2008, p. 48). This article draws from Scott's definition, further articulating how conflicting institutional logics erode what are seemingly stable institutions and contribute to the creation of new ones.

Institutional Theory in IS

In IS research, an increasing number of studies have adopted an institutional perspective to examine processes of IT development, implementation, and use, with a focus on institutional influences on technological changes (Orlikowski & Barley, 2001). For example, an early study by Kling and Iacono (1989) shows how a computer-based IS with stable structures was difficult to change. However, Fountain (2001) criticizes IS studies for ignoring the role of IT in shaping existing institutions, and for not acknowledging the reciprocal effects between institutions and technology. In a similar vein, Avgerou (2002) argues that IT, on its own, can be considered as an institution that can be seen to account adequately for the processes of transformation of organized activities in a society. From the perspective of HMIS, Noir and Walsham (2007), drawing on empirical material from the Indian healthcare sector, describe the ceremonial roles that "ICT for development" plays in legitimizing development initiatives. Similarly, based on their work in Ethiopia, Mekonnen and Sahay (2009) discuss how the institutional context mediates the processes of standardizing and of scaling of health information systems. Though most IS studies have adopted the theory to understand stability of institutions and resistance to change, they have given limited attention to how institutions change or erode away—in short, to how processes of deinstitutionalization take place (Oliver, 1992). Our study contributes to this debate through the analysis of contradictory institutional logics that lead to the process of deinstitutionalization.

Institutional Logics

The concept of institutional logics was initially introduced by Alford and Friedland (1985) to describe contradictory social practices, though it was subsequently expanded by others (e.g., Thornton & Ocasio, 1999, 2008; Scott, Ruef, Mendel, & Caronna, 2000). For example, Thornton and Ocasio define institutional logic as "the socially constructed,

historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality" (1999, p. 804). These logics inscribe the "organizing principles" that supply practice guidelines to field participants, guiding both the means and ends of individual behavior (Friedland & Alford, 1991). Institutional actors, then, can be viewed as agents and carriers for producing and reproducing the logic within a specific institutional environment (Scott et al., 2000).

Institutional logics work at different levels, both within institutions, such as health services, and between institutions, such as the various professions engaged within health services. In addition, actors are part of other institutions that are apart from, though not independent of the institution in question. For example, religion, marriage, cultural, and ethnic boundaries carry their own logics to govern behavior (North, 1990; Ingram & Klay, 2000), and people engaged in the health sector also operate within the boundaries of these institutions. Decisions are thus not only based on individual agency, but are greatly formed by the institutions in which actors operate, and from which they draw legitimacy and identification (Jackall, 1988; Friedland & Alford, 1991).

Institutional logics are never homogeneous; within an organization, multiple logics may be simultaneously in play, contributing to institutional contradictions (Friedland and Alford 1991). For example, in the context of Geographical Information Systems (GIS) use in the forestry sector in India, Sahay and Walsham (1999) elaborate on two logics in play. The first concerns how foresters make decisions on forest management based largely on political and social considerations, such as the Minister of Environment and Forests wanting to implement water conservation activities in his political constituency. The second concerns the contradictory logic inscribed in the GIS, which is itself based on making such decisions (of locating forestry interventions) via scientific modeling enabled through the GIS. The interplay of these two logics, Sahay and Walsham point out, contributes to the less-than-effective uptake of the GIS in the forest department.

Such contradictory logics can also provide the potential for eventual change. Thornton and Ocasio (2008) discuss four mechanisms of change: (a) insti-

tutional entrepreneurs, who are agents of change and play a critical role, taking advantage of the position they assume in social locations; (b) structural overlap, which occurs when previously distinct organizational structures are forced into association; (c) event sequencing, or the temporal and sequential unfolding of events that dislocate and transform interpretation and meaning of cultural symbols; and (d) competing institutional logics that may facilitate resistance to change and can be pre-existent or a consequence of change. For example, Currie and Guah (2007) illustrate how competing institutional logics (the change initiator vs. healthcare practitioners) influenced an IT-enabled change in six UK National Health Services. It is also worth noting that institutional change brought on by a change in the institutional logics does not necessarily happen from the periphery. The exposure to different institutional logics may increase the awareness of shortcomings of the dominant logics and enable central actors to become institutional entrepreneurs (Greenwood & Suddaby, 2006; Thornton & Ocasio, 2008).

Deinstitutionalization

Negotiating and reconciling conflicting institutional logics may contribute to the deinstitutionalization of the existing logic and re-institutionalization of the new (Jepperson, 1991). Deinstitutionalization is "a process by which institutions weaken and disappear" (Scott, 2001, p. 182), and it "takes place when established meanings and action in an organization are discredited, either as a result of competing meanings and actions or because they are seen as failing to contribute to the institutional raison d'être" (Avgerou, 2002). Further, Oliver describes deinstitutionalization as

> the process by which the legitimacy of an established or institutionalized organizational practice erodes or discontinues. Specifically, deinstitutionalization refers to the delegitimation of an established organizational practice or procedure as a result of organizational challenges to or the failure of organizations to reproduce previously legitimated or taken-for-granted organizational actions. (Oliver, 1992, p. 564)

Oliver points out three key factors that contribute to deinstitutionalization: political, functional, and social. Political pressures may evolve under threat of erosion or displacement, as new and emerging practices may challenge the utility and legitimacy of existing ones. Functional pressures relate to technical or functional considerations that may compromise or raise doubts about the instrumental value of an institutionalized practice. Social pressures include increasing normative fragmentation within an organization as a by-product of other changes, such as increasing workforce diversity or addressing the problem of high turnover. There can be disruptions to an organization's historical continuity, such as mergers, or changes in state laws that can prohibit or discourage the perpetuation of an institutional practice and its associated deinstitutionalization. For example, Nicholson and Sahay (2009) observed the role of dissensus and consensus—around both political and cultural factors—in the software exports policy-making process in Costa Rica, with the former leading to erosion of institutions, and the latter reinforcing existing institutions. Apart from intentional change processes (for example, purposely dissenting), there can be unanticipated or unintentional consequences of purposive activities leading to new institutions (Hwang & Powell, 2005). Moreover, Currie (2009) illustrates how functional pressures were confronted by normative pressures in deinstitutionalizing the existing professionally dominated UK healthcare sector to a new institution based on market mechanisms.

In summary, the focus of our theoretical analysis is to first identify the existing and proposed institutional logics surrounding the introduction of computer-based health management information systems in Tajikistan. The concept of deinstitutionalization further helps us to theoretically understand the interplay between different logics, why certain logics stay, why others erode away, and what social, political, and functional pressures contribute to this.

3. Research Methods

Research Approach

A useful method to develop and implement an HMIS in developing countries, suggested by Braa, Monteiro, and Sahay (2004), is that of action research, based on the principles of "networks of action" (p. 339). They build this argument within the context of a global interaction identified as the Health Information System Programme (HISP), which involves, among other things, the design, development, and implementation of a free and open-

source software called the District Health Information Software (DHIS). Taking their point of departure of trying to address the commonly perceived problems of lack of sustainability and scalability of HMIS in developing countries, the three authors draw on Elden and Chisholm (1993) to argue for the need to carry out action research in networks, rather than in singular units. Such an approach, they argue, provides the potential for multiple sites to learn with each other, share experiences and knowledge, and plan and implement action in a context-specific manner.

With this in mind, we applied an action research approach and addressed the question of network-building at both a global and local level:

1. Global level: Examine how the global HISP network could be leveraged to support the process of adaptation to the local context of Tajikistan, and mutually, how the global network could learn from the Tajikistan experience.

2. Local level: Within Tajikistan, understand what kind of sociopolitical, technical, and health-related networks could be mobilized to support overall project aims of HIS-related reforms.

The specific interventions that we carried out with respect to building these networks of action at the two identified levels are summarized in Table 1.

Data Collection Methods
Data were collected through various means. The following two tables summarize the data collection methods applied. While Table 2 provides detail about the type of methods we used and when they were conducted, Table 3 sums up the respondents by institution, issues raised, and length of the interview.

Data Analysis
At the end of the intervention in Tajikistan, while organizing our material, it became clear that most of the challenges encountered could be ascribed to different mindsets. This led to a categorization of events into these conflicting mindsets. The interview transcriptions and meetings notes were increasingly seen in this light, and we distilled the underlying

assumptions that led to the different views. This, in essence, led to the institutional logics discussed in this article, while the literature review was not initially focused in this direction. It increasingly became clear, however, that theories of institutional logics provided us with the language to analyze and communicate these findings.

4. Case Study

The project started when a University of Oslo professor was invited by the ADB (Asian Development Bank) to work with HSRP on the design, development, and implementation of a computer-based HMIS in Tajikistan. The project was carried out over an intensive period of about three months from November 2007 to early February 2008. Broadly, the project components involved an initial situation analysis and identification of local technical partners, followed by a month of systems development and the pilot testing of the first prototype, and then by two weeks of initiating pilot testing in one district (Kulyab). The case narrative is structured in two sections: (a) the existing situation that highlights institutional logics already at play; and (b) the HMIS intervention, which summarizes proposed institutional logics. In both these sections, the focus is on artifacts and processes, which are the manifested expressions of the institutional logics we studied. At the end of each section, we have distilled out the institutional logics they represent.

Existing Situation: Institutional Logics at Play
Central control of the HMIS was under the Medical Statistics division (MedStat), which, true to its name, treated the HMIS as an annual statistics-generating tool. The MedStat division used out-of-date software (also called MedStat) built on a FoxPro platform that basically was capable of entering data on the existing 37 reporting forms by the facilities and generating the aggregated reports by rayons, oblasts,[1] and nationally. From the reporting forms, two were reported monthly, and the rest were done annually. MedStat was not capable of generating any indicators (such as percentages or rates per thousand that required calculation with a numerator and denominator). For this purpose, the required

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1. Rayon and oblast are the Tajikistani equivalents of district (typically 50,000 to 100,000 inhabitants) and province (10 to 15 districts), respectively.

Table 1. Interventions and Their Relation to "Networks of Action."

Action interventions carried out in Tajikistan	Global network building and leveraging	Local network building
Situation analysis: Document study, interviews, presentations, discussions	• Adopt best practices from global experience to the specific needs of Tajikistan • Gain experience from Central Asian primary health care practices	• Enroll participation in HMIS reform process • Establish local network covering the fields of health and IT • Build awareness of HMIS challenges and ways to address them
Software development: Expand functionality, database design, application translation, report generation, creating validation rules	• Adapt Global DHIS to the Tajikistan context • Advance DHIS with new functionalities developed in response to Tajikistan requirements • Enroll Tajik competence in global DHIS development • Establish a software development node in Tajikistan that could potentially serve as a future hub for Central Asia	• Develop a local team committed to free and open-source software development • Develop feedback mechanisms between users of DHIS in the district and the developers • Build capacity of local team to support HSRP and build the community of users
Capacity building: Training sessions and follow-up activities at district and national levels	• Adapt training material and practices from other settings to Tajikistan • Contribute to global repository of training material and examples from Tajikistan • Create training material in Russian that could be made available to other Russiansn-speaking nations	• Formalize training procedures and content for health information officers • Develop training capacity at national and district level • Conduct orientation training to help create greater buy-in and support

data were fed in separately to a WHO-created program called Data Presentation System (DPS), and the generated indicators were uploaded into a national Web site. Another program, Factor, obtained data from the oblasts on five variables related to maternal health. Electronically, the three programs did not "speak to each other," despite all being under the control of the MedStat division; the IT specialist said there were no plans to further upgrade the MedStat software.

Below the level of the 37 forms that corresponded to different health programs (with a great deal of overlap and redundancies) were another 367 recording forms used at the primary health facilities to record the provision of basic services. At the rayon level, the different health programs put their respective data on MedStat forms, which were then sent to the corresponding oblast health program, as well as to the Statistical Department at the Central Rayon Hospital. Further, there were parallel reporting systems in place, with both the health programs and the MedStat department sending the same information to their corresponding superior level. However, since the MedStat software was not compatible with other software, computer use was limited. A tuberculosis (TB) program manager described this:

> Also, we have 16 computer specialists, but only in Kulyab and Dushanbe. But the problem is we cannot use the data from Kulyab and Dushanbe which is entered in Epi Info, because we have to adapt the data to be entered in MOH formats. So, to MedStat, we only send data on written form . . . this is a structure which is more than 75 years old. (TB program manager, Dushanbe, November 2007)

Further, poor IT resources in particular health divisions further impeded the use of computerized data, as related by a deputy director of the national TB program:

Table 2. Overview of Data Collection Methods.

Type	Nature and volume	When
Interviews	10 at national	Situation analysis
	6 at district	Pilot implementation
Presentations	4 for Asian Development Bank (ADB), Ministry of Health (MOH), donor partners, and closing presentation for HSRP, MedStat, and MOH	Situation analysis and at end of project
Workshops	Training and discussions: one for national level partici-pants, one for province and district level, and one in pilot district for district health programs	Launch of Version 1: Tajikistan HMIS and pilot project
Document study	Previous projects reports, current reporting forms	Situation analysis
Informal discussions	Numerous with HMIS consultant, HSRP staff, local soft-ware developers	Daily
Participant observations	Use of MedStat software at national and district level. Study of information flows and practices around recording of data, use of registers, and so forth	Regularly
Data collection through e-mails	E-mails with HMIS consultant, software team, and among ourselves	Continuous and ongoing
Software prototyping	During definition of datasets, creation of reports, identification of controls	Continuous and ongoing

Table 3. Interviews Conducted.

Institution	Respondents	Types of issues raised	Time
Different national health programs	Deputy director or director level	Current system and its challenges, data quality, information needs, information gaps	1.5 hours
Different district health programs	District or central district hospital program directors	Information flow, use of information, re-porting routines	30–45 minutes
International NGO	Country representative and HMIS representative	Past experiences of HMIS implementa-tion in which they were involved	1.5 hours
Local software entity	Director and staff	Technical and infrastructural challenges related to software implementation	1.5 hours

We want to include all data in Tajikistan, but some is always missed. Now we need one IT spe-cialist and train him full time to work on Epi Info. How we reach the 66 centres, when we have no budget, no travel money, no nothing? (Deputy director of the national TB program, Dushanbe, November 2007)

Further impediments to the use of computers were the availability of and permission to use paper. We were told that paper was not regularly provided, and that the limited budgets did not allow for its local purchase. For instance, in the Kulyab district, the yearly budget for gasoline would be spent in

just a couple of weeks of normal activity, so the pur-chase of paper was not a high priority. A donor agency senior official narrated how inventive meth-ods were applied to produce reports at the local level:

When asked how the reports were prepared, he (a doctor at the rayon level) said he will tell (about how reports were prepared) if his name is not quoted. He said he bought one chocolate to the room of the specialist responsible for the data. The specialist generated the report for the whole district. We (the aid agency official) told [the director of MedStat] that this is the cost of

Figure 1. *Emergency Form on Infectious Diseases with Key Diseases (listed in rows) and Rural Health Centers (listed in columns).*

institutional logics at play. They were not the only institutional logics identified, but they were dominant and stood out because they so clearly contradicted what we tried to introduce (see next section for explanation). The first was a central planning logic—perhaps a set of logics—where a curative, rather than preventive, approach was taken. This was evident by how the data were collected for top-level use only, with the focus being on collecting raw data, rather than on calculated indicators, on an annual basis. Supporting this was the HMIS-inscribed logic, where we found the system to be built for one purpose only: the provision of statistics for central planning. It was not designed to support local use, as evidenced by the extra emergency form that the Kulyab district office had developed for this purpose. Related to this is the gigantomania we mentioned earlier of wanting to cover—to the smallest detail and on a routine basis—all data that could be related to health. For much of the data, it makes more sense to do periodic surveys, rather than to aim for complete national coverage of data collection every year. The other key logic was one that linked to paper technology, in that once the forms had been agreed upon, they could not be revised before the end of the five-year planning period. Even when showing how improvements could be made to the forms, the perceived costs of such action were based on a completely paper-based system. In a computerized environment, this rigidity becomes meaningless.

The existing institutional logics we identified are summarized below:

- Central planning for statistics management (supporting curative rather than preventive health), based on:
  - Centralized structure rather than decentralized.
  - HMIS as annual statistics-generating tool.
  - Gigantomania collection of extensive data signals, seriousness, and scientific vigor.

your reporting system—one bar of chocolate. (Donor agency official, Dushanbe, November 2007)

Given the huge amount of the data to be reported (about 30,000 data elements) on a routine basis, the extremely poor HMIS-related resources, and the view that reporting was an irrelevant exercise, data quality obviously suffered. The head of the HMIS task force at the MOH admitted that the use of the ICD 10 codes for classification was fraught with errors, and he estimated that 35% of the data in this system would be incorrect from classification errors itself.

The reporting forms were poorly designed and comprised multiple subforms. For example, we found a form titled "Treatment Prophylactic Activity of Facility" that contained about 50 subforms, covering 1,836 data elements and spanning about 75 pages. This "gigantomania" fostered intermediate forms that were designed locally for local use. For example, the Infectious Diseases Department at the central district office provided what they called an "emergency form" that listed eight essential diseases (with space left for others) reported by the different rural health centers (shown as columns). This form (Figure 1) was used for local purposes in addition to the standardized recording and reporting forms that were prepared for national reporting.

Based on these findings, we identified two key

• Rigidity of paper means that decisions are final and static for the duration of planning cycles. Computers can be employed to automate paper-based systems.

HMIS Intervention: Proposed Institutional Logics

The proposed HMIS was a system based on a free and open-source HMIS application designed and developed under the HISP network (Braa & Hedberg, 2002). The institutional logics behind our suggestions were based on: (a) a belief that local decision-making produces the quickest and most appropriate response to emerging health issues, based on routinely collected essential data; (b) the HMIS thusly being indicator-driven, so as to be able to compare across time and space, as well as to collect data that is necessary for taking local action, which we strongly believe is the result of; (c) a much smaller data set to reduce the burden of collection, improve quality, and enable decision makers to process it adequately; and (d) technology's role being to internalize routine aggregation, increase flexibility, and decrease response time, rather than to increase the capacity and speed of a system that adhered to a paper-based design logic and five-year planning cycles.

A first step in the design process was the reorganization of the existing data forms. We proposed to organize health data in relevant health categories rather than on forms. Further, we suggested that data be organized into two broad categories: routine data (reported monthly) and semi-permanent data (reported annually).

In addition, we suggested a radical reduction of data to be collected and a shift to indicators (rates and ratios), rather than just data elements (counts). A smaller system would have a positive impact on both time consumption for data entering and ambiguities related to correct use. Hopefully, it would also help to improve the level of data quality. Through shifting the focus from counts to indicators, the data would assume relevance for decision-making across time and space.

However, our proposal for redesign based on data sets (and not forms) was rejected. We were told that the Central Statistics Authority had approved the existing 37 reporting formats, and that we were not even allowed to change or add a logo to the form. We were not even allowed to change

the location of a single piece of data in the existing formats. So, we then made a design decision that each of these reporting formats would represent a data set, with groups defined in each of them, and with each corresponding to a subform. Our design approach, then, resulted in the development of a maximum data set, rather than a minimum data set. We rationalized this rather unpleasant decision to automate existing inefficiencies by telling ourselves that this one-to-one approach would allow us to input the existing data into the computer. This step could then be followed with analysis of existing data, which would make the poor data quality visible to the planners, and thus allow us to make a stronger argument for applying a minimum data set approach in the next iteration. But, as the World Bank representative noted, a smaller system was not seen as compatible with central planning, and he was skeptical about our chances of success:

> We wanted to simplify the system. When the consultant showed the MOH a system with 15 indicators, they laughed, how can it meet the needs of the health system? They laughed and did not accept it. This is the paradox—we want a huge system, but don't have the money. They are suspicious of small systems. (World Bank representative, Dushanbe, November 2007)

The issue of control rules is worth mentioning. The tabular forms in MedStat required many data items to be recorded twice. For each row item, such as Malaria, there would be columns both for age groups and gender, as well as a column for the total. Data would then appear twice, both in a specific age group and in the total. In the software application (DHIS) introduced, data items could be calculated automatically by aggregating other items; totals, then, can be produced on demand and not have to be entered at all. This could reduce the amount of data items by around 3,000. However, this automatic aggregation of totals was not to be implemented, as it was still the MedStat administration's intent to manually enter totals and then run checks on them against their various components. This function had been included in MedStat software with a set of so-called "controls." These controls made sense in a paper system, where manual aggregation into totals could produce errors. This "paper verification logic" was applied to a computer system where the possibility of manual aggregation

error could be eliminated altogether. The MedStat team insisted that development of the same set of controls in DHIS as in MedStat be a compulsory requirement. These examples of often-contradictory assumptions and directions point to the different underlying institutional logics in play; they also helped us to identify our beliefs and assumptions as also being rooted in certain logics.

The HMIS intervention-related institutional logics we identified are summarized below:

- Decentralized decision-making, based on routine data, specifically:
  - HMIS is indicator- and action-led.
  - Small, essential data sets best support action and improve data quality.
- Computer systems should be employed to internalize routine aggregation, increase flexibility, and decrease response time to changes in epidemiological information needs.

5. Analysis: Interplay of Logics and Implication on Deinstitutionalization

In the case study, we elaborate on the institutional logics found to be in play when conducting the situation analysis of the HMIS in Tajikistan, as well as the logics that we believed were inscribed in the HMIS-related intervention that we were seeking to introduce. In this analysis section, we will describe the interplay of these two sets of logics and how this shaped the deinstitutionalization process we wanted to bring about in the existing HMIS. Specifically, we discuss two sets of interplays:

1. Statistics for central planning and control versus using information for decentralized action
2. Rigidity of paper-based reporting formats versus the flexibility of customizable electronic forms

Statistics for Central Planning and Control Versus Using Information for Decentralized Action

The Tajik system is a historical product of a Soviet system of governance, and nearly two decades after the collapse of the USSR, the deep-rooted Soviet institutions can still be seen in play. In another context of collectivization (before WWII), this has been

described by Scott (1999) as "gigantomania," referring to the focus on trying to collect huge amounts of data as a form of centralized planning and control. In the post-Soviet system in contemporary Tajikistan, the routine health system seeks to collect data on more than 30,000 data items relating to all kinds of diverse items, such as soil samples, airplane vibrations, and cigarette smoking, as well as health programs.

Further, the Soviet system prides itself on being based on a strong scientific foundation. This historical tendency is reflected in the Tajikistan's MOH decision to use the full version of the ICD10 system. The implication of this was that each disease was classified by various codes, and that each code had various subcodes and sub-subcodes. In the Soviet era, when there was a high level of scientific and technical experts, the data collected from the peripheral levels was subjected to a serious scientific scrutiny at the central level. Now, however, the number of such experts has been dramatically reduced. While similar levels of detailed data are expected to be collected, there has also been a simultaneous decrease in both the capacity to collect good quality data and in the skills to analyze and use the data.

In contrast to this existing system, the HISP philosophy—under which all authors have been working for years in other countries—toward HMIS development can be seen to be a historical product of postapartheid 1994 South Africa, a period of ANC-driven reform that was based on an agenda emphasizing decentralization and integration (Braa & Hedberg, 2002). Within this context, the HISP project sought to develop free and open-source software that could be installed at the local levels. Large-scale capacity-building programs would be carried out to empower health workers and compel them to use information for local action. These principles and practices of the HISP initiative were inscribed into the design of the DHIS software, which emphasized local flexibility and user control, and became part of the training material used for processes of capacity-building for the health staff.

However, adapting these principles of use of information for local action in Tajikistan would involve incorporating a whole range of HISP principles, including the creation of a minimum data set, the linking of data being collected with indicators, and the implementation of large-scale capacity

building programs of the health staff, with a focus on the use of information at the local level. However, we soon realized that these aims were unattainable in the present scenario. First, no permission could be obtained to make any changes—even the removal of duplicate data elements included in the same form. Further, the system we found was not mature enough to absorb the shock of these large-scale and radical changes. Since even the basic information processing systems were not in place, such as those for collecting quality data, it was too ambitious on our part to expect local staff to start on the analysis of data. Further constraints included the poor capacity of the health staff, very weak infrastructure, and the extreme climatic conditions that made it difficult to travel to the districts to carry out the training programs.

The interplay of the two sets of logics thus resulted in our adapting a strategy of maintaining the status quo in terms of the reporting forms, their numbers, and their design, but by translating this status quo into an automated form. We reasoned that the information inscribed in this status quo system would spotlight the poor quality and the absurdity of the current design. We believed this could help us make a stronger case for change in the future, and when changes were approved, we would be able to easily adapt the system to the flexible DHIS-based HMIS application.

Rigidity of Paper-based Reporting Formats Versus the Flexibility of Electronic Customizable Forms

For both institutional and technical reasons, the paper formats in use were inscribed with a deep sense of rigidity. Institutional reasons for this included the costs associated with the production of new formats, the logistical problems of reproduction, and the difficulty of distributing them to hundreds of facilities, some of which were located in geographically inaccessible regions. The size of the individual forms made the task of changing a paper-based form daunting. Furthermore, the existing forms had only recently been approved by the Central Statistical Authority, so no further revisions could be made for at least five years, which corresponded to the national planning cycle. The technical reason contributing to the rigidity of the form was their much-cluttered design, full of multiple rows and columns. Some of the forms had approximately 250

rows and 12 columns, making them very difficult to modify in technical terms.

Bathed in the philosophy of flexible systems and local action, HISP saw forms as something very flexible that could be modified at will, based on user needs. The entire software had been built on a modular structure, and changes could easily be made at the data entry level without affecting other parts of the system. Furthermore, some technical innovations were created by the software development team, particularly the "multi-dimensional" data element that was developed to replace the existing uni-dimensional data element. Through this innovation, previous multiple uni-dimensional data elements (for example, children in different age categories were treated as different elements) could now be treated as a single data element (children) having multiple categories (representing age groups). This innovation was combined with the development of a customized data entry screen that replicated the paper form versus having to enter data through a list of data elements organized vertically. The following screen shots (Figures 2 and 3) illustrate the two systems of data entry. The combination of these two technical innovations provided our team with a great deal of flexibility in the design of the forms.

The interplay of these two logics occurred when we started to make suggestions in the design of the screens, showing how space could be used better, or by making aesthetic-based improvements. However, we still did not get permission to make changes. When we suggested trying out some new designs on an experimental basis—we could revert back to the original design if they did not work—we were again denied permission to make these kinds of revisions.

Interplay of Logics and Implications for Deinstitutionalization

As Oliver (1992) has pointed out, deinstitutionalization arises from social, political, and functional pressures. If these pressures gain enough momentum, they can create a sense of dissensus in the existing institutions and provide the impetus for their dissipation or erosion. In the case we described earlier, the interplay of the institutional logics could show a great deal of functional dissensus and demonstrate how the existing system was operationally inefficient, based on receiving poor quality data and

1. INFECTIOUS DISEASES

Name of disease	№ row	Code ICD-10	Registered diseases										From paragraphs 3,4,5,6 organized		Rural inhabitants		Registered death cases	
			Total	From them														
				0-14 Years old	0-1 Years old	1-2 Years old	3-4 Years old	5-6 Years old	7-14 Years old	15-17 Years old	18-19 Years old	Nursery visits	Visits of kindergar ten	Total	including 0-14 years	Total	includin g 0-14
A	Б	C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Infectious diseases, total	1																
Cholera	2	A00															
Vibriocarrier of cholera	3	Z22.1															
Abdominal typhoid	4	A01.0															
Paratyphoid A, B, C	5	A01.1,2,3,4															
Bacteriocarrier of abdominal typhoid and paratyphoid	6	Z22.0,1															
Other salmonellosis infections	7	A02															

Figure 2. Form 1 Customized Data Entry Form (English version).

Nr	Data Element	Min	Entry	Max	Comment
1	cholera				[No comment] ˅
2	Infectious disease total				[No comment] ˅
3	vibrocarrier of cholera				[No comment] ˅
4	abdominal typhoid				[No comment] ˅

Figure 3. Form 1 With Data Elements Listed Vertically in Standard Layout.

providing data that could not be used. We demonstrated this functional deficiency through our analysis; for example, we showed that nearly 90% of the data was being reported as zeros or blanks on some of the forms. We also argued that while a huge amount of data was being collected, no indicators were being used. The Ministry of Health, however, insisted that all data being collected were being used as indicators. When we showed examples to the contrary, they were simply dismissed as being exceptions.

A degree of social pressure had been placed on the MOH to reform their HMIS through efforts of the World Bank and the ADB that had created specific structures (for example, the HSRP office) for guiding reform efforts. However, as the HSRP was an independent structure and had a time-bound life of three years, its recommendations were non-binding for the MOH. On the political front, we failed to create adequate momentum and pressure to trigger change. The political decision-making center was at the MOH, an organization closely aligned with MedStat, so our influence there was minimal. Our alignment was with the ADB, primarily considered a donor (and that in the form of loans) and thus not sufficiently powerful to enforce change.

In summary, it could be seen that the interplay of logics primarily occurred on the functional domain. Confronted with a strong, historically embedded system, we could hardly make a dent on the political domain. However, where we did succeed was in creating some seeds of change, primarily by building a system with an inscribed flexible logic that could be modified into a more effective HMIS in the future (when political conditions might be more favorable). Also, through our various reports and presentations, we introduced new discourses into the HMIS reform efforts, such as those related to use of information, use of indicators, and data quality and validation. So, while some seeds for deinstitutionalization were planted, there was not adequate political pressure for deinstitutionalization to take place at the time. We should also note that institutional change processes can be painfully slow. Future efforts in this direction could focus on gathering a critical mass of supporters with enough power to influence these change processes. However, while arguing for even piecemeal change at the ministerial level, we found a reflection of our own ideas and philosophies in the pilot district of Kulyab. There, the so-called emergency form captured precisely the kind of logics with which we had become acquainted in

South Africa. The district needed a limited set of data on notifiable diseases to be able to manage and assist its rural health centers in case of an outbreak. This form was not part of the official HMIS, but the doctors and managers maintained this extra system, despite all the work they required to complete the official forms. From this, it is clear there were domestic seeds of conflicting logics, but the (weaker) district's strategy was to avoid conflict. The training in data analysis in Kulyab, using local data, was met with a degree of enthusiasm beyond what would be found at the national level. These local-central differences in logics guiding behavior were also found in a similar study in Cuba (Sæbø & Titlestad, 2004), a country sharing some political and economic history with Tajikistan.

7. Conclusions

The interplay of the two sets of logics basically involved two paradigms, which at one level were irreconcilable and could not coexist. However, we believe that in such a historically embedded system, a paradigm shift could only come about if mandated explicitly from the top political authority—the health minister. While local level incremental efforts may be useful to create some local expertise and knowledge, these lower levels have no authority or voice to influence change. The strategy of local empowerment, which had worked for the HISP project in South Africa, was a product of the historical moment that existed, one arising from the breakdown of the apartheid system and the political agenda that mandated decentralization and integration.

This study makes some interesting contributions to the IS field. First, it brings into focus a study from a country that, to date, has been nearly invisible to the IS community. Hence, the article expands the already existing knowledge about IT-enabled HMIS change process in developing countries. Second, it contributes to the debate about bottom-up and top-down implementation models by arguing that such decisions are products of historical circumstances, and that bottom-up, though ideologically appealing, may not be always most effective. Third, the conceptual framework of institutional logics, their interplay, and implications for deinstitutionalization provides an interesting approach to study implementation experiences more broadly, not just HMIS in a

post-Soviet republic. In other circumstances, there would be different forms of logics in play; studying them would provide rich insights into the implementation dynamics. ∎

References

Alford, R. R., & Friedland, R. (1995). *Powers of theory: Capitalism, the state, and democracy.* Cambridge: Cambridge University Press.

Antelava, N. (2008, February 14). Enduring Tajikistan's coldest winter. *BBC News.* Available at: http://news.bbc.co.uk/2/hi/programmes/from_our_own_correspondent/7243704.stm

Avgerou, C. (2002). *Information systems and global diversity.* Oxford: Oxford University Press.

Braa, J., & Hedberg, C. (2002). The struggle for district-based health information systems in South Africa. *The Information Society, 18,* 127.

Braa, J., Monteiro, E., & Sahay, S. (2004). Networks of action: Sustainable health information systems across developing countries. *MIS Quarterly, 28,* 337–362.

Currie, W. L. (2009). From professional dominance to market mechanisms: Deinstitutionalization in the organizational field of health care. In R. Hirschheim, A. Heinzl, & J. Dibbern (Eds.), *Information systems outsourcing* (pp. 563–589). Springer-Verlag: Berlin Heidelberg.

Currie, W. L., & Guah, M. W. (2007). Conflicting institutional logics: A national program for IT in the organizational field of healthcare. *Journal of Information Technology, 22,* 235–247.

Elden, M., & Chisholm, R. F. (1993). Emerging varieties of action research: Introduction to the special issue. *Human Relations, 45,* 121–142.

Fountain, J. E. (2001). *Building the virtual state.* Washington, DC: Brookings Institution Press.

Friedland, R., & Alford, R. (1991). Bringing society back in: Symbols, practices, and institutional contradictions. In P. J. DiMaggio & W. W. Powell (Eds.), *The new institutionalism in organization analysis* (pp. 232–266). Chicago: University of Chicago Press.

Greenwood, R., & Suddaby, R. (2006). Institutional entrepreneurship in mature fields: The big five accounting firms. *Academy of Management Journal, 49,* 27–48.

Hwang, H., & Powell, W. W. (2005). Institutions and entrepreneurship. In A. R. Alvarez & O. Sorenson (Eds.), *Handbook of entrepreneurship research, S. A.* (pp. 179–210). New York: Springer.

Ingram, P., & Klay, R. (2000). The choice-within-constraints new institutionalism and implications for sociology. *Annual Review of Sociology, 26,* 525–546.

Jackall, R. (1998). *Moral mazes: The world of corporate managers.* New York: Oxford University Press, Inc.

Jepperson, R. L. (1991). Institutions, institutional effects, and institutionalism. In P. J. DiMaggio & W. W. Powell (Eds.), *The new institutionalism in organization analysis* (pp. 204–231). Chicago: University of Chicago Press.

Kling, R., & Iacono, S. (1989). The institutional character of computerized information systems. *Office, Technology and People, 5,* 7–28.

Mekonnen, S., & Sahay, S. (2009). An institutional analysis on the dynamics of the interaction between standardizing and scaling processes: A case study from Ethiopia. *EJIS, 18,* 98.

Nicholson, B., & Sahay, S. (2009). Deinstitutionalization in the context of software exports in Costa Rica. *Journal of Information Technology, 24,* 332–342.

North, D. C. (1990). *Institutions, institutional change and economic performance.* Cambridge: Cambridge University Press.

Oliver, C. (1992). The antecedents of deinstitutionalization. *Organization Studies, 13,* 563–588.

Orlikowski, J., & Barley, S. R. (2001). Technology and institutions: What can research on information technology and research on organizations learn from each other. *MIS Quarterly, 25,* 145–185.

Sahay, S., & Walsham, G. (1999). GIS for district-level administration in India: Problems and opportunities. *MIS Quarterly, 23,* 39–65.

Scott, J. C. (1999). *Seeing like a state: How certain schemes to improve the human condition have failed.* New Haven, CT: Yale University Press.

Scott, W. R. (2001). *Institutions and organizations.* Thousand Oaks, CA: Sage Publications.

Scott, W. R., Ruef, M., Mendel, P., & Caronna, C. (2000). *Institutional change and health care organizations: From profession dominance to managed care.* Chicago: University of Chicago Press.

Sæbø, J., & Titlestad, O. (2004, January). Evaluation of a bottom-up action research project in a centralized setting: HISP in Cuba. *Proceedings of the 37th Hawaii International Conference on System Sciences, Hawaii.*

Thornton, P. H., & Ocasio, W. (1999). Institutional logics and the historical contingency of power in organizations: Executive succession in the higher education publishing industry, 1958–1990. *American Journal of Sociology, 105,* 801–843.

Thornton, P. H., & Ocasio, W. (2008). Institutional logics. In R. Greenwood, C. Oliver, R. Suddaby, & K. Sahlin (Eds.), *The SAGE handbook of organizational institutionalism* (pp. 99–129). Los Angeles: Sage Publications.

World Health Organisation. (WHO). (2008). Tajikistan, facts and figures. Geneva: WHO.

III

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Comparing strategies to integrate health information systems following a data warehouse approach in four countries

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This paper addresses one of the major obstacles of reaching the Millennium Development Goals (MDG): inefficient and unreliable information systems. Leading international organizations have called for integrated data warehouses as one of the solutions, but this remains hard to achieve. This paper presents four country cases of standardizing and integrating health data which are all following what is here termed a data warehouse approach; data from across different health programs are organized in one database framework – or data warehouse. In all countries, fragmentation of health information in different partly overlapping subsystems run by different vertical health programs represented a major problem for the efficient use of health information. While South Africa developed a new integrated system in addition to the existing fragmented subsystems, Zanzibar, Sierra Leone and Botswana all aimed to encompass all or most of the data from the existing systems. The three latter countries all followed slightly different approaches, more or less incremental in the approach to standardizing health data, and more or less strict in whether to include "all" data, and whether to solve all inconsistencies between the various data sets included early on. The four cases demonstrate that integration is as much, and maybe more, about aligning organizational-political actors as it is about technical solutions. The technical solutions are, however, important in aligning these actors and in enabling integration. We argue that "attractors," technical solutions or standards that achieve a certain level of success and enable the building of momentum, are important in aligning the various political actors. In turn, these attractors need to evolve within the changing context of a growing health information system in order to achieve the scale needed to address the MDGs with full force.

Keywords: integration; standardization; health information systems; data warehouse

1. Introduction

In 2010, 10 years have passed since world leaders agreed to eight Millennium Development Goals (MDG), which are to be achieved by 2015. Three of these goals are health-related, namely: goal 4, reduce child mortality; goal 5, improve maternal health; and goal 6, combat HIV/AIDS, malaria, and other diseases. To reach these goals, managers at all levels need to base their decisions on reliable, timely information for the resources spent to have the most impact. International organizations need to monitor progress and adjust policies and funding priorities, national health administrations need to strengthen the health services by identifying bottlenecks and emerging trends, and distribute health personnel and resources, and local managers need to respond to the needs of their communities. All this depends on well-functioning health information systems (HIS), one of the six pillars of a health system (WHO, 2005, 2007). At the same time, there has been a realization that many of the problems with HIS in

developing countries stem from the practice of installing specific, narrow information subsystems, often covering limited information needs. Without a comprehensive strategy, these subsystems evolve into a range of fragmented, expensive, often overlapping, and inefficient systems, in turn leading to less use of information for health improvement. With the number of global health initiatives focussing on specific health priorities still rising (IHP +, 2010), this fragmentation of efforts, and their HIS, seriously undermines the work toward the MDGs.

This has led to several international organizations that specifically address these challenges with new strategies. The International Health Partnership (IHP+ established in 2007), aims to *harmonize* aid agencies, and *align* international efforts with national systems. The partnership in statistics for development in the twenty-first century (PARIS21, established in 1999) helps countries adapt *evidence-based* policy-making and implementation to reach the MDGs. The Health Metrics Network (HMN, established in 2005) was created to strengthen country HIS and information use, through *integration* of subsystems and data sources. Other international donors, the initial source of many of the fragmented systems, have as a result adapted a strategy of improving integrated national HIS rather than implementing new, narrow, specific subsystems.

This process of integration, however, is less than trivial. Integration takes place at several levels at the same time, from the purely technical to the organizational, and the interplay of these levels throughout the process very much determines the appropriate strategy. A central part of the HMN technical strategy to overcome the problems of fragmentation and lack of data standards is the establishing of data warehouses, or data repositories, for the storage of essential data and indicators from multiple data sources. This data repository will then provide shared access to information across the various health programs and user groups (HMN, 2008). In this article, we describe and discuss different varieties of such a "data warehouse approach" as they are applied in four countries. Botswana, Zanzibar and Sierra Leone represent relatively recent developments (since 2005/2007), whereas in South Africa, the process has been ongoing since 1995. While in Botswana, Zanzibar and Sierra Leone they have followed various strategies to include all data routinely collected from the health services by different health programs in one data warehouse system, in South Africa they started out with a minimum essential data set strategy (i.e. only a subset of data reported), which has gradually evolved to include more data through a longitudinal standardization process.

Integration as demonstrated in the four cases, however, is not primarily a technical process, but rather a political one. Nevertheless, the technical and the non-technical dimensions sway one another. In all cases, the overarching problem of fragmentation was caused by different organizational actors working independently. Providing a technical solution to integrate two different systems is relatively easy, but the politics of negotiating this among the actors involved is key to attain any use, and hence sustainability. However, in turn, the potential of the technical solution to get actors to understand it and perceive their interest is not to be neglected. Our cases show that mindfully using ICTs can align different actors toward a common goal; the development of strong and use-oriented HIS so necessary to reach the MDGs.

This article will proceed as follows. First, we present the methods applied. Then we present relevant literature on the issues of integration and standardization in developing countries, before presenting the four cases, the discussion and finally the conclusion.

2.   Methodology

2.1   *Action research in four countries*

This article draws on case material from direct involvement and experiences in the development and assessment of HIS in South Africa, Zanzibar, Sierra Leone, and Botswana. The authors are all involved in one or more of the four countries, as well in the broader network of the Health

Information Systems Programme (HISP) (Braa, Monteiro, & Sahay, 2004; see also http://www.hisp.info). HISP started in South Africa in the 1990s as a conscious effort to adapt and apply central features of the Scandinavian action research tradition in IS development, such as user participation, evolutionary approaches, and prototyping, to the context of Africa (Braa & Hedberg, 2002). Action research aims at generating new knowledge through taking part in the full cycle of design, development, implementation, use, and evaluation and analysis together with all involved parties before the interventions are adjusted accordingly, and the cycle starts all over again (Susman & Evered, 1978). In each of the four countries, the authors have been engaged in repeated prototyping cycles of the DHIS software, system development such as revision of data sets (i.e. what data to collect and process) and capacity building, and exploration of ways to access, present and analyze the information in the system.

The authors have through this immersion in the system reform processes played various roles. The work spans from the purely technical domains (software development) to the political (strategy meetings with directors, ministers), but it has been in the role as interpreters and mediators between these various domains that we have been able to address the very complex task of integration from many angles. In all countries, one or more of the authors have been involved over several years, both through many on-site visits (length of stay varies from a week to a year, with a total length of over 6 months in all countries), and also through continuous communication via email and telephone.

The selection of countries came naturally as South Africa was the place the HISP started, and the subsequent involvement in other countries came about due to specific projects funded by external partners, partly based on the proven success in South Africa. Following the increased focus on HIS globally, increasingly international donors and agencies play a role in the circulation of best practices, also in the countries included in this study; the European Union funded the project in Botswana, DANIDA (the Danish aid agency) initiated the one in Zanzibar, and WHO and HMN initiated the project in Sierra Leone. The authors have also been involved in similar processes in other countries, but the four presented here were found to best highlight the distinct approaches to integration. They are also countries where the authors have been the most involved, and would thus provide richer material to analyze.

2.2   *Linking global and local efforts*

The research and lessons in South Africa, where HISP was initiated in 1995, forms the basis for the research and interventions in the three other countries. The overall HIS development approach first used in South Africa, including the focus on the local district level, data standardization based on essential information needs, and local use of own data, has been adapted to the other country contexts. As the context differs considerably between the countries, a major research challenge has been to ensure a framework for cross-country comparative and collaborative learning and intervention. The methodological approach to address this cross-country challenge is based on a "network of action" strategy (Braa et al., 2004), where, first, a mutual beneficial "win–win" collaboration is sought between action projects, which then is fostered through, second, the circulation of people, best practices and lessons, and software and other materials. The PhD program at the University of Oslo is including 15–20 African students and is facilitating comparative action research within and between countries and thus enables the needed "circulation of people" and sharing of experience. Three of the authors of this article are part of this program. Shared development and application of the DHIS software, which is used in all four countries, make up an important generator of "win–win" collaboration between the countries, while at the same time providing a concrete vehicle of sharing material and experiences.

2.3 *Data analysis process*

The projects described in this paper have been ongoing for several years. Through the active involvement in the work in these (and other) countries, we have naturally gone through a maturation process in our approaches to integration. The development of the four models of integration discussed in this paper has come gradually, and coincides also with a change in climate toward integrated approaches from international donors, often a key source of funding for health systems in poor countries. Finally, the continuous development of the software used has led to more flexibility in terms of leveraging the software for the different integration strategies. The data analysis stems from the repeated evaluation cycles of action research, namely asking the questions what worked, why, or why not, which subsequently lead to a different approach in the "next" country. Over the years, this led to the distinct strategies explained in this paper, and the confirmation that there is no "one size fits all."

3. Conceptual framework

3.1 *Heath information systems*

National HIS in developing countries are often plagued by fragmentation, where vertical, disease-specific programs run their own information-gathering systems (Stansfield, Orobaton, Lubinski, Uggowitzer, & Mwanyika, 2008). A typical situation in a developing country is that: (1) there is a national HIS run by the Ministry of Health aiming at covering data from across the various health services and disease-specific health programs (e.g. HIV/AIDS, Tuberculosis, Maternal & Child Health, Disease Surveillance, Vaccination Programme (called EPI)); (2) the general health services and the national HIS are relatively weak with insufficient resources; (3) while many of the vertical programs are comparatively rich as they are funded from international sources (e.g. HIV/AIDS), and these programs need to provide their funders with quality information on their activities and achievement in order to maintain funding. As a consequence, (4) not being satisfied with the data from the national HIS, the vertical programs develop their own sub-HIS with international funding (Braa, Hanseth, Heywood, & Shaw, 2007).

There is often lack of data harmonization across these subsystems which both results in duplication of data collection and reporting requirements among health workers at community and facility-level, as well as extremely difficult conditions for health managers at all levels to get the full picture of the health status of their population. This can be illustrated by the challenging task for a manager to monitor and make evidence-based interventions on MDG 4, to reduce child mortality, which would involve the need to get data from many different programs and subsystems of the HIS; the reproductive health program for still births and neonatal deaths, the immunization program during the child's first year, from the nutrition program, and for deaths due to major diseases they would need to get data from Malaria, Tuberculosis and HIV programs, and most likely from the program for Integrated Management of Childhood Illness. To add to the complexity, these data will normally be available in a range of different formats, from paper reports to a mix of different electronic outputs, and another key challenge for the managers is the struggle to get data from the private facilities, as well as from the community, in order to get a more complete picture of all the relevant health events in their area.

The involvement of multiple funders and organizational actors make integration highly political. HIS integration is thus a non-trivial process, involving more than just integration at a technical level. Sahay, Monteiro, and Aanestad (2009) bring the attention to the political aspects of integration, and claim that, with a few notable exceptions, literature on the topic seems to be too positive and too technology-oriented. For instance, integration would also

include aligning the efforts of several ministries (Sæbø, Braa, & Chandna, 2007), a challenge of institutional nature.

3.2   *Integration and interoperability*

Despite its common use and perceived attractiveness, the qualifier "integration" or "integrated" in the context of information systems remains notoriously slippery as "individuals often have a different understanding of the meaning of the word" (Gulledge, 2006, p. 5), or it can "mean all things to all people" (Wainwright & Waring, 2004, p 229). During a one-week online forum organized by the RHINO network on "integrated HIS" in July 2009, it became evident that also in the global health HIS domain, there are different understandings of the term integration. While the more technical-oriented participants focussing on electronic medical record systems, argued that integration is not possible because it means monolithic rigid systems and that open standards and interoperability is the way to go, the public health participants tended to argue that integration is best understood as efforts to harmonize and bring together the various vertical disease-specific reporting systems and sub-HIS. The HMN framework (HMN, 2008) is in fact combining these two perspectives by arguing for a central data repository that integrates the different data sources to one harmonized system, and the key mechanism for doing so is to apply inter-operable solutions between the various subsystems and the integrated data repository itself.

The dominant perspective on integration in information systems research has largely been prescriptive in character and technical in orientation (Grimson, Grimson, & Hasselbring, 2000). Strategies and approaches to integration vary (Hasselbring, 2000) and include technical solutions at different levels and forms of integration frameworks or mechanisms are identified such as data base schema integration, middleware software platforms (Corba, COM2), application or service architectures (service-oriented architecture, SOA, .NET).

More recently, however, the complexity facing integration within and across organizations have been brought more into the foreground. Singletary (2004) surveyed practitioners' perceptions of the downsides to integration including lock-in with vendors, costs, and project risks. Wainwright and Waring (2004) have identified four domains of integration, namely *technical*, *systems*, *strategy*, and *organizational*, and argue the importance of including the organizational domain in the integration strategy, which "is rarely acknowledged in the IS/IT literature" (Wainwright & Waring, 2004, p. 342).

3.3   *Understanding the integration process – mechanisms for harmonization and alignment*

We have pointed out above how the literature distinguishes integration as belonging to various levels, ranging from the technical to the organizational, or the political. What is missing, however, is a deeper understanding of the relationship and interaction between the different domains or levels of integration. In order to address this issue, we will adapt an integrative framework developed for managing knowledge across boundaries by Carlile (2004). The framework includes three progressively complex borders; syntactic, semantic and pragmatic, and three correspondingly progressively complex processes; transfer, translation and transformation. Communication, sharing and agreeing across these increasingly complex borders are about developing appropriate boundary objects that match the needs of the borders (Carlile, 2002; Star & Griesemer, 1989), an adequate common lexicon, or standards, at the syntactic border, shared meaning at the semantic border and aligning interests at the pragmatic, political or organizational border. A fourth element of the proposed framework is the iterative cycling

through the levels in order to step by step develop common understanding and alignment of interests. Repetitions are needed because consequences cannot be seen and addressed with one try, and new agreements and changes are developed through an iterative and evolutionary process. We draw on this concept in trying to understand the standardization processes needed to achieve HIS integration, and standards tend to be evolving through negotiations between actors facilitated through ongoing efforts to develop standards in practice, rather than through early agreements (Braa et al., 2007; Egyedi, 2002; Hanseth, Monteiro, & Hatling, 1996).

In the form of shared methods or technological artifacts, the boundary objects play an important role in providing the capacity to negotiate interests (Star & Griesemer, 1989), and may "facilitate the transforming of specialized knowledge into novel jointly produced knowledge that transcends each community's local interests" (Barrett, Oborn, Orlikowski, & Yates, 2007). Barrett et al. (2007) go further in trying to understand how the boundary object (in this case a technological artifact) not only helps to translate meaning, but also plays an important role in reshaping boundary relations between occupational groups in an organizational setting. both positively and negatively, and draws on the notion of boundaries as dynamic and relational (Abbott, 1995).

Eoyang's (1996) work from complexity science on the concept of "attractors" is helpful in understanding the role of technological artifact in enabling organizational change in our case studies. Eoyang argues that "attractors," e.g. successful pieces of software, play a key role in adapting the various actors to common practices within a complex system by creating momentum through shared practices. Building on this concept again, Braa et al. (2007), argue that attractors are crucial in the evolution of new standards generally, and in the complex health system context particularly. An important part of HIS integration at the country level is to get the various actors to agree on shared standards. Attractors, such as successful examples of software or data standards, may be important in convincing, or aligning through practice, the various actors in health care (Braa et al., 2007).

Having worked extensively with national HIS in South Africa, Braa and Hedberg (2002) argues that inscribing flexible standards in the software used for an HIS could allow a "hierarchy of standards." For health management, there are different information needs depending on the hierarchical distance to the patient. Doctors would need detailed information on patients, districts would need community information to supplement their core health indicators, while national levels would only need a few health indicators to prepare a budget and take strategic decisions. Typically, the amount of information required would diminish as one went higher in the hierarchy, that is, closer to the national level. Scaling of national standards to lower levels had to be complemented with the ability of lower levels to define their own, additional, information standards.

Drawing on the concept of inscriptions (Hanseth & Monteiro, 1997), we can see that certain solutions prescribe certain behavior, and that inscribing software with incentives to integrate can be a fruitful approach. If attractors, successful standards or artifacts that offer a gravitational field among seemingly disparate actors (Braa et al., 2007), embedding such inscriptions can be created, a powerful tool for integration has been developed.

4. Case studies

In this section, we present a series of four case studies from South Africa, Botswana, Zanzibar, and Sierra Leone, all related to the global HISP, and more specifically to the implementation of the DHIS software. First we provide a general background on the DHIS' role in supporting an integrated HIS approach.

4.1   *The DHIS software – flexible design to enable integration*

Very often a computerized HIS is a direct computerization of the various forms and reporting structures that exists in the paper-based HIS. A result of such an approach is often lack of flexibility to modify the systems when the paper-based equivalent changes or to incorporate new needs like integrating additional programs or additional indicators. Such approaches, which strengthen the existing structures of fragmentation, are typically found in the various health programs where focus is often on reporting huge amounts of detailed data upwards in the hierarchy to the national level and to donor agencies.

To integrate information at the district level and to provide flexibility to meet the rapidly changing requirements of the healthcare domain, the DHIS design strategy is based on a more flexible model that goes beyond the typical "computerize the forms"-approach. Instead of computerizing the form as a whole, the DHIS is computerizing every data item or data element in the form independently. By breaking up the form into more fine-grained building blocks of data, the software also breaks up the fragmentation the forms represent and provides the possibility of manipulating and presenting data across health programs and forms, a prerequisite for integrated data analysis. This fine-grained or atomic design enables the user to define calculated indicators (combining data elements into formulas), custom reports, tables, and graphs for analysis that are completely independent of the collection forms and can instead be understood as user-defined assemblies or reconstructions of the data (elements) that was captured using the forms. This flexibility makes DHIS a more suited tool for public health management than the more typical computerized reporting tools that exist in the various fragmented departments of the health system. The DHIS allows, e.g. a district manager to combine all relevant data on child mortality (MDG4), originally from multiple sources and subsystems, into one common report that can be used for routine monitoring of interventions related to this specific target.

4.2   *South Africa*

In South Africa, the HIS reform process started in the 1990s after the abolishment of apartheid and was part of the ANC Reconstruction and Development Plan (ANC, 1994a; Braa & Hedberg, 2002). During apartheid, the health services were extremely fragmented and inequitable and health services and geographical areas were separated according to race and the system of "homelands." Until May 1994, there were 14 departments of health at the central level; the general National one, separate "white," "Colored" and "Asians" administrations, and 10 "black" homeland administrations. As a result, there were no health data standards and a multitude of forms for reporting data were in use. The new national health plan (ANC, 1994b) made it very clear that the health system needed to be reconstructed based on equity in health services provision to ensure the inclusion of those who had suffered during apartheid. In order to monitor to what extent this goal was properly addressed and to pinpoint communities in particular need, access to good quality essential health data, integrated across services and geographical areas, was seen as an absolute requirement.

HISP started in three pilot districts in Western Cape Province in 1995 with the aim of developing a district-based integrated information system. It turned out to be difficult to get all the actors to agree on common standards for reporting. After an "endless" array of workshops, the breakthrough came with the development of the DHIS in the conjunction with the testing of a first version of a minimum integrated data set in the pilot districts in 1997/1998. The Province agreed to test it further and the success was rather instant; for the first time, health managers had data available at their own desktop computer without having to wait for annual reports or enquire for data at various head offices. Having seen the success in Western Cape, the

neighboring Eastern Cape province also wanted to go for the DHIS software. In Eastern Cape, a project funded by USAID had developed and implemented a minimum data set in all the health facilities in the province, but had serious problems with the software they were using. They contracted HISP and implemented the DHIS successfully at the end of 1998 and could provide full coverage data for the province early 1999. Seeing the success in two provinces, other provinces also wanted to join the process and by 2001, the DHIS and data set approaches were endorsed by the National Health Information Systems committee of South Africa as a national standard. Since 2001, South Africa has established national standard essential data and indicator sets which all provinces are required to report. In addition to this, and given the federal institution of South Africa, each province is free to collect and manage the data and indicators they want. The principle of hierarchy of standards, enabled by the DHIS, was important in creating agreement among the provinces and other actors. According to this principle, each organizational unit in the health hierarchy is free to collect the data they want and thereby pursue their own interests, as long as they adhere to the standards of the level above. Each province could then continue to collect their own data as long as they reported the required standards to the national level. There are large differences between the data sets collected by the different provinces, but they all include the core national standards. The national core standards have gradually been expanded to more use areas since 2001.

This standard reporting format was in the beginning an addition and "on top" of all other reporting forms. Through its relatively instant success in terms of data quality and easy and immediate access, more provinces joined, but also, as the momentum grew, gradually vertical programs included their basic data requirements within the national minimum data set, which later changed name to "essential data sets." The immunization program, for example, realized that the quality of their data that were included in the minimum report was higher than in their own data reporting system, and subsequently "gave in" and included their vaccine reporting in the now national essential data set.

There are several electronic record systems in South Africa, or computerized transaction systems as seen related to the data warehouse debate. For the Tuberculosis electronic register and from some Anti-retroviral Treatment electronic registries for AIDS patients, "extract, transform and load" functionality is established with the DHIS; the standard, more technically advanced "Western" data warehouse model is gradually being adopted.

4.3 *Botswana*

The HIS in Botswana is extremely fragmented, with several ministries involved in the collection, compilation, and use of health data. In 2005, a centralized initiative to integrate the HIS was established through the Health Statistics Unit, which was to collect one form containing the essential data from a range of health programs. However, the main reason for collecting this data was for the compilation of an annual book on health statistics, not for supporting local health information use. At the national level, the compilation of the health statistics book was two years delayed (Sæbø et al., 2007). As a response, various health programs still relied on their own systems, which were designed and run by each individual health program. At the district level, however, most of these information systems were handled by one or two persons in one office, representing a form of human data warehouse. Some of the richer health programs, most notably, the HIV program of Prevention of Mother To Child Transmission (PMTCT), set up their own infrastructures to collect timely data by hiring their own people and equipping them with computers and software solutions.

The approach in Botswana was to make a direct mapping of the paper-based system into the DHIS version 1.4, meaning that each cell in the paper forms represented a unique definition in the

software. Even if the paper forms had overlaps and duplications, the duplications were transferred to DHIS, without standardization of, in essence, equal data definitions. This approach would not reduce the amount of data to be entered, it would not solve the duplications (which turned out to sometimes contain different figures in different forms), but it did allow for a fast implementation by avoiding "political" obstacles in the set-up of the database. As long as no paper form was changed as it was copied to an electronic format, a database could easily be agreed upon by the various stakeholders. This strategy opted for a quick solution in an environment where the capacity to negotiate an integrated solution was not present at the time. The semi-integrated data collection tool, the DHIS, was then to be used as a platform for further integration. The nature of the project organization posed severe limitations in this direction.

As part of an EU-funded research project (BEANISH[1]), the Ministry of Science, Technology, and Communication oversaw the initiation of the data warehouse implementation. Assigning the administration of the implementation to their IT-unit seconded to the Ministry of Health, the project was distanced from the health domain from the start. While the IT-unit physically worked at the Ministry of Health building, its main activities here consisted of setting up the network, assigning e-mail addresses, procuring hardware, and the like. The placement of the project implementation with the IT-unit meant that the project came to be seen as a "computer project" by the various health-affiliated stakeholders. This division between health and IT became stronger over time, and the project failed to enlist "champions" in the health programs. To complicate further, public health services at the district and facility levels were run by yet another actor, the Ministry of Local Government. Unable to tie the necessary links with the Ministry of Health-run national health programs and the Ministry of Local Government, the IT-unit, formally under the Ministry of Science, Technology, and Communication, became increasingly focussed on just the computer-technical side of the implementation.

A spin-off of the data warehouse project in 2007 is worth mentioning. Looking for software to ease data collection for their CRIS analytic software, UNAIDS adopted DHIS. Driven by local champions both at national and district level, UNAIDS rolled-out this new software bundle nationwide over the following year. Representing so far a new, independent, vertical reporting structure, the network UNAIDS has established, comprising national and local actors, might also manage to integrate the other HIS in place, from which UNAIDS retrieves their HIV/AIDS specific data.

4.4   *Zanzibar*

In November 2004, a joint survey to study the HIS status was conducted by the Danish International Development Agency (DANIDA), World Health Organization (WHO), Ministry of Health and Social Welfare (MOHSW) and University of Oslo. The survey revealed poor HIS characterized by fragmented data collection and reporting due to many subsystems in healthcare service provision, and little use of information. As a result of this, in 2005, HISP started working with the newly established Health Management Information System Unit (HMIS Unit) at the Ministry, to implement a computerized HIS. Key objectives of the project were to (1) strengthen information use at the district level, and (2) set up an integrated data warehouse at the national level to facilitate access to information by all health programs and stakeholders. Ministry stakeholders, health program managers and district medical officers, and HISP consultants conducted a series of meetings to agree on a set of standardized data collection forms (data sets) that would form the basis of the integrated data warehouse.

To implement the same integrated data repository approach throughout the country (10 districts and a population of 1 million), a combined paper and computer strategy was implemented. The glue between all levels were the standardized essential data sets including essential data

from all health programs taking part in the integrated approach (Reproductive and Child Health, Immunization, HIV/AIDS, and Disease Surveillance). These standard data sets were both made available on paper forms to be used for data reporting between the health facilities and the district level, and electronic forms as part of the DHIS software used to register, validate, analyze, and report data at district and national levels.

In 2005, the customization and implementation of DHIS started by using the new version 1.4, which was actually under development. This caused some technical problems during the first 1–2 years, as Zanzibar acted as a test site and bugs documenter for the new DHIS version being developed in South Africa. The approach to visually break up the harmonized database into multiple essential data sets to accommodate health program needs was different from the South African way of using only one essential data set for all the data collected, and this was an important feedback to the global DHIS development process. Communication of requirements and testing of new functionality from Zanzibar became an important process in supporting the development of a more flexible and globally relevant DHIS software.

Every year since the first version of the unified data collection forms, there has been a revision process (a 3–5 day workshop), whereby the data sets are revised and updated based on negotiations among key stakeholders (health programs and other departments at the MOHSW), and as a result, the paper and electronic forms are updated on an annual basis to adapt to these revisions. While the standardization process in Zanzibar toward one harmonized system has been relatively successful due to solid political backing the other key objective from the reform process, to strengthen information use at the district level, has been a slower process. Changing the culture of dealing with health data from a hierarchical reporting perspective to one of information for local management has proved to be a long-term process and still requires lot of emphasis on capacity and awareness building.

4.5   *Sierra Leone*

Sierra Leone, a relatively small country in West Africa, is one of the poorest countries in the world and was ravaged by civil war that lasted for ten years before it was officially declared over in January 2002. The public health system, which suffered from a huge loss of both personnel and infrastructure during the war, is slowly rebuilding the capacity to improve the service provision across the country. This effort is led by the government and supported by many international agencies, and aims at achieving the health MDGs. The rapid growth of various health initiatives has created a situation of fragmented information systems, common also in other developing countries (Braa et al., 2007; Sæbø et al., 2007). Figure 1 depicts the fragmented situation characterized by overlapping data collection tools and data elements. The overlapping rate between two different forms can vary from 0% to 50%. In 2008, each facility reports about 17 forms.

From the fragmented HIS described above, the main issue was to provide meaningful and relevant information for decision-making and to diminish the workload of staff who are collecting and reporting the data. The suggested way forward was to use DHIS to integrate the various data flows and data sources and thereby to provide an integrated framework for M&E and data management. To achieve this, attention was devoted to the data warehouse as a starting point. All data elements were identified and sorted out in order to identify and avoid (a) duplication from overlapping data forms (b) overlapping data elements – in term of their definition. As a result, a coherent integrated data warehouse was built, where one data element in the database can be related to a field in several data collection forms. Figure 2 shows how multiple, duplicate data elements from the existing paper system were integrated "behind the scenes" in the data warehouse.
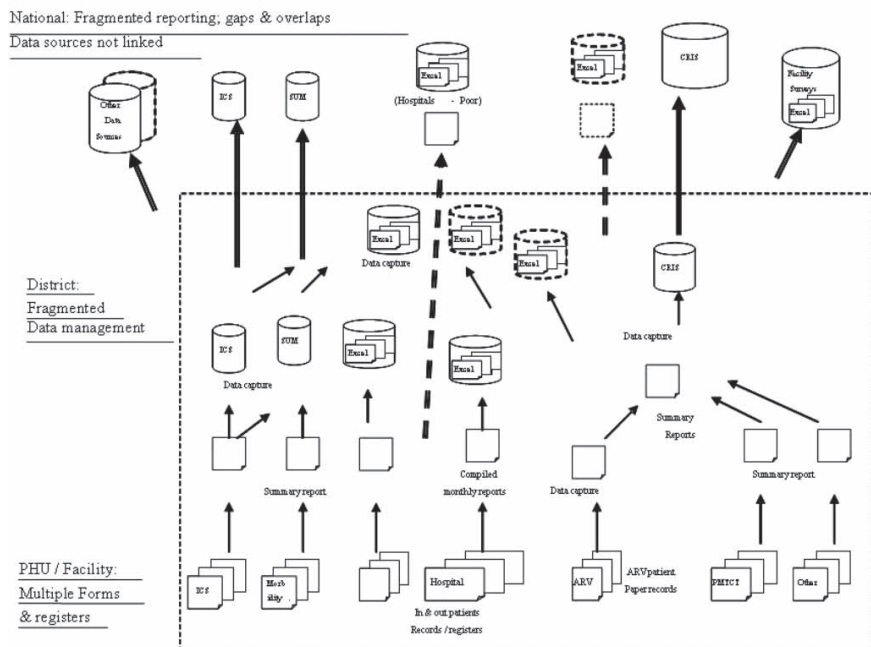
Figure 1. Illustration of the fragmented HIS in Sierra Leone in 2005.
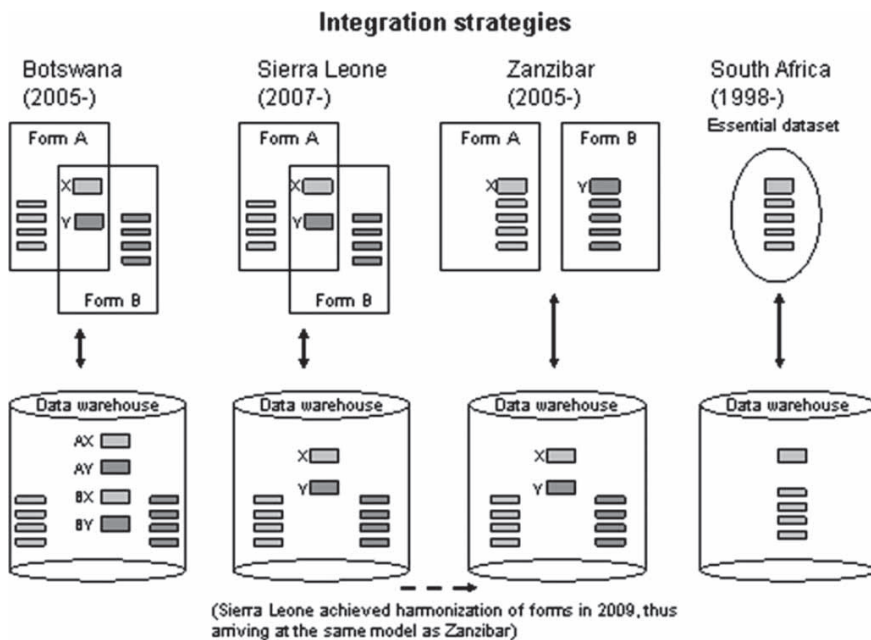

Figure 2. Integration strategies and degree of integration.

In January 2008, this integration approach was implemented in four of the 13 districts in Sierra Leone, and 6 months later in three more districts. Intensive training was carried out, each district captured their data in the DHIS and exported the data to the national DHIS by the use of memory sticks. An extensive process to capture and import backlog data from the various electronic systems from all districts was put in place, and a rather extensive national data set was available for analysis during the second half of 2008. All stakeholders were made part of the process which convincingly documented the problems with the current system such as overlapping data collection forms, inconsistent data definitions, poor data quality in terms of both correctness and completeness. At the same time, through actually doing it, it was also documented that shared common data sets in a national repository was possible to achieve. This learning process sparked an increased interest to revise the current collection forms, and during 2009, a series of meetings took place among the key stakeholders to negotiate a new set of harmonized data collection forms. As a result, since January 2010 a new set of completely rationalized and harmonized forms have been in use, very different from those of the previous years.

Coupled with extensive training in the analysis and use of the resulting information, districts are starting to show improving health indicators. With the availability of data from across the country, one district medical officer was appalled at his district's comparatively low institutional delivery rate, an indicator directly linked to MDG Target 5a (reduce maternal mortality rate), but also MDG 4 (reduce child mortality rate). Involving health staff and civil society in discussing approaches to improve the situation, they managed to significantly increase the rate both in urban and rural areas over the course of 2009.

4.6   *Summary of the case studies*

Figure 2 illustrates the different approaches to HIS integration in the four countries. The fine-grained data element design of DHIS allows for breaking up the forms into smaller atomic data elements which may or may not (in the case of Botswana) be harmonized in the data warehouse. From left to right, we see increased harmonization of data both in the forms and in the data warehouse. Table 1 summarizes the four case studies on key topics related to the integration process.

5.   Discussion

As we have seen from the cases, there are both similarities and differences between the countries that highlight certain lessons. The similarities are perhaps the easiest to pinpoint; an initial situation of fragmentation and independent information structures, quite obstructive to efficient management to improve the health situation, including reaching the MDGs (not to forget, the poor information systems also influence other health areas than those spelled out in the MDGs). The differences are more diverse, and stem from the socio-political entity of the wider health system, including power structures, skill levels, pressure to see quick results due to funder's priorities, and entrenchedness of the former systems. In the following discussion, we try to categorize the main findings according to concepts introduced in Section 3.

5.1   *Contrasting the cases – data warehousing and integration*

South Africa and the three other countries represent distinct integration strategies. While in South Africa, the new system was built bottom-up and incrementally in addition to an existing array of partly inconsistent subsystems, the other three countries tried to encompass all the

Table 1. Summarizing the cases.

	South Africa	Botswana	Zanzibar	Sierra Leone
Data warehouse standardization approach	Essential data sets. Specific paper reporting forms collected uniformly across country, eventually in addition to other forms	Including all existing report forms – little revision of overlap and inconsistencies between forms and data elements. Fragmented db.	Full revision of all report forms – no overlap between forms and data elements. Annual revision process	All existing report forms – no revision of forms, overlaps solved in database, inconsistencies identified and addressed. Harmonized db.
Process started	1995	2005	2005	2007
Why this approach was selected	Extreme fragmentation caused effort to establish new unified reporting forms in addition to all other reporting routines	Capacity to lead integration not available. Data warehouse to highlight to stake-holders the need for integration	All stakeholders agreed to revise and coordinate their reporting forms and solve problems of overlaps	Previous efforts failed because not all programs were included. Now include all data reporting and stakeholders. Show overlaps and inconsistencies
Main challenges with the approach	Keep pace with new developments and technologies and remain in the forefront; e.g. on top of HIV/AIDS reporting development	To direct the early momentum gained into real integration. Avoid entrenchment of fragmented system by computerizing it	Integrated data warehouse does not automatically lead to more local use of information. More capacity in the use of information needed	Align all actors in the integration process. Local capacity building. Supporting infrastructure. Harmonization of collection tools and indicators
Main benefits of this approach	The smaller and simpler data sets gives better quality and availability of needed data from across programs	Quick computerization, fast results in populating the data warehouse	Systematic approach, combine management of data from all programs	Reduce amount of manual data entering, highlight overlaps, all data available in database. Shows early the benefits early.
Status	National standard. High quality data and level of use. Being gradually extended to new data sets and use areas	Slow to gain momentum within MoH, but full local responsibility assumed by 2008. UNAIDS-fork in nationwide use	National standard. Use of data and data quality is slowly increasing through regular district data use workshops	Stakeholders agreed on shared harmonized data sets which are implemented countrywide in February 2010

existing data and systems, each following different strategies. South Africa has gradually extended the scope of the data sets by convincing and enrolling new service areas and programs through providing good results and thus creating a momentum (Braa et al., 2007). Zanzibar represents the opposite approach: to a large extent, the old reporting systems were revised and combined into a newly integrated system. This was possible through strong political and financial support, and because they met the basic requirements of the important stakeholders, not met by the old systems. In Sierra Leone, the aim was similar, but they went through an intermediate process of including all the existing reporting formats and data sets in the data warehouse while at the same time solving the inconsistencies in the internal data structure. Through this process, problems with the existing fragmented system and the advantage of integration was documented and the stakeholders have been convinced to revise and integrate the entire system of data collection, and new integrated data standards have been decided upon. Solid political support from the Ministry of Health and the HMN was important. In Botswana, also the aim of the intermediate process was to document and convince stakeholders, but the results were less convincing. Lack of political support and commitment from within the Ministry of Health were major obstacles, and the results from the pilots did not create sufficient interest.

At the technical database level, the different strategies may be outlined as follows:

South Africa is different from the others in that they followed a data for the decision-making approach, only including the most important data from each area. As the momentum grew, gradually more areas and data were added, which was easily accommodated through the flexible database structure. In this way, national standards for essential data were developed "on top of" other existing systems. The three other countries, Botswana, Sierra Leone, and Zanzibar, all followed different all-encompassing strategies; (1) Botswana: include all data "as they are," without solving inconsistencies between them, (2) Zanzibar: start with revising the data collection tools and solving the inconsistencies before setting up the data warehouse, (3) Sierra Leone: two phases; (a) accept that there are different overlapping data collection forms in use, but solving the inconsistencies in the metadata structure of the database, (b) use this approach to demonstrate that "full" integration similar to the approach in Zanzibar is possible.

Ideally, the best approach to standardizing health data and integrating different vertical data reporting systems would be to make all actors agree upon and implement a revised and harmonized set of standards. This is to some extent what was achieved in Zanzibar. However, due to the wide variety of vertical donor initiatives, which all tend to have their own separate reporting requirements, and overall changes in information requirements within and between the various vertical health programs, standardization of health data is a complicated process. Standards tend to be evolving through negotiations between actors facilitated through ongoing efforts to develop standards in practice and by good examples working as "attractors" that are creating momentum rather than through early agreements (Braa et al., 2007; Egyedi, 2002; Eoyang, 1996; Hanseth et al., 1996). This is illustrated well by the case of South Africa, where the first limited data set and database became successful, first in one, then two provinces, before later being adopted across the country as a result of the momentum created by successful use. The first phase in Sierra Leone also managed to create an attractor as the usefulness of the data warehouse approach was demonstrated in such a way that the involved actors agreed to go for full integration in a phase 2.

In Botswana, however, the problems of fragmented health and lack of standards were addressed mainly through a technical solution, which turned out not to be very useful; the problem of fragmentation was addressed by including all data in one data warehouse. By "dumping" all data from different health programs in one data warehouse, without solving the overlaps and inconsistencies between the data sets, analysis and use of data across the

data sets were still difficult. Overlap of data will still produce different and confusing figures for the same phenomenon. The number of pregnant women receiving antenatal care, for example, is reported through both the Mother and Child Health program and the PMTCT, resulting in different figures for the same number of pregnant women. It is therefore obvious that integration and standardization of data between these two health programs need to be negotiated between the two organizations, and they will have to agree on shared data definitions at the semantic level. There are no technical short-cuts.

It may be added that maintaining a heterogeneous data warehouse as in Botswana will require more skilled data managers interacting with advanced data warehousing tools to produce an abstracted, harmonized level on top of the heterogeneous data sources, than what is required for a strictly standardized one. Consequently, this approach is not recommended for developing countries where human resources make up the bottleneck.

Contrary to the case of Botswana, we see that in the three more successful cases, the processes of developing the system and standardizing the health data reporting have taken place at the organizational level. To what extent the solution supports integrated information use is the key criterion for success.

5.2   *Spanning boundaries through flexibility*

Carlile's integrative framework is helpful in highlighting how the four countries have followed different paths in their quest for integrated HIS, and in understanding how software and implementation strategies collectively developed in the global network of HISP have played the role as boundary objects in this longitudinal collection of case studies.

The integration process in Sierra Leone followed Carlile's processes of (1) transfer – adoption of the technical solution to share data and identify indicators and data elements, while collection forms were kept as before. (2) Translation – a new common lexicon of harmonized data elements was created in the back-end of the data warehouse, removing overlaps and duplicates that existed in the collection forms. Examples of integrated data analysis were produced and shared among stakeholders. (3) Transformation – in 2009 after using the integrated data warehouse for more than one year, stakeholders acknowledged problems of data quality with the existing fragmented collection forms and were convinced of the need for data harmonization. A revision process was started, and in February 2010, the new harmonized and standardized data collection forms were implemented countrywide. And (4) iteration – during the harmonization process, stakeholders agreed to meet on regular basis to review and renegotiate the shared and harmonized standards. This iterative process, similar to the development of the gradually expanded essential data set in South Africa and the annual revision of forms in Zanzibar, allows for integration of new and emerging initiatives and information needs, such as the country-wide launch of the free health care initiative in Sierra Leone, April 2010.

Although we have demonstrated that the political and organizational dimensions of integration are critical, there is also a role to play for the technology. Furthermore, the cases of South Africa and Sierra Leone show that the DHIS data warehouse was instrumental and worked as a boundary object in providing the capacity to negotiate interests between the actors and to transform knowledge and practices. In the first phase in Sierra Leone, the flexible data element design of DHIS allowed for a harmonized data warehouse at the back-end while keeping the clear borders of the health programs' collection forms in tact at the front-end. The inherent flexibility of the technology could this way show the benefits of integrated data analysis and attract interest (Braa et al., 2007), while at the same time delaying the political battle to harmonize the collection forms until the stakeholders had been convinced. This maturation process was followed by a second phase where the data standards and collection forms

were harmonized in a negotiation process between the health programs and the national HIS unit. In this process, the relational borders between these subsystems were reshaped into a mutually beneficial integrated information system (Barret et al., 2007).

In Botswana, the DHIS failed to play the role as a successfully attractive boundary object and did not enable any change to the relational borders between health programs, departments, and ministries, and as a result little integration took place. While the data warehouse in Sierra Leone was harmonized at the back-end and therefore could communicate the benefits of integration, in Botswana the clear borders of the health programs' forms were mirrored in the technology (Figure 2). This way, the DHIS was not able to demonstrate integrated information use and consequently failed to bridge the technical and the organizational levels of the HIS in Botswana.

5.3   *Maintaining attractiveness in a changing environment*

To explain the difference in approaches, especially the contrasting cases of Sierra Leone and Botswana outlined above, it is important to look at how the boundary objects and attractors have evolved over time. As noted in chapter 2, this study spans many years, in which changes have occurred at different levels. The implementers (and authors) have been part of an evolving network, in which both feedback and ideas from countries and research institutions have shaped the understanding of HIS and approaches toward integration.

The DHIS application has gone through many development cycles since its first use in 1996. The needed flexibility in the design, as well as the necessary experience of the DHIS implementers were not available in 2005 in Botswana, but had been developed in time for a more successful data warehouse design in Sierra Leone in 2007. Important lessons were learned in Botswana and Zanzibar, especially in dealing with multiple data sets and accommodating collection forms across health programs, which was very different from the one essential data set approach of South Africa. These new experiences and emerging requirements were fed back into the global HISP network, which again benefitted other countries, including Sierra Leone.

Furthermore, the global community of health has changed, with global partnerships like HMN and IHP+ campaigning for harmonization and integration, and giving legitimacy to formerly more marginalized groups advocating this at the country level. The strong backing of HMN in Sierra Leone played an important role in pushing the agenda for change and strengthened the effect of the DHIS as a boundary object, in contrast to the more difficult political context in Botswana 2 years earlier.

On top of all this, the projects themselves changed in nature as they scaled; from pilots to established systems which a lot of people depended on for their daily work. What was useful for bringing two initial groups together, might not be sufficient to keep growing, reaching the crucial scale necessary to offer a comprehensive system supporting the MDGs.

In South Africa, more than ten years ago, a relative simple but flexible software application supporting a minimum essential data set created an attractor, which was both addressing immediate needs for many users but also demonstrating how "similar" problems could be solved. The easiness with which to define and implement new data sets integrated with other data sets using the DHIS led to innovations and new use areas, and it led to the spread of the DHIS and HISP approaches to new countries. The strategy that has led to success in South Africa and to some extent also in Sierra Leone and Zanzibar, and generally in the DHIS and HISP networks, has been to create an attractor by initially providing easy to make, but useful solutions, which may later evolve and become more comprehensive as new actors and use areas are included (Braa et al., 2007).

Through the changing context brought by external and internal factors, as well as scaling of the initiatives themselves, the forces of gravity emanating from the attractors grow and wane in strength. Maintaining attractiveness, then, becomes a key goal. The first efforts in South Africa started before the MDGs were formulated. The projects in Zanzibar and Botswana were initiated as HMN was just starting to build global legitimacy for an integrated approach. By the time Sierra Leone reformed their HIS, an integrated system supporting the MDGs was very much a core requirement. The DHIS software has over the years closely followed this trend. Flexibility to integrate various data sets and to customize data collection forms and reports have ensured that health programs could opt for a quick win; joining the "integrated" data warehouse without having to reform their data collection tools and to use the data warehouse as an active instrument in the continuous process of standardization and integration, as we have seen in Sierra Leone.

The reason why DHIS is still used to create attractors in new countries and use areas is that it has been under continuous development and has managed to evolve with the requirements of the ever-changing needs of global health, and has thus managed to stay attractive over time. The fact that DHIS is still an attractor, however, also demonstrates that the problems of fragmentation and challenges of integration are not yet solved.

6.   Conclusion

With 10 years spent pursuing the MDGs, there is still a lack of adequate HIS for management and monitoring capacity in many countries. In response to this, and the sorry overall state of HIS and use in developing countries in general, the international community has advocated integration to reduce the inefficiencies of the fragmented legacy systems of decades of uncoordinated development interventions. This paper has addressed the challenges to such an integration by investigating four country cases, all of which had different approaches to integration.

We have argued that integrated information systems and quality information are needed in order to achieve the MDGs. In order to, for example, substantially reduce maternal and child mortality and to successfully combat HIV/AIDS, both targeted action and coordination of health services will be needed. This again will require the use of quality data for both local level decision-making and services delivery, as well as integration of information across health programs.

We have described and discussed four cases of applying a shared data warehouse – as a tool to facilitate practical integration of information across different organizational structures. The lack of success in Botswana and the relative success in the other three countries, clearly indicate that although following a technically termed "data warehouse approach," in order to be successful, integration needs to be rooted at the institutional and organizational political level. The data warehouse approach, when applied successfully, has turned out to work as an important mediator and boundary object facilitating the negotiation between the organizational actors.

We argue that "attractors," technical solutions or standards that achieve a certain level of success and enable the building of momentum, are important in aligning the various political actors. The networks of action approach followed in this longitudinal research project enables circulation of methods and software between country implementations, and facilitates learning and sharing over time. These networking mechanisms are important in making sure that the attractors evolve within the changing context of a growing HIS, in order to achieve the scale needed to address the MDGs with full force.

Note

1. Building Europe Africa collaborative network for applying IST in health care sector (see http://208.76. 222.114/confluence/display/BEANISH/Home).

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References

Abbott, A. (1995). Things of boundaries. *Social Research*, *62,* 857–882.

ANC (1994a). *The reconstruction and development programme*. Johannesburg: African National Congress.

ANC (1994b). *A national health plan for South Africa*. Johannesburg: African National Congress.

Barrett, M., Oborn, E., Orlikowski, W., & Yates, J. (2007). *Boundary relations: technological objects and the restructuring of organizational boundaries* (Working Paper Series of the Judge Business School, Cambridge University. No. 16, 2007). Cambridge: Computer Society Press, Cambridge University.

Braa, J., & Hedberg, C. (2002). The struggle for district-based health information systems in South Africa. *The Information Society*, *18*, 113–127.

Braa, J., Hanseth, O., Heywood, A., & Shaw, V. (2007). Developing health information system in developing countries: The flexible standards strategy. *MIS Quarterly*, *31*, 381–402.

Braa, J., Monteiro, E., & Sahay, S. (2004). Networks of action: Sustainable health information systems across developing countries. *MIS Quarterly*, *28*(3), 337–362.

Carlile, P.R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science*, *13*(4), 442–455. doi:10.1287/orsc.13.4.442.2953

Carlile, P.R. (2004). Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization Science*, *15*(5), 555–568. doi:10.1287/orsc.1040.0094

Egyedi, T.M. (2002). Standards enhance system flexibility? Mapping compatibility strategies onto flexibility objectives. In *EASST 2002 Conference: Responsibility under uncertainty*. York, UK: European Association for the Study of Science & Technology, University of York, July 31–August 3.

Eoyang, G.H. (1996). "Complex? yes! Adaptive? Well, maybe…". *Interactions*, *3*(1), 31–37. doi:10.1145/223500.223509

Grimson, J., Grimson, W., & Hasselbring, W. (2000). The SI challenge in health care. *Communications of the ACM*, *43,* 48–55. doi:10.1145/336460.336474

Gulledge, T.R. (2006). What is integration? *Industrial Management & Data Systems*, *106*(1), 5–20. doi:10.1108/02635570610640979

Hanseth, O., & Monteiro, E. (1997). Inscribing behaviour in information infrastructure standards. *Accounting, Management & Information Technology*, *7*(4), 183–211. doi:10.1016/S0959-8022(97)00008-8

Hanseth, O., Monteiro, E., & Hatling, M. (1996). Developing information infrastructure: The tension between standardisation and flexibility. *Science, Technology and Human Values*, *11*(4), 407–426. doi:10.1177/016224399602100402

Hasselbring, W. (2000). Information system integration. *Communications of the ACM*, *43*(6), 32–38. doi:10.1145/336460.336472

Health Metrics Network (2008). *Framework and standards for Country Health Information Systems*. Retrieved from http://www.who.int/healthmetrics/en/

IHP+ (2010). Retrieved 28 May, 2010, from http://www.internationalhealthpartnership.net/en/about

Kossi, E.K., Braa, J, Tohouri, R., Uggowitzer, S., Yumkela, F., Bye, K., …, McEwen, E. (2008). De-fragmenting health information systems in Sierra Leone: Horizontal and vertical integration.

In P. Cunningham and M. Cunningham (Eds.) *IST-Africa 2008 Conference Proceedings* (Ref. No. 95). IIMC International Information Management Corporation.

Sæbø, J., Braa, J., & Chandna, O. (2007, May 28–29). *A flexible approach to integrating health information systems: The case of data warehouse as integrator in Botswana*. Paper presented at the IFIP WG 9.4, São Paulo.

Sahay, S., Monteiro, E., & Aanestad, M. (2009). Configurable politics and asymmetric integration: Health eInfrastructures in India. *Journal of the Association for Information Systems*, *10*(5), Article 4. Retrieved from http://aisel.aisnet.org/jais.

Singletary, L.A. (2004). Applications integration: Is it always desirable? In *Proceedings of the 37th Hawaii International Conference on System Sciences* 1–9 (pp. 265–273).

Stanford University (1998). Data warehousing at Stanford, Retrieved from http://infolab.stanford.edu/warehousing/warehouse.html

Stansfield, S., Orobaton, N., Lubinski, D., Uggowitzer, S., & Mwanyika, H. (2008, July 13–August 8). *The case for a National Health Information System Architecture: A missing link to guiding national development and implementation*. Paper presented at the Making the eHealth > Connection: Global Partnerships, Local Solutions Conference, Bellagio, Italy.

Star, S., & Griesemer, J.R. (1989). Institutional ecology. "Translations," and boundary objects: Amateurs and professionals in Berkley's Museum of Vertebrate Zoology, 1907–39. *Social Studies of Science*, *19*, 387–420.

Susman, G., & Evered, R. (1978). An assessment of the scientific merits of action research. *Administrative Science Quarterly*, *23*(4), 582–603.

Wainwright, D., & Waring, T. (2004). Three domains for implementing integrated information systems: Redressing the balance between technology, strategic, and organizational analysis. *International Journal of Information Management*, *24*, 329–246.

WHO (2005). *Health and the millennium development goals*. Retrieved from http://www.who.int/mdg/publications/mdg_report/en/

WHO (2007). *Everybody's business: Strengthening health systems to improve health outcomes: WHO's framework for action*. Geneva.

IV

NETWORKS OF NETWORKS – COLLABORATIVE EFFORTS TO DEVELOP HEALTH INFORMATION SYSTEMS ACROSS DEVELOPING COUNTRIES

Abstract: The challenge of scale and sustainability in health information systems development, especially in resource-poor settings, is well known. Earlier studies have argued for organizing such development in networks to increase the chances of success, as well as the heterogeneity leading to better understanding and thus better products. This paper looks at ongoing efforts in West Africa, which have grown in scale to include networks of networks. This has large synergetic effects, much beyond linear growth. The study discusses these effects, as well as the strategies of achieving such second order networks, using notions of attractors, architecture, and standards. The specific case involved is the convergence of many efforts to strengthen health information systems across the region, linking networks whose primary focus vary from global to regional and local, from policies to software development and advocacy.

Keywords: health information systems, West Africa, Sierra Leone, networks, action research

NETWORKS OF NETWORKS – COLLABORATIVE EFFORTS TO DEVELOP HEALTH INFORMATION SYSTEMS ACROSS DEVELOPING COUNTRIES

1. INTRODUCTION

This article describes and discusses the way in which different processes and networks for strengthening Health Information Systems (HIS) in West Africa have developed, converged and mutually strengthened each other creating a significant momentum for change in the area of HIS in the region. At a more general level and building on the concept of "networks of action" (Braa, Monteiro, Sahay 2004), we describe the phenomena under development in West Africa as the building of "Networks of networks of action". The concept of networks of action was developed in 2004 as a response to the fact that individual pilots and action research projects tended not to survive in the longer run unless they formed collaborative networks with other similar projects and other activists. Based on the analysis of the case from West Africa, we bring this concept one step further; when already existing networks are coming together through mutual benefit and shared interests, their combined momentum, relevance and impact will by far go beyond the sum of the networks. The effect of networking existing networks of action is far greater than networking singular units and actors.

In this earlier study, it was pointed out that each one of the projects or initiatives may be too weak to survive alone, but by combining forces by building collaborative networks sufficient strength may be achieved to build further momentum (ibid.). Furthermore, the individual projects will need to scale in order to get beyond the pilot phase. In general terms this is about building tools, knowledge, trust and competence enough to actually convince user organisations that the results of the pilot need to be implemented and scaled up. More specifically in the area of HIS, an added complication is that country health administrations tend to require country-wide solutions, causing the "all or nothing" problem. Both components of the networks of action concept are important in this story: 1) create more strength by joining disparate actors, and 2) create momentum through scaling.

Networks range from the formal to the informal. The West African Health Organisation, to be described in the case section, is a formally organised network of 15 member states. The Health Information Systems Programme (HISP) network, also to be described, is much less formal, but with many nodes run by budgets and other formalities. Networks of second order, networks made up by networks, are rarely developing and converging by design, rather convergence and growth of networks seem to be emerging. Central to the emerging of such new order are attractors (Braa et al, 2007). Attractors may emerge and become de facto, industry standard such as MS Windows, or they can emerge as networks that are attracting increasing attention and following as the network around the open source DHIS2 software, which is one of the networks in our case material. The development of this network has not been by design; the interacting networks are too many to make it possible to see far into the future. Rather this network has emerged as an attractor through directional improvisations and an ability to align other actors and forge strategic relationships, and in applying an open architecture that allows networks to link up.

The strive to achieve the United Nations Millennium Development Goals (MDG), where 3 out of 8 goals are health related, has led to a strong demand for quality health information in order to be able to see if efforts to improve the situation are working (see for example Chan 2007, HMN 2010a). The availability of quality information depends on well-functioning HIS, one of the six pillars of a health system (WHO 2005, 2007). The MDG process has led to increased donor support for many programs (such as TB, malaria, vaccination programs, maternal health care,

etc.). Unfortunately, donors often introduce particular systems for data collection and reporting that sidestep established reporting routines. The resulting complexity, coupled with poor human resources and infrastructure, easily leads to fragmentation and poor data quality.

This again has led to several international organizations specifically addressing these challenges with new strategies. The International Health Partnership[1], aims to harmonize aid agencies, and align international efforts with national systems. The Partnership in Statistics for Development in the 21st Century[2], helps countries adapt evidence-based policy making and implementation to reach the MDGs. The Health Metrics Network (HMN)[3] was created to strengthen country HIS and information use, through integration of subsystems and data sources. Other international donors, the initial source of many of the fragmented systems, have as a result adapted a strategy of improving integrated national HIS rather than implementing new, narrow, specific subsystems. There thus seems to be a considerable consensus on the need for consolidation, integration and collaboration in health information systems globally (AbouZahr and Boerma 2005; Tierney et al. 2008).

Over the last 3-4 years more than 60 countries have applied tools developed by HMN to assess their current HIS, and then based on this assessment develop strategic plans for strengthening their HIS. The third phase of this HMN strategy is, obviously, for the countries to implement their strategic plans. The problem, however, is that there are no funds readily available to support countries to implement this. The current situation is thus that multiple countries are eager to get going with their HIS processes and are looking for partners and funding, while at the same time regional and global agencies and networks are increasingly looking for partners to assist countries. This is the fertile and enabling context for the building of networks of networks, which will be described and discussed in this article.

The development of the HISP network during the nineties and the early 2000s formed the basis for the concept of networks of action. HISP was engaged in HIS development, open source software, education and action research, and the development of the network during the period was more characterized by "up-hill" hard work and more by "push" than by "pull". Pilot projects and educational schemes were established in different countries, and HISP was engaged in the global debate on strategies for HIS development, of which there were no global consensus. This situation changed by the establishment of HMN in 2005, first more generally by gradually establishing a kind of global consensus on the need for integrated HIS approaches, and second, more specifically linked to key HISP software activities; making the use of a country data warehouse a standard approach to HIS integration. The DHIS2 Open source application suite being developed by HISP was well aligned with this new standard promoted by HMN, as were the ten years of experience from HIS development in many countries, leading to a significant increase in global interest in HISP. The concept of networks of networks are developed as a way to better explore and understand the current enabling global context for HISP and HIS network building, the topic for this article.

Outline of the article; first we present methodological considerations, then we present a conceptual framework focusing on networks and the role of attractors before describing the case, discussion and conclusion.

2. METHODOLOGY

This paper builds on case material from a set of global and local activities that converge in West Africa, and that are the operational results of a long-term, ongoing, action research project the

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[1] http://www.internationalhealthpartnership.net/en/home

[2] http://www.paris21.org/

[3] http://www.who.int/healthmetrics/en/

authors are engaged in. Action research is a form of participative research where the researcher takes part in the change processes in an organization, actively trying to improve some stated problem (Checkland and Holwell 1998; Avison, Lau et al. 1999).

Our research then, centers on understanding the processes at work, while at the same time use this understanding to improve on the current situation. We are all, to various extents and changing over time, immersed in change-processes, working closely with the owners of the problems we try to solve. As such, we are involved in open-ended and continuous phases of design, development, implementation, and evaluation of interventions, with a stated aim at improving some given subject, as according to principles of action research (Susman and Evered, 1978). The authors have thus participated in most of the events described in the case description later.

In 2004, Braa, Monteiro, and Sahay articulated the networks of action approach for the HISP network, which discussed the value of learning and doing in networks rather than in isolated instances. The point of departure for this articulation was earlier studies of action research concluding with the need to situate the action within networks rather than on singular units because isolated action research projects did not manage to create enough momentum to attain sustainability. Therefore, the focus needed to be shifted "from single organizations and workplaces…to networks" (Engelstad and Gustavsen 1993, p. 209). Activities within an action research setting could be geared towards creating collaborative linkages, which would be harder applying a less participatory research method.

As the title of this paper suggests, the research in this study is even more broadly based, in networks of networks of action. In other words, the research described herein is based on active participation by the authors in various change processes (organized as networks of implementation and research localities), converging in a common, larger, process involving several such networks varying in nature. The concept of networks and the four networks involved are described later; here it suffices to say there are differences in scope, location, approaches, and legitimacy, while the similarities are strong enough to foster strong collaboration towards shared aims.

The authors hold pivotal positions in three of the networks portrayed in this paper, and have thus different perspectives on the processes described. In some sort of "perspective triangulation", this has enabled us to look at events and processes from different angles, and we have also a broader set of experiences as we approached these events with different agendas and backgrounds in the first place. Furthermore, three of the networks are global, with related work going on in many different localities. Conceptualizing the herein described events builds on comparative experiences from many other countries, a base of experiences that help discern particularities from generalities.

2.1. Data collection

The authors have all been part of a wide range of activities in Sierra Leone, West Africa, and other countries implementing the same HIS applications. Two of the authors have spent considerable time in Sierra Leone for the University of Oslo and Health Metrics Network, key nodes of two of the networks, traveling the country developing, implementing, and adapting software, and above all engaging in capacity building. This amounts to several months each over the last three years. Combined, the authors have been involved in all aspects of the Sierra Leone implementation, from the technical aspects to discussing data reporting harmonization among health development partners, presentations with the Ministry of Health to donors and partner organizations, and coordinating feedback to the global distributed user and developer community around DHIS2. At the regional level, supporting implementation of the two applications DHIS2 and iHRIS in several countries, participation in workshops, and working closely with other partners, has been undertaken. All these heterogeneous activities have put the authors in contact and communication with a wide range of stakeholders, from nurses and information officers in facilities and districts, to ministers and directors of large organizations. A range of field diaries, trip reports, scientific

papers (see for example Sæbø et al. 2011) , reports for external funders (for example HMN 2010b), and email threads provide a rich source of information on the longitudinal processes.

2.2. Data analysis

The conceptualization of the events and processes described in this paper has taken place over many years. With all authors based in different geographical locations, recent workshops in relation to the work in West Africa were used to discuss the processes and events leading to the acceleration of scale and scope of implementation. The ideas around networks of networks, and more specifically how these meta-networks emerge, can thus be said to be greatly facilitated by these networks themselves, as they brought together the range of perspectives that shaped our understanding.

3. THEORETICAL CONCEPTS

In this section we *briefly* present some theoretical concepts that are useful for analyzing the networks of networks. Again, we draw on the research by Braa, Monteiro, and Sahay (2004), discussing and describing the growth of the HISP project into a network. The network was already then heavily engaged in the real world politics of competing agendas. Being involved in the development of national health information systems in India and several African countries, HISP was everywhere caught in the cross-fire of different political interests, as donors, health programs and health authorities would all pursue their own interests. The political context of competing agendas was played out very much as the issue of which network will end up dominating the others. In this context, Castells' (1996) analysis of the constitution, logic, and dynamics of networks was used to formulate the agenda of HISP, which was working in several countries, as the making and growth of networks. Furthermore, it was used to pose the questions such as whose networks are these, and who gets included or marginalized by certain dynamics.

Building on this theorizing, in this paper we outline and discuss the concepts and values of an approach that we term "networks of networks of action." Networks of networks are qualitatively different than singular networks. The difference is surely not in linear terms and based on numbers (of networks), but in qualitative terms based on the substantive interests and roles of the networks.

A network is a relatively loose construction consisting of individual, projects and organizations bound together and networked through a more or less shared agenda. For example, if we regard HISP as one network, other open source software groups working in health are also making up networks. Another such network consists of various projects and implementers related to the OpenMRS software. The Health Metrics Network (HMN) represents another typical network engaged in strengthening HIS in countries. While having their base formally located within WHO, a number of countries, organizations and individuals are being networked through the HMN and their activities. The notion of networks of networks is referring to the situation where such different networks are aligning their interests, or gravitating around an attractor, and forming exactly that; networks of networks.

To better understand how networks are being aligned and converged into networks of networks, we draw on the theories of complex adaptive systems (CAS). CAS is concerned with the dynamics with which complex systems, or networks in our case, evolve through adaptation. CAS are seen as being made up of semiautonomous agents with the inherent ability to change and adapt in response to other agents and to the environment (Holland 1995).

Of particular importance is to understand how order within such systems is created without a "designer", but rather emerges. Central to the emergence of orders are attractors; a limited range of possible states within which the system stabilizes. The simplest attractor is a single point (Braa et al. 2007; Eoyang 1996). Patterns exhibited during changes of complex systems are described as attractors, "which have the ability to concentrate activity around them, for example the sun. A

smaller planet that is attracted by two suns would have a more erratic path, being attracted at different stages of its orbit to each of the two suns." (Shaw 2009, page 28).

Orders emerge around attractors through various feedback mechanisms, and through path-dependent processes of many small steps that may end in lock-in situations (David 1986). A de facto, or emergent, standard, such as MS Windows or the QWERTY keyboard, is a typical example of an attractor. The use of "attractors for change" is recommended when seeking to bring about changes in areas where there is only moderate certainty and agreement (Plsek and Wilson 2001). More generally, attractors are useful as they help describing the stages of the evolution of systems (Butz, 1997).

Attractors then provide a focus on which the different networks can converge. In the case study, we discuss the SDMX-HD standard on interoperability and how it has evolved into a status of an attractor to which different networks are converging. As contrasted to a singular network, in a network of networks the forces of convergence (as well as divergence) are magnified allowing the attractor to take on even more significant roles.

Networks of networks heighten the nature of indeterminacy of processes and with it both potential and challenges to new efforts. When different networks are linked, new attractors may be created with potential to attract even others, as in the example of the SDMX-HD standard will show.

4. EMPIRICAL CASE – THE CONVERGENCE OF NETWORKS

4.1. Summary of events

While the story in this article is unfolding in West Africa, two of the networks involved are of global nature. The Health Metrics Network (HMN) at WHO, initiated in 2005 to strengthen HIS globally, developed a set of three steps to be followed by countries; assessment, develop strategic plan, and implementation. Important in this story is that 1) they selected Sierra Leone, in West Africa, as one of five pilot countries to generate knowledge about implementation processes, and 2) they developed the HMN Framework; an overall HIS architecture describing different building blocks, all of which feeding data into a pivotal integrated data repository, building on general data warehouse principles. For the pilot in Sierra Leone, HMN required an open source application filling the requirements of a data warehouse in the context of one of the poorest countries in the world, just recently emerging from civil war. Given these requirements, and the track records of the MS Office based DHIS v1 in other African countries, HMN chose to use the DHIS2 software, being developed by the HISP network, the second significant network in this story. Development of the web based and fully open source software DHIS2, started in 2004 and had in 2007 been implemented in pilots in India. During 2008-2009, the DHIS2 as well as the overall HIS in Sierra Leone developed into a best-practice project in West Africa, which was widely communicated by HMN as they approached the end of their first five years and needed to show results. Due to this, more countries in West Africa started to look into the DHIS2, with the Gambia as a first newcomer in 2009. International focus on interoperability led to a pilot setup of an integrated suite, starting in Sierra Leone, where the OpenMRS (medical records) and the iHRIS (human resource records) Open Source applications exported their aggregate data to DHIS2. At this point the West African Health Organisation (WAHO), the third significant network here, got interested. Their Human Resource department would like the member countries to use the iHRIS application, developed by the fourth network, Capacity*Plus,* who was in discussion with HISP, HMN, and Sierra Leone about iHRIS implementation there. WAHO started to use the fact that it was integrated with DHIS2 (by now well established as part of HMNs success in Sierra Leone) in their promotion of the use of iHRIS, which again was increasing the interest by countries to use the DHIS2.

4.2. Presentation of the networks

The Health Information Systems Programme (HISP)[4] is a loose network of universities, developers, implementing agencies, and individuals. Many nodes are formalized around certain budgeted activities, such as implementation of DHIS in a country, or managing programs of higher education at universities. The main activities are software development of DHIS, both v1 (South Africa) and v2 (distributed, coordinated from Norway), research, education at Master and PhD level in several countries, and HIS strengthening.

The Health Metrics Network[5] is based at the WHO headquarters in Geneva, Switzerland, and was established by this organization to strengthen HIS in countries. It has since 2005 supported more than 60 countries in doing HIS assessments, half of those leading to strategic plans for HIS strengthening, and been an important voice in advocating for investment in integrated information systems assisting monitoring and evaluation of the health systems as a whole in several seminal conferences and workshops.

WAHO, the West African Health Organization[6], was officially created in 1998 as a health division of ECOWAS, the organization for political and economic integration and cooperation of West Africa. It consists of 15 member countries; 2 lusophone, 5 anglophone, and 8 francophone, and is mainly self-funded through regional import taxation. This makes it independent from changes in donor priorities, often a huge problem for national health initiatives. Being a fairly young organization operating in a landscape of shifting political stability, WAHO is still building capacity to help countries improve their health systems and meet the challenge of an increasingly integrated and mobile population.

Capacity*Plus*[7] is a donor/project-driven network; the USAID-funded global project uniquely focused on the health workforce needed to achieve the Millennium Development Goals. CapacityPlus helps partner countries achieve significant progress in addressing the health worker crisis while also having global impact through alliances with multilateral organizations. The project builds on the accomplishments of the Capacity Project, which worked in 47 countries.

The table below shows some important features of the networks in this study.

	HISP	WAHO	HMN	Capacity*Plus*
Main activities	Research and implementation of HIS, specifically DHIS2, an open source HMIS platform	Guiding member states with policies, capacity building (workshops), and technical support	Assist countries in doing HIS assessments and make strategic plans. Standard setting and advocacy for HIS investment	Build country HRH capacity; strengthen health workforce information
Base of legitimacy	Scientific, sustainable and participatory approaches. Capacity building in implementing countries. Proven success. Members from implementing countries.	Ownership and self-financing from member states (15). Health arm of ECOWAS, political support. Proximity and personal relations with key actors	Framework and Standards for HIS becoming both de facto and de jure standard. Partnership with WHO, professional for over 50 years.	USAID flagship global project for HRH, open source iHRIS software becoming reference implementation
Important actors in	Universities, HIS	Ministries of Health,	WHO, global actors	USAID,

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[4] www.hisp.uio.no/

[5] www.healthmetricsnetwork.org

[6] www.wahooas.org

[7] www.capacityplus.org

network	units in ministries of health, distributed development centres.	Donor organizations, ECOWAS political umbrella	like Global Fund, UNAIDS, CDC Other collaboration centres and initiatives	IntraHealth, TRG, Abt, LATH, IMA – formal partners, many regional and country HIS partners
Table 1. Presentation of the networks				

4.3. The first attractor – Creating a success story

As mentioned, the first two networks to come together were HMN and HISP, collaborating on the implementation of a data warehouse at national and district level in Sierra Leone from late 2007. HMN had signed a letter of agreement with the Ministry of Health and Sanitation, forming a relationship at the highest political level, while HISP was contracted as an implementing partner largely working with the national HIS unit and in the districts. In early 2008, four out of 13 districts were selected to pilot the new data warehouse, and substantial efforts were laid down to train district staff in using the application to collect, process, analyse, and use health information. By the start of 2009, the data warehouse had been implemented in the rest of the country. Consolidation of the implementation took place throughout the following year, with steadily increasing data reporting rates, and a few districts beginning to see results on health indicators from their use of information for planning. This was capitalized on by HMN, who sent an information officer to write up a story about the emerging success (HMN 2009a). The HMN secretariat also reported to the board, in October that year, "Sierra Leone's example of demonstrating the performance and utility of the information produced by the DHIS is a best practice that must be shared with other countries" (HMN 2009b, p 13). HMN was facing increasing pressure to document and disseminate results as their main financial grant was coming to an end. They had achieved much less success in their other pilot countries, reflected in the amount of weekly information bulletins distributed to around one thousand readers globally over the last 2 years; 3 on Sierra Leone, and 1 on another country building on the lessons from Sierra Leone, compared to 3 from the other four pilot countries combined[8]. HMN needed a success, and it was found in Sierra Leone. The country in turn dominated the HMN Results Report, summing up the achievements of HMNs investment in country support (HMN 2010b).

The success of the new system in Sierra Leone was real. In 2009 a review of the current data reporting forms in Sierra Leone was done, and a harmonized, reduced, set of forms were implemented from 2010 (for a discussion on these processes, see REF comparative paper). The fairly instant improvements in data reporting rates were received positively by a domestic network of health development partners, consisting of the main donors and NGOs active in the country, including WHO, UNICEF, JICA, IRC, CARE etc. By late 2009, several of them agreed to rely on the national data warehouse for their reporting needs, thus discontinuing parallel information systems, and they were included in subsequent workshops to build capacity in the use of the system. In 2010 then, with the introduction of the latest generation of harmonized reporting forms, the system was acknowledged as the national HIS when it was decided that it, and only that system, would be used to track and evaluate a major initiative to offer free mother and child health care, a program funded by a major donor and in which the president put his prestige. These events undoubtedly represent a huge success, though there still are challenges as expected from such a long-term process to sustainably change a whole set of institutions. The important issue here is that HMN made this success *visible*, by using it for advocacy, self-legitimacy, and fund raising at

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[8] See http://www.who.int/healthmetrics/news/weekly_highlights/en/index.html for all bulletins

the global level. An example had been pushed forward, and an attractor for other countries in the region had been created. This would grow to be a major force for bringing the networks together.

4.4. The second attractor – Interoperability enabling modular architecture

In late 2009, WHO had initiated a process to develop a data exchange standard for health metadata and statistics, building on an existing standard for financial transactions. This new protocol, SDMX-HD[9], was still not implemented by any application, far less in any real use-case setting by early 2010. Nevertheless, HMN and HISP decided to push this forward with implementation in Sierra Leone of a system that could both track patients on Anti-Retroviral Therapy (ART), and share this data with the data warehouse running on DHIS2, as stipulated in the original strategic plan for the country. OpenMRS, a medical record application, was set up in the main hospital, and in the weeks before this took place in February 2010, major advancements were made to SDMX-HD, spurred by the fact it was now implemented in two applications. The main idea is that OpenMRS has the functionalities needed for doctors and nurses to track patients over time, while the aggregate data from this system is used for general health management at hospital, district, and national level. This two-level use applies to other domains and applications also, such as logistics management, human resource management, lab systems, health finances etc. With SDMX-HD set to go live in Sierra Leone at a given date, developers behind DHIS2 and OpenMRS not only pushed development forward by implementing this standard in the respective applications, they also contributed the necessary use-case to solve outstanding issues.

The development of SDMX-HD made an HIS architecture of various applications for different business domains a reality, through a standard developed and promoted by WHO. Anyone able to share data on this protocol could now be "plugged in" in a country HIS. In addition, this important step was clearly associated with Sierra Leone, a fact which greatly spread the knowledge about the ongoing activities there. These two facts combined; the interoperability being possible and backed by WHO, and that it was seen as growing out of the Sierra Leone implementation, spurred further events.

While HMN and HISP were collaborating in Sierra Leone, Capacity*Plus,* a partner of HISP and HMN specializing in strengthening health workforce information systems, was partnering with WAHO to pilot open source HRIS software in Ghana.

In May 2010, fairly short after the first implementation of the simple interoperable architecture with DHIS2 and OpenMRS in Sierra Leone, WAHO presented the results of the Ghana pilot to the human resource and IS leadership of countries in the ECOWAS region. Capacity*Plus* participated in the meeting and encouraged WAHO to invite the participation of HMN to discuss the planned expansion of the "Sierra Leone architecture" also with iHRIS, their suite of applications for human resource (HR) management. Since iHRIS was also implementing the SDMX-HD standard, aggregated data could be shared with DHIS2. Many of the participating countries planning implementation of iHRIS were by now also planning implementation of DHIS2, and WAHO, HMN, and Capacity*Plus* decided to host a joint workshop to offer training in both, and quickly included HISP and WHO in the planning.

With a tight schedule, the workshop being planned for September 2010, things moved fast. The prospect of demonstrating interoperability with DHIS2, which was attracting considerable interest in the region due to the Sierra Leone implementation being pushed as a big HMN success, led Capacity*Plus* to finalize SDMX-HD compatibility of iHRIS. WHO also sponsored lead developers to join, for a second "Connectathon", the first of which was the initiation of work on SDMX-HD the previous year. Present were also organizations of other applications planning the implementation of SDMX-HD compatibility. At the end of the workshop, interoperability of DHIS2, iHRIS, OpenMRS, and the WHO Indicator Measurement Registry (IMR), was officially

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[9] see www.sdmx-hd.org

launched, with one WHO representative pointing out the appropriateness of this taking place among countries adopting the standard-supporting applications.

During the workshop, several countries made more formal request to HISP, HMN and Capacity*Plus* representatives there for support of implementation of DHIS2 and iHRIS. WAHO was already supporting iHRIS implementation, and invited HISP, Capacity*Plus*, and HMN to the first annual WAHO HIS strengthening workshop and Partner's Forum in November the same year, where HIS staff from all 15 WAHO member states were present. There, it was decided that HMN, WAHO, HISP, and Capacity*Plus* should collaborate to develop a centre of excellence at WAHO for supporting member countries in adopting the interoperable solutions which had grown out of Sierra Leone.

5. DISCUSSION

In this section, we would like to highlight two key aspects drawing upon the case study presented. The first concerns the synergies that have emerged from the creation of networks of networks. The second concerns our reflections on the strategies – formal and informal – that have helped enable these synergies.

5.1. The synergies emerging from networks of networks

In simple terms, synergies can be understood as the value added effects that arise when two or more singular events or parties come together (1+1>2), and in this process both events and parties benefit mutually. Through the case described, we can discern several kinds of synergistic effects from the creation of networks of networks.

Often health information systems implementations are impeded by the lack of political legitimacy from the multiple levels (global to local) that are needed to make them work. Local field efforts while building user level legitimacy run into roadblocks while trying to scale because they have not obtained the buy in from the national level. The HISP network for many years focused on small scale pilots, for example two districts in Cuba, which never scaled because of the lack of legitimacy of the central unit in Havana (Sæbø and Titlestad 2004). Similarly, often national level efforts require the endorsement of global actors like the WHO and HMN. For example, the routine immunization system in India could be mandated to every district in the country because it had the legitimacy of WHO behind it. Any one group of actors cannot come with the legitimacies representing these different levels, and fundamentally requires networking that creates such legitimacies and visibility that mutually feed on each other.

For example, in our case, HMN with its global legitimacy derived from its WHO links opened the possibility of the HISP network to work on the ground in Sierra Leone which again helped to create local legitimacy through the successes achieved. This success was important and used by HMN to showcase and enhance their own legitimacy, and of course both HISP and the country gained by showing what could be achieved in the most trying of conditions. The success was then spread to other countries in the region and then taken up by the WAHO network, leading to further invitations by them to support efforts of the WAHO countries. Creating and reinforcing such legitimacy at multi-levels, which becomes easily visible in the contemporary context with the help of the Internet and rapid movement of people, was a definite synergistic effort gained through the network of networks.

5.2. Self-reinforcing effects and the role of attractors

Attractors help to provide a consistent point of convergence which helps to bring a sense of order in a situation of relative chaos. Attractors can help to create self-reinforcing effects, where as events and people converge on the attractor, the legitimacy of the same gets reinforced which helps to attract more and create more order. And particular forces that converge to the attractor themselves gain in legitimacy and strength by aligning itself to the attractor. From the case, we discuss the role of two attractors that provided significant networked effects.

The first can be described as the "showcasing of the Sierra Leone success" in the country, the region and the global HMN. The HMN started with 5 countries including Sierra Leone in which they sought to demonstrate their interventions with respect to health systems strengthening. For various reasons, efforts in the other countries did not show much positive results (except in Belize, a country "adopted" as success story after the success had taken place), and it was only Sierra Leone where positive results were in evidence. HMN needed to show some success, and only Sierra Leone qualified to be described as one, leading to HMN declaring it as a success. With this, it became more of a success, making it an attractor, and more of a "political attractor."

We can further describe two "technical attractors", first in the form of the DHIS2 software application, and then as the SDMX-HD standard developed by the WHO to enable the interoperability of aggregate data. The HMN technical framework, established as a standard for country HIS integration and strengthening, included the establishment of a country data repository to manage aggregate data from various sub-systems. The DHIS2 was the data repository used in Sierra Leone, and when Sierra Leone was declared a success, implicitly DHIS2 was also. Furthermore, there were no other open source software applications of generic and shareable nature used in other countries, so DHIS2 emerged as a key technical attractor from the Sierra Leone case during 2008 and 2009. In 2010 the WHO project to develop the SDMX-HD standard for interchanging aggregate data was first implemented and tested to transfer data from OpenMRS and DHIS2 in one hospital in Sierra Leone. A few months later, in September 2010, the standard was officially launched at a WAHO workshop in Accra where the interoperability between DHIS2, iHRIS and OpenMRS was the case in question. The efforts to develop a standard for exchange of aggregate data had been ongoing in WHO for some time before without much success. But now that first the efforts in Sierra Leone had been initiated and had high visibility, it lead to a large focus on the workshop in Accra, and thereby to establish the SDMX-HD as a second technical attractor in this story. This time by bringing together the various networks of WHO, HMN, WAHO, iHRIS/Capacity*Plus*, OpenMRS and DHIS2/HISP, a strong and fundamental technical attractor was created.

The evolving of this second technical attractor has significant further implications – the positioning of an architecture over an individual system solution. Although the DHIS2 is what the countries want to implement first, the fact that DHIS2 is a central piece of a larger architecture, the first step of implementing the DHIS2 becomes more inviting for others to join, it is more inclusive. The iHRIS network wants to plug in to this architecture, thus furthering the networking effects. Sierra Leone themselves are keen to explore how other systems like for example logistics management can also plug into the architecture. In this architecture approach, we may say that whole networks are literally "plugged in" by being included in the architecture. At the global level, WHO will like to showcase the success with the standard they have developed and this may lead to other effects.

However, it is also important to note that while attractors can trigger of self-reinforcing effects, they themselves can be redefined with time, and with different meanings for the actors that have been attracted to it. For example, as the focus of HMN is becoming redefined from health information systems strengthening to vital events registration, the attractors described above – both technical and political – will not have its original meaning, and may need to be redefined to the new setting of vital events for it to be useful.

5.3. Strategies enabling these synergies

What have been the HISP strategies to enable such synergies? Strategies have not been formal or well planned and documented which all members are trying to follow. Yes, despite this, there has been a definite direction, a path in which constant movement has taken place. On reflecting over events say over the last 5 years or so, we can try to identify some key elements of our strategic effects.

Directional improvisation is a term we coin to describe the process of our movement. In her classic book "Plans and Situated Action," Suchman (2007) describes the differences in approaches of a European and Trukese navigator. While the former works by first creating a plan and then acts in relation to that, the Trukese has a vision of direction in place, and then takes advantage of the existing conditions (the wind, the waves, stars etc) to navigate the path. The HISP approach is akin to that of the Trukese, the broad direction (of wanting to create such enabling networks) is known, but the conditions –such as political support, available technologies, resources etc – are a product of the here and now which have to be acted upon with best effects.

To enable the above, we use the acronym of AAA. **A**wake means HISP tries to be present in situations where they perceive opportunities may arise. For example, being present in Dakar in the WAHO meeting provided the opportunity to network with 15 countries in one framework. **A**lert means to be alive to the different possibilities that exist given the conditions, and use the experience and understanding to make choices. **A**gile means the quality to act quickly and decisively, for example by being able to provide support to countries in the West African region that are in the process of implementing the DHIS2, such as Liberia, Ghana and Burkina Faso

The second element of the strategy can be seen as understanding and working towards the ***networking role of architectures***. Architectures are not only technical artefacts as is described by many of the technologists today. The important and neglected aspect of architectures is that it creates networking effects and with it the resulting synergies.

The interoperability SDMX-HD standard not only brings three technical systems (DHIS2, iHRIS and OpenMRS) together, but with it the surrounding networks and their further networks. Such networking provides then the pooling of interests, resources, and opens up strategies for scaling. Put differently, the architecture approach, made possible by shared standards, allows not only technical artefacts to be integrated (in our case software), but so also the networks that surround and support these artefacts.

An important and conscious aspect of the HISP effort is to see how different actors through networks can ***leverage complementarities***. In the WAHO-HISP relation for example, WAHO comes in with the strength of its political legitimacy and mandate to support the countries in the region. HISP has its legitimacy as a strong technical support group in HIS; with roots in the University of Oslo and educational processes. Through its networking, WAHO gains in strengthening its technical capacities, HISP strengthens its presence in the region, while simultaneously their original capacities are reinforced.

6. CONCLUSIONS

In this paper we have described synergies arising from the growth of networks of networks of HIS strengthening. While the benefits of such networks are many, the question arises as to how such networks of the second order can come to be. We argue that attractors of several domains play a large role, as well as an application architecture promoting the linking up of several networks. In this context, directional improvisation, a proactive use of flexibility, is useful for taking full advantage of the emerging momentum, as well as directing where the momentum will lead. As for replicability in other regions and for other domains, the position held by WAHO seems so far to yield the crucial level and positioning of legitimacy for HIS scaling and sustainability, a lesson hopefully applicable with similar regional political units.

Future research on this topic in general should focus on how such networks of networks can be leveraged to strengthen local capacity in developing countries, an area where this approach has much potential. Also, given that one of the major networks described, the HMN, has recently scaled down operations and changed strategic direction, the landscape of global legitimacy and support for HIS strengthening has changed. How such a change influence the dynamics of the processes described is yet to be addressed.

7. REFERENCES AND CITATIONS

AbouZahr, C, and Boerma, T, (2005) "Health information systems: the foundations of public health", in Bulletin of the World Health Organization 2005;83:578-583. http://www.who.int/bulletin/volumes/83/8/578.pdf

Avison, D., F. Lau, et al. (1999). "Action Research." Communications of the ACM **42**(1): 94-97.

Braa, J., Monteiro, E., and Sahay, S. (2004) "Networks of Action: Sustainable Health Information Systems Across Developing Countries" MIS Quarterly (28:3) 2004, PP 337-362

Braa, O., Hanseth, O., Heywood A, Shaw, V (2007) Developing health information system in developing countries: the flexible standards strategy. MIS Quarterly Vol 31 Special Issue August 2007

Butz, M. (1997), Chaos and complexity: implications for psychological theory and practice. Washington DC, CRC Press.

Castells, M. *The Rise of the Network Society*, Basil Blackwell, Oxford, 1996.

Chan, M (2007) Opening remarks at the Fourth Global Meeting of Heads of WHO Country Offices, November 12, 2007. Accessed March 4, 2011 http://www.who.int/dg/speeches/2007/20071112_geneva/en/

Checkland, P. and S. Holwell (1998). "Action Research: Its Nature and Validity." Systemic Practice and Action Research **11**(1): 9- 21

David, P. A., and Shurmer, M. (1996) "Formal Standards-Setting for Global Telecommunications and Information Services," *Telecommunications Policy* (20), 1996, pp. 789-815.

Engelstad, P., and Gustavsen, B. (1993) "Swedish Network Development for Implementing National Work Reform Strategy," *Human Relations* (46:2), February 1993, pp. 219-248.

Eoyang, G. (1996) "Complex? Yes! Adaptive? Well, maybe..." *Interactions* (3:1) , pp. 31-37.

HMN (2009a), "HMN focus" October 2009 issue, accessed November 28, 2010, http://www.who.int/healthmetrics/HMN_Oct09_newsletter_web_new.pdf

HMN (2009b) "Secretariat's Report to the Board" [B2009/13/3], in board proceedings for the 13th HMN Board Meeting, Geneva, 14-16 October 2009. accessed November 28, 2010, http://www.who.int/healthmetrics/HMN_13Board_Meeting_web1.pdf

HMN (2010a) "Better country data needed to assess progress towards health MDG targets", May 2010, accessed March 4, 2011 http://www.who.int/healthmetrics/news/weekly_highlights/MDG_targets_need_better_country_data/en/index.html,

HMN (2010b) "Results Report June 2010 – Building momentum and saving lives", accessed November 28, 2010, http://www.who.int/healthmetrics/news/HMN_Results_Report_2010_web.pdf

Holland, J. H. (1995) "Hidden Order - How Adaptation Builds Complexity*"*, Addison-Wesley, Reading, MA,

Plsek, P. E., and Wilson, T. "Complexity Science: Complexity, Leadership, and Management in Health Care Organisations,"
British Medical Journal (323), September 2001, pp. 746-749.

Shaw, V. (2009), A complexity Inspired approach to co-evolutionary hospital management information systems development. Case studies from the "South". Faculty of Mathematics and Natural Sciences, University of Oslo.

Suchman, L. (2007). "Human and Machine Reconfigurations: Plans and Situated Actions." Cambridge, Cambridge University Press.

Susman, G., and Evered, R. (1978) "An Assessment of the Scientific Merits of Action Research," Administrative Science Quarterly (23:4), pp. 582-603.

Sæbø, J., and Titlestad, O. (2004). "Evaluation of a Bottom-Up Action Research Project in a Centralised Setting: HISP in Cuba". Paper presented at the 37th Hawaii International Conference on System Sciences, Hawaii.

Sæbø, J., Kossi, E., Titlestad, O., Tohouri, R., Braa, J., (2011) "Comparing strategies to integrate health information systems following a data warehouse approach in four countries" Information Technology for Development, Volume 17, Issue 1, January 2011

Tierney, W. M., Kanter, A. S., Fraser, H.S.F, Bailey, C. (2008) "Establishing Partnerships to Promote eHealth in Developing Countries: Lessons from Africa", available from
http://ehealth-connection.org/files/conf-materials

WHO (2005) "Health and the Millennium Development Goals",
http://www.who.int/mdg/publications/mdg_report/en/

WHO (2007) "Everybody's business: Strengthening Health Systems to improve Health Outcomes: WHO's Framework for Action", Geneva

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Developing decentralised health information systems in developing countries –cases from Sierra Leone and Kenya

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Abstract:

Health service provision is a public concern that mostly takes place at community level, through primary health care. Using cases from Sierra Leone and Kenya, this study shows how country health information systems, producing simple information products such as quarterly bulletins and league tables being distributed widely, have enabled the communities to be engaged in improving the health status of the population. The community based information systems were part of a national system and the usefulness of comparing local data with data from other communities and from across the country in pursuing equity in health services provision is demonstrated. A community based information system is thus benefiting from being part of and integrated with the larger national system. The article presents and discusses community based participatory approaches to developing information systems which are enabling the community to take ownership and 'cultivate' culturally appropriate systems. Illustrated by the cases, the article argues that modern ICT and Internet based technologies, and even 'cloud' based infrastructures, are indeed appropriate technologies even at community level in rural Africa.

Introduction

The vast majority of communities in Africa, and in the developing world more generally, are plagued by poor health services and poor health status. Global efforts to improve this situation have recently gained momentum as part of the UN Millennium Development Goals (MDG) project, where three of the eight MDGs, MDGs 4 and 5 (reduce child and maternal mortality) and 6 (combat HIV/AIDS, malaria and other killer diseases), are health related. The MDGs are addressing the need for changes and improvements at the community level and can only be achieved through active community participation. Framed within the global efforts to improve health in poor communities, this article address the issue of community participation through strategies to engage the community level in the design and development of Health Information Systems (HIS). Without reliable information on current situation and trends in health status, it is not really possible to improve the situation, as one would not even know whether the MDGs are achieved or not. With only few years left until the 2015 deadline to achieve the MDGs, global agencies such as the WHO are giving considerable attention to efforts to develop efficient HIS to measure progress made towards achieving the health-related MDGs (see for example WHO 2011). In this article we present a case study on the development of the HIS in Sierra Leone, a project initiated and initially funded by the WHO/Health Metrics Network as a pilot for how a Least Developed Country could take advantage of modern ICT and develop their HIS despite very poor infrastructure.

Illustrated by a case study from Sierra Leone, this article addresses the issue of strategies for developing decentralised bottom-up HIS in developing countries more

generally, and for the development of community based HISs aiming at empowering local communities and their structures in particular. The project was following a community based participatory approach which we term 'cultivation' (Braa, Sahay, 2012) in contrast to 'construction'. Cultivation denotes a way of shaping technology that is fundamentally different from rational planning and engineering methods as it is based on the resources present in the local social system. Given the provision of technology components such as software, hardware and standards, the overall information system is regarded as something that grows into place, based on the potential in what is already present in the community. This community based approach is strongly linked to the central role given to community participation in the WHO's Primary Health Care (PHC) approach (WHO, 1978), which requires and promotes maximum community trust in the system and participation in developing and running the health services

In terms of information systems and technology, the project has applied a strategy of integrating various smaller subsystems into a data warehouse. The resulting integrated data warehouse includes information of different types, such as data on health services, health statuses and demographic surveys needed to address equity in health services provision and health status and thereby the needs of disadvantaged communities. Important in this context is that striving for equity between poor and rich geographical areas and population groups will require an HIS that, for core components, is shared across a country, state or region to measure and monitor the extent to which equity is being achieved and to pinpoint areas where more resources and efforts are needed. Thus, for an HIS to best address the needs of local communities, it will need to be an integrated part of a larger area HIS framework.

This paradox, that locally based HISs that are addressing the needs of communities need to be part of something bigger in order to be useful, will be described and discussed in this paper using the case study from Sierra Leone. Important in this context is that Sierra Leone is a small West African country ravaged by a civil war in late 1990s. It is one of the poorest countries in the world and was ranked 180th out off 182 in UNDP Human Development Index report in 2009 (UNDP 2009). In order to complement the case study from Sierra Leone, where the infrastructure is still poor, with cutting edge infrastructure development currently being established in some parts of Africa, we give a brief description of an HIS implementation in Kenya, which is similar in content and aim but different in the infrastructure used. In Kenya the system is implemented using one central server and "cloud infrastructure" using Internet over the mobile network. While in Sierra Leone the traditional Chiefdom structure is using the HIS to address equity and document their demands for improved health services, in Kenya the significant issue is that improved Internet and mobile telephone infrastructure is enabling the community level to get access to their own information and to analyse and to disseminate it within a larger framework, and thereby, potentially, to be better able to address their demands.

The research presented in this article has been part of the Health Information Systems Program (HISP) research network, which started in South Africa in the 90's and has since then been engaged in action research, participatory design and open source software development in a number of developing countries (Braa et al. 2007). The development and application of the free and open source software called District Health Information Software 2 (DHIS2) as a joint collaborative effort across countries

and institutions have been an important part of the research in the HISP network. Development in both Sierra Leone and Kenya is based on the DHIS2.

This article will proceed as follows; the next section will provide some background on related research, then we will present the methods applied, before describing the case of Sierra Leone. Thereafter, the case and its implications are discussed using "snippets" from the Kenya case before the conclusion is finally reached.

Background

Trends in global health and the HISP project

The recent years have seen an increasing focus on HIS as important for effective and efficient health systems, especially in developing countries. The international community has also emphasized the need for better HIS to track the MDGs, and several initiatives have been set up to tackle the challenge. In 2005, the Health Metrics Network was created as "the first global partnership dedicated to strengthening national health information systems" (HMN 2005). At the same time, many of the challenges countries face with their HIS come from fragmented systems propagated by the diverse international organizations supporting them, leading HMN to become a strong advocate for the building of national HIS integrating data from the various health services and health programs as well as from various donor initiatives. Following the HMN initiative, many developing countries are in the process of strengthening and revamping their national HIS. On the ground, however, HIS development in developing countries has proved difficult due to organisational complexity, fragmented and uncoordinated organizational structures due to similarly uncoordinated donor initiatives all maintaining their own HIS (Braa et al. 2007), unrealistic ambitions leading to a "design-reality gap" (Heeks 2002), and more generally, due to the problem of sustainability (Kimaro and Nhampossa 2005, Sahay et al. 2000).

National HIS are including aggregate statistical data of various types from health services and the population served by these services. The primary aim of these information systems has, until recently, been to provide health management and service providers at all levels of the health services with timely and accurate data, based on which, for instance, resources can be allocated and epidemics can be monitored. As part of the HMN approach (HMN 2008), however, dissemination of information to community and political structures, media and the general public has been advocated as an equally important objective for national HIS, as a way to promote health advocacy, transparency, democracy and good governance. Following this, the HMN recommends countries to include free access to health information in their national legislation.

Communities, widely speaking, will have their interest linked to this latter outwards reaching aspects of the HIS. In this perspective, organized community structures will use information from HIS in their efforts to improve health services and for development of their communities more generally. The community is generally seen as a key level for social development in developing countries. Such development will rely upon community participation in decision-making for social development at the local level (Midgley 1986). Community based participatory design (Braa, 1996,

Byrne, Sahay, 2006) is extending this perspective of social development to the field of information systems and the tradition of participatory design. Community based participatory design in health care in developing countries will most often refer to the design of systems for community health workers, or systems to support various outreach health services in the communities. In this article, however, we will use the term community participatory design in a much broader sense to address the design and development of systems aiming to serve and support the whole community, the organised community structures as well as the general population in the community. Furthermore, these systems are also addressing the needs of the health workers working in and for the community. In this way our perspective on community informatics is in line with de Moor and De Cindio (2007), who are arguing that the requirements for such systems are fuzzy and, as with the supporting ICT, in a constant state of flux.

The case studies from Sierra Leone and Kenya presented in this article are both reporting from development of HIS and software carried out within the HISP network. HISP started in three pilot districts in Cape Town at the advent of democracy in South Africa in 1994/95, as part of the new government's reconstruction and development program. Equity in service delivery and uplifting of those who had suffered during Apartheid, and the creation of a decentralised health system based on districts, were key objectives in the reform process. The role of HISP in this period was to identify information needs and to engage the community of end users and local management structures in the process of developing new health information systems supporting the decentralisation (see Braa, Hedberg, 2002, Braa et al. 2004).

It is important to note that the original key members of the HISP team in South Africa had background as social/political activists in the antiapartheid struggle and other social movements, or they had background from the Scandinavian participatory tradition. As a consequence of the background of the team members and the political context of South Africa during these formative years, HISP activists have always explicitly and implicitly seen themselves as political actors in a larger development process.

HISP, participatory design and the community based cultivation approach

The HISP participatory approach to action research and information systems design was initially influenced by the so-called Scandinavian tradition: a number of union-based action research projects carried out in Scandinavia during the 1970s and 1980s. The focus in the earlier participatory design projects was on empowering workers, who were affected or threatened by new technology, by exploring ways in which their influence over technological solutions could be ensured (Sandberg, 1979; Bjerknes et al., 1987). Later projects focused on more instrumental design issues and shifted toward producing technological alternatives by involving workers in cooperative design at the workplace (Greenbaum & Kyng, 1991). Adaptation of information systems to the local context, local empowerment through participation and practical learning, and the creation of local ownership through participative processes are central issues in the Scandinavian tradition, which, despite the differences in context, have been adapted to the contexts in Africa and Asia through action research in HISP.

The community based participatory approach to the design and development of information systems in developing countries developed within HISP may best be understood through the concept of 'cultivation'.

The concept of cultivation (Braa, Sahay, 2012), in contrast to construction, denotes a way of shaping technology that is fundamentally different from rational planning, engineering methods and the construction of technology. Cultivation is about interfering with, supporting and controlling natural organic processes that are in material; as the seeds sprout, they must be provided with proper cultivation; the soil must be prepared and the saplings cared for and nourished. The term cultivation covers these processes, and in our case, adapting the principles, tools and basic set-ups of the health information system, and then helps them grow into place within the local social system of work practices, culture and technologies, through processes of learning. The health information system being cultivated in this way may thus be regarded as a socio-technical system, or an organism, with a life of its own, with its ability to learn and grow. The spread of technology is therefore better understood as a process of technology learning, rather than 'technology transfer'. Technology, like institutions, is also shaped through such processes of learning and growing into place. Methodologically, cultivation is characterised by incremental and evolutionary approaches, described in terms of 'piecemeal engineering'.

The DHIS software

The key "organising" element in the HISP network has been the continuous and longitudinal development and application of the open source software platform called DHIS - District Health Information System. The DHIS is a software tool for collection, validation, analysis, and presentation of aggregate statistical data, tailored to support integrated health information management activities, but it can also be adapted to serve other areas. It is designed to serve as a district based country data warehouse to address both local and national needs. DHIS is a generic tool rather than a pre-configured database application, with an open meta-data model and a flexible user interface that allows the user to design the contents of a specific information system without the need for programming. The DHIS is developed to serve as a flexible tool in what is described as a cultivation approach above. The software is flexible and it can be easily tailored to particular needs and requirements.

DHIS development has evolved over two versions. The first – DHIS v1 – was developed since 1997 by HISP in South Africa on MS Access, a platform selected because it was, at that time, a de facto standard in South Africa. The second – DHIS v2 – is a modular web-based software package built with free and open source Java frameworks, continuously developed since 2004 and coordinated by the University of Oslo.

Methodology

This paper primarily describes a case from an ongoing action research project in Sierra Leone that the authors are engaged in. Action research is a form of participative research where the researcher takes part in the change processes in an organization, actively trying to improve some stated problem (Checkland and Holwell 1998; Avison, Lau et al. 1999), in this case, the poor provision of health services throughout Sierra Leone, in particular, at community level. Our research, then, centres on

understanding the processes at work, while at the same time using this understanding to improve the current situation.

We are all, to various extents and changing over time, immersed in change-processes and working closely with the owners of the problems we try to solve. As such, we are involved in open-ended and continuous phases of design, development, implementation, and evaluation of interventions, with a stated aim at improving some given subject, as according to principles of action research (Susman and Evered, 1978). The authors of this paper have thus participated in most of the events described in the case description later.

Three of the authors have been involved in the project in Sierra Leone on an on-and-off basis, spending considerable time in the country through many visits of up to 2 months. The fourth author is a formal employee of the project and a national of Sierra Leone, working in the Ministry of Health there for the last 4 years. The fifth author is working in the Ministry of Health in Kenya and played a leading role in the project in Kenya, where also the third author participated.

The project started in 2006, with the authors given a mandate to improve data management through the establishment of an integrated data warehouse and build institutional capacity for data analysis. The background for this was a situation of fragmented data streams, duplication of data collection, and little use of information from community to national levels. The research approach was thus solution-oriented, without a clear formulation of hypothesis beforehand. Rather, the research part of the project was focused on the interaction between technology, organization, and community through a participative cultivation approach in reaching the above mandate. Over several engagements, research questions were formulated to help with the various practical challenges that would emerge. Central to these were the following two interrelated challenges, 1) to cultivate the system at local level in order to become relevant and useful to the local community, and 2) 'scaling' the system to multiple communities in order to ensure that local decision makers had access to not only their own, but data from across the country to allow for comparison and evaluation. Within the larger combined research area, local cultivation and scaling, research questions were open-ended and dynamic.

Over these years, all authors, apart from our co-author from the Ministry of Health in Kenya, have been repeatedly travelling through Sierra Leone, engaging in participatory design of software and data reporting forms, and training in the use of these. Furthermore, we have been actively engaged in promoting information use at all levels through preparing for and participating in review meetings.

The primary mode of engagement has been capacity building, at all levels. This has taken place not only as formal training workshops, but also as on-site training at district levels and in relation to national and district review meetings. These training sessions have all been used in the development process to include the users by getting feedback and inputs from them on how the system could be made more appropriate and relevant for them. Training has also been used to foster a culture of information use by discussing how districts could engage with their communities to improve health services. Thus it is fair to say that a clear-cut division between training and participative development, and research for that sake, did not exist.

In 2008, a three-week training for national and district staff was carried out, focusing on computer use (a large proportion was computer illiterate at the time), using the data warehouse application, and analysing data from an epidemiological point of view. All districts have later been given additional on-site training during their day-to-day work. Refresher trainings have been held when district supervisors were visiting the districts, and also as joint workshops for all districts. Training has also been an arena to engage with other actors; a workshop was held for representatives from international NGOs to look at their information needs and how they could get this information from the new system. All trainings were semi-structured, trying to promote informal discussions with the participants.

In addition, more quantitative research methods were employed, especially in relation to data analysis. Health data would be processed and analyzed to prepare for review meetings, both in relation to actual use of the data for health management, and for assessing data quality and areas of potential redesign of the reporting forms. For this we used two key data collection forms, for which we had data from most of the country's around 1000 health clinics. Data since 2008 were included in this work.

Kenya represents another action research project that is related to Sierra Leone in terms of technology, goals, strategy, and people involved. The same methodology has been applied in Kenya though the Sierra Leone involvement spanned more than 4 years compared to the about one and a half year research and implementation that took place in Kenya.

Community participation: the case of HIS development and use in Sierra Leone

This paper builds on events related to reforming the health information systems in Sierra Leone in the period 2006-2011; a process that is still ongoing. Sierra Leone is a small country in West Africa, with approximately 5 million inhabitants, and has, as recently as 2001, come out of a decade-long civil war. Picture 1 shows the innovative data collection tool for illiterate community health assistants, representing both the sorry state of the country and how this is often solved locally in communities. With this background, many international organizations have been present in the rebuilding efforts, and in 2006 Sierra Leone was selected along with a few other countries to be a "wave one" country by the Health Metrics Network (HMN), a Geneva-based partnership with the World Health Organization (WHO). This spurred the events described in this document, of which there have been many participants, from the local clinics and district health

Picture 1: Simple but genius data collection tool for illiterates, where stones are put into boxes representing outcomes of births.

offices, to national authorities, NGOs and donors in-country, international organizations like WHO and HMN, universities, and other regional actors like the West African Health Organization.

Summary of events

The case is a longitudinal action research project spanning many years, and a full description of the process is beyond the scope of this paper, though a short summary is useful to put the discussion in context. First, from 2007, the HMN-led project focused on introducing software to handle aggregate health information from health facilities, with two early goals: geographical coverage of all 13 districts in the country, and content coverage by including as many monthly reporting forms in the software as possible. For this the HISP group was engaged for implementing a data warehouse, using the DHIS2 software, and build capacity related to this at national and district level. The first two years were thus about piloting and rolling out this software, with the majority of effort going into capacity building. Once geographical coverage had been achieved, the utility of the data increased, and expansion in this phase (2009-10) shifted towards creating the demand for the information, including capacity building at national level and for NGOs, as well as development of information products and active dissemination of both these and the processes behind making them. It was in this phase that information use at the community level became a priority, which will be described below.

System development

In order to design or customize DHIS2 as an integrated data warehouse (IDW) that fit Sierra Leone, a technical team was established. The team was composed of HISP members, Monitoring and Evaluation (M&E) officers at national level and district levels, M&E officers from health programs, IT technicians, public health officers, and health workers. However, prior to the technical team creation, DHIS2 experts from HISP had created a prototype of the IDW showing how different data sources can be integrated together and enable a cross data analysis that would generate more meaningful information. The prototype contained the hierarchy of organisational units as given by the MoH: National level → districts → local councils → health facilities. This geographical and hierarchical representation of the HIS matches with the MoH structures and channels of data reporting and use. In addition to this hierarchy, data from three different sources were integrated: namely population data, Extended Program for Immunization (EPI) and human resource data. Data available from 2005 was imported by district into the system for three reasons: show how data from different sources could be integrated, have data to perform training of the software with, and to give a base for comparing newly entered data. At that time, the system was able to generate automatically health worker distribution per population and per district. It was the first time such a graph was available from one system in Sierra Leone. This is shown in Figure 1 below. The prototype was purposefully designed to help stakeholders at different levels understand what an IDW is and thus enable their active participation. Having seen the potentials of this solution, the first concern of districts M&E officers was to be able to generate health information out of the system by chiefdom, local councils and health facilities. While generating health information and feedback reports by health facilities is obvious because data is captured by health facilities, there emerged a challenge to represent another sub-district level, the chiefdom. If health facilities can fit into chiefdoms and local councils, the hierarchical

relationship between local councils and chiefdoms is not one "parent" to one or many "children". Local councils are hierarchically above chiefdoms but one chiefdom can belong to two local councils. The representation of such complex hierarchical relationship is not straightforward in the DHIS2 hierarchy logic. However, the participation of district M&E officers helped us understand their needs better and we used alternative hierarchies in DHIS2 to represent both local councils and chiefdoms.

Through this participatory process we gradually integrated different data sources – HIV/AIDS, reproductive health, maternal and child health etc – and defined required indicators as well as feedback reports that would be used at different levels of the health system. Awareness meetings with local councils and other local stakeholders were conducted as part of this process.
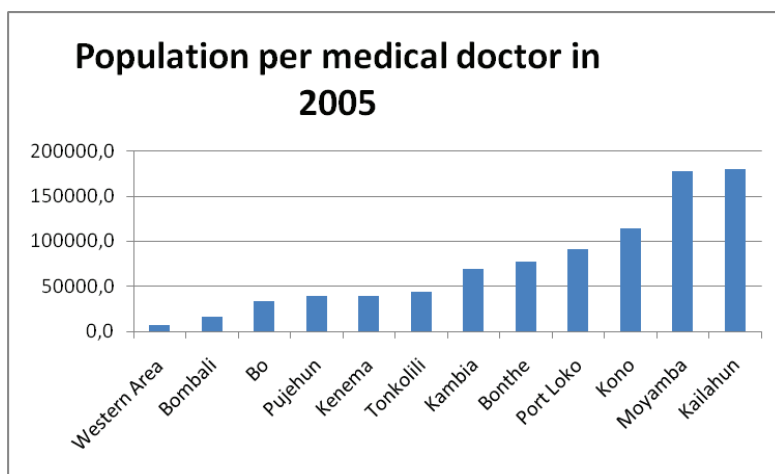

Figure 1: Population per medical doctor and per district

The initial customization described above took place within a training framework so that the core national team was trained to learn the software which enabled them to participate in the customization. Training of the larger group of users, district information officers, health program M&E officers, and the like, was then initiated and has been a core focus for the project.

While the software DHIS2 was the natural subject of training, it was also a platform to cover issues such as data quality, analysis, and general epidemiology to decide what kind of data was important and what kind of information products should be created. From the onset of the project, a three-week intensive course was held for all district M&E officers, with the aim of preparing them as independent teams for districts, able to work closely with communities and civil society in processing and disseminating relevant data. This was also used to foster local participation, as the training was used to discuss information needs, problems with data quality, and how they saw the new system as being representative of their needs. The developers of the software participated at this training, and discussions about functionality with district staff provided important input to the development process. Many new functionalities in DHIS2, for instance reporting on data completeness, originated from this training.

A second phase of training took place at the local level around the country. In relation to installation of hardware and software in the districts, training was given on-site to M&E officers, and supervisory visits that were carried out regularly also included re-training. In these sessions, the core team would sit with only 2-3 people, focusing on the information cycle from collecting data (at facilities and district offices), processing it (in relation to planned monthly review meetings), presenting and analyzing it and making action plans (at the review meetings with participation from facilities and civil society).

Infrastructure and HIS architecture

The civil war that ended in 2002 had destroyed many infrastructures and when full-scale implementation started in 2008, roads, power supply, and internet availability were still major problems. Internet availability was very limited both in the capital and in the upcountry. The main source of power supply was generators, and getting power from the national grid was incidental. These settings made running a computerized information system very challenging. In addition to these infrastructural challenges, lessons learned from the implementation of software in 2007 showed that keeping the computers virus free and up and running was not trivial. The lack of connectivity made it difficult to update antivirus software in the districts, and consequently the entire MS Access based database was often corrupted or destroyed by viruses. Moreover, when district health offices called local IT service providers for troubleshooting, the solution they often offered was to format the computer without regard to the existing data.

Being mindful of the issues mentioned above, and keeping in mind that DHIS2 is a web based system, a decision was made to go for a replication of instances of the system in every district. In each district a local server, one client computer and a local area network were thus deployed. Both the local server and the client computer were low power based and able to run on car battery that can be charged with solar panel or a generator – when there is fuel to run it. The operating system (OS) adopted was Ubuntu Linux to make sure that they will be less sensitive to virus and thus not rely on inadequate local IT support service. However, existing computers running MS Windows OS were also included in the network as clients. So while the local server is Linux based and runs DHIS2, client computers in the local network area can access the same system and work collaboratively on the same database even if they have different operating systems. This networking aspect of the settings was quite useful for district people because they could now work from different computers on the same database. At the national level DHIS2 was also installed on a server running the same Ubuntu Linux OS. A local area network was also set up within the MoH to enable access to DHIS2 within the MoH.

At the end of every month, district M&E officers are supposed to capture data coming from health facilities within their district, generate an export file from DHIS2 and send it to the national level. The export file is sent via email when internet is available or very often in person on a USB pen drive. At the national level the administrator of the system collect the district export files and import them into the national instance of DHIS2.

On the one hand, although this organization and these procedures look more appropriate to the context, it was very challenging to maintain and keep updated all the local instances of DHIS2. For instance, any changes to the metadata in the national database have to be replicated in all other instances to keep them compatible. Obviously this requires travelling to all the 13 districts on poor roads.

On the other hand the low power computers were not very strong and parts had to be changed because of various failures in the warm, humid, and dusty environment. Fortunately, as the government was investing in infrastructure, power supply improved and the system moved gradually from low power computers to regular ones. However, despite the progress in road construction and power supply, internet availability and reliability is still weak and hampering the shift from distributed instances to one central server.

Information use

As the use of the new data warehouse was maturing, work began to start utilizing the data it produced. This is, of course, the reason for the introduction of the system in the first place, but it is also a strategy to improve data quality, as only by use and self-interest in the data the quality would come under scrutiny and new solutions be proposed. The project thus initiated the use of quarterly bulletins, a modest 4-page leaflet comparing all districts on a handful of health indicators, as well as some indicators on data quality. The first bulletin was released in May 2009 and disseminated widely, including all districts and members of a group of international health partners (WHO, World Bank, DFID, etc.).

Picture 2: the front page of a quaterly bulletin in Sierra Leone

The bulletin contained charts derived from DHIS2, ranking the districts from worst to best performers. Picture 2 shows the front page of one bulletin. While the data was of dubious quality, based on partly incomplete data, the effect was at least to start discussions about how to improve it. Shortly after, data reporting increased significantly, so that the next bulletin had more complete data.

In addition to the bulletin, a league table was developed, in which a few key indicators were used to give each district an overall score, ranking them based on data quality, institutional delivery rate, immunization rate, antenatal care coverage and the like. This league table was presented at the annual review meeting at the Ministry of Health, with participants from all districts. The league table raised much discussion especially in relation to a few indicators that had much variation among the districts. One such example is institutional delivery rate, an indicator directly linked to the Millenium Development Goals about maternal and child health.'

The development of the bulletin and league tables were initiated at the national level. The selection of indicators to include was based on relation to the MDGs, and data quality, such as institutional delivery rate (linked to infant and maternal health), and reporting rates of the main data collection forms that contained this data. Since the data completeness was an issue, only indicators for which there would be adequate data available were included.

In 2009 Western Area (mostly consisting of the capital Freetown) was one of the districts scoring very low in term of institutional deliveries. Being very concerned by the poor performance of his district, the District Medical Officer (DMO) in Western Area decided on two strategies to improve. First, to collaborate with private facilities (of which the district has many more than rural districts) to get their data on institutional deliveries, and second, to release a note in the newspaper informing the public that maternal and child health care was now to be free of charge in Western Area district. As shown in the Figure 2 below, institutional deliveries have increased steadily in the district. The free maternal health care policy could not alone explain this increase, the involvement of private facilities has to be taken into account, but in any case the results are remarkable and were soon distributed globally by the Health Metrics Network as a strong case for investing in health information systems. The new figures in turn help them plan well and advocate for adequate resources for the district.
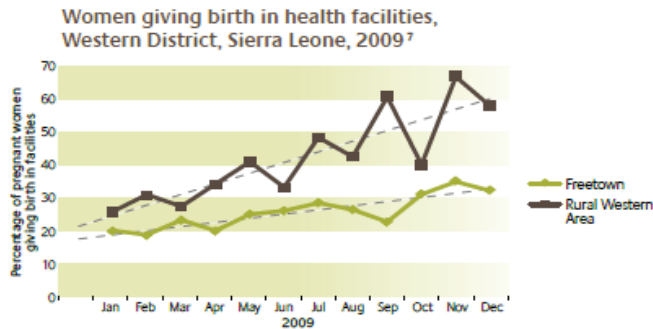

Figure 2: Increasing institutional delivery rates in Western Area, from the HMN Results Report (2010)

Districts also have their monthly review meetings, and following the example of the bulletin and league tables, several districts started to make chiefdom league table, ranking the sub-districts (chiefdoms) in a similar way. These review meetings are attended by all district stakeholders such as health partners, community counsellors, health providers, traditional and religious leaders, etc., and have led to a plethora of locally driven initiatives on improving service delivery in their respective communities. The development of a district and chiefdom league tables covering important health indicators, the active dissemination of these, and discussions with key stakeholders on how to improve on these indicators form the highlight of such review meetings. For instance, the use of the chiefdom league table showing performances of each chiefdom on key health indicators (such as institutional delivery, fully immunized children, etc.) in Moyamba district has raised a competitive feeling among the local communities. Table 1 shows an example of chiefdom league

table.

Chiefdoms	% Full Immunized 2nd Quarter	% PHU Delivery 2nd Quarter	% 3rd ANC Visit	% 2nd Dose of IPT	% MMRC Submitted	% Exclusive Breastfeeding at Penta3	Average Score	Ranking
Kongbora	98.2	45	170.9	96.6	86.6	93.3	5.3	1
Fakunya	124.3	62	154.3	86.2	100.0	48.1	5.0	2
Dasse	134.9	57	90.5	86.3	100.0	45.9	4.8	3
Kaiyamba	90.3	55	162.7	93.4	75.0	71.3	4.8	3
Timidale	140.3	46	106.8	91.7	91.7	33.0	4.8	3
Kowa	118.4	52	96.5	46.7	100.0	78.2	4.7	6
Lower Banta	88.3	48	201.6	120.8	100.0	35.6	4.7	6
Bagruwa	61.4	37	110.3	92.4	93.0	32.1	4.3	8
Kamaje	55.6	35	69.7	140.7	100.0	86.5	4.3	8
Kargboro	80.4	45	93.2	77.6	100.0	36.5	4.3	8
Kori	49.8	40	92.6	89.4	86.6	64.0	4.3	8
Ribbi	71.8	26	53.7	57.4	100.0	60.5	3.7	12
Upper Banta	61.1	29	68.0	101.2	77.8	38.6	3.7	12
Bumpeh	54.9	29	73.8	38.2	100.0	28.3	3.2	14
Total	91.4	43	114.3	32.4	93.6	20.8		

Table 1: chiefdom league table in Moyamba district

In this case, Kongbora chiefdom, after coming last in the first quarter review, improved to take the first place in both the second and third quarter reviews. Fakunya Chiefdom was the sixth in the first quarter review, but improved to take second and third places in the second and third quarter reviews. Dasse Chiefdom was eighth in the first review meeting but took third and second places in the second and third quarter reviews. Certificates of this, provided to the paramount chiefs at the review meetings, were brought to local council meetings as proof of good performance, as shown in the Picture 3 below.

Picture 3: P. C Banya (Kongbora chiefdom) with chiefdom league table certificates (2nd and 3rd quarters) at Moyamba district council monthly meeting, where health and other local issues are discussed.

By comparing themselves and knowing more about health indicators, local community leaders decided to better organize health service delivery in their community and put more pressure on upper level for more resources and more support. In many communities, local counsellors are now putting in place bye-laws for the Traditional Birth Attendants (TBAs) to help pregnant women deliver in the health facility where they can have a clean and safe delivery with trained staff in attendance. The District Health Management Team also organized outreach activities eagerly requested by community leaders (Paramount chiefs) after

the review meetings to increase the coverage for key health outcomes like childhood immunization. Some communities have also used these meeting to advocate for more resources (human, financial and infrastructure) in order to address the low uptake of services in their catchment areas. In some chiefdoms where institutional delivery rates are low, the paramount chiefs mobilized local resources to build birth waiting homes where pregnant women staying far away from health centres could stay until they delivered.

Involving the communities, including religious leaders, traditional health service suppliers, and the paramount chiefs, the districts are improving the institutional delivery rate, an efficient strategy to reduce infant and maternal mortality. The Moyamba DMO is very proud of the interest expressed by the community members who are now determined to improve service delivery coverage in their communities. "Using the data from the DHIS for the quarterly review meetings, the population better understand the health services performance and are happy and interested to be involved," claimed Dr Kandeh, the Moyamba DMO. "Without their interest, we could not move forward and have high performance". Being able to show improvement in service delivery by using health information at district level, and regularly share it with key stakeholders, led to a major change in prioritizing health services with the community involvement.

The possibility of being part of a larger set of other communities made it easier for local communities to compare themselves with neighbouring communities which in turn triggered the propagation of best practices leading to improvement of health services and high performance. While the data quality shown in table 1 is obviously an issue, as seen from the rather wild percentages for some of the chiefdoms, these problems have triggered a review into denominator data such as population figures which tend to be outdated and not take into account recent migration.

Online web based access in Kenya – Empowering rural communities

Participatory design in the cloud

Sierra Leone is one of the poorest countries in the world and the infrastructure is poorly developed. It has therefore not been possible to implement the DHIS on a central server, which would have been much easier and which is the "industry standard" of doing things in the industrialised world. As the Internet and mobile technology is spreading rapidly in Africa, we include a limited case study from Kenya, where the infrastructure is much better, and probably quite similar to what it will be in most of Africa relatively soon since it is driven by mobile network technology.   DHIS2 is currently being rolled out in Kenya based on a central server solution. Initially, the plan was to implement standalone instances in districts around the country, the traditional African way, but during a field visit to Machako in October 2010, a district hospital not far from Nairobi, the course of action was changed. Testing the DHIS2 online server in the information office, everything went well until a power cut left the line dead. As it was a hospital, the generator started and power came back, but the Internet was gone as it would have to be restarted somewhere down the line. The team was just about to conclude that Internet was still not reliable when one of the staff suggested using his "dongle", the modem for the Internet over the mobile network, which, it turned out, worked fine as the mobile networks are not affected by local power cuts. Immediately after this revelation, Internet modems were

tested around the country and found to work , and the decision was taken to go for a central server solution, probably the first time for such a country-wide public sector project in Africa. However, the server in the Ministry of Health could not be used as the connectivity was too poor in the building and the server setup not reliable. As a temporary solution therefore, a commercial server was rented through a London based company, meaning cloud computing, although politically it may not be accepted to locate national health data outside the country in the long run. The Coast province was selected as a pilot, and the system was implemented in all districts and hospitals there in January 2011. All users were provided a modem and a budget for airtime. The network was working, but the bandwidth was limited many places, and the cost of the airtime restricted the amount of time online. In order to address a multitude of problems the DHIS2 lab was literally moved to Kenya; the lead developer and others took part in building a local team and engaging in rapid prototyping cycles on site with the users in the Coast province. In fact, "rapid prototyping" changed its meaning; working on an online server meant that the system changed as according to users' input, if possible, on the fly, or overnight.

After the initial pilot and testing in the Coast province, the system was rolled out country-wide during March-September 2011. During a field visit in the western parts of Kenya, in Nyanza and Western provinces, and to remote areas, such as Homa Bay district, where two of the authors participated, the most surprising finding was that the users in districts and health facilities said they had easier access to their own data, as well as data from the rest of the country, than they had had anytime before. The argument was that they could access their data regardless of power-cuts (when they used their laptop), viruses or computer problems, because the data was "up there", always available, "in the Internet". Furthermore, they really appreciated the dynamic updates of data from around the country and the messaging system in the DHIS that was used for communication between users and the system support team to report bugs and to get help when having problems. "Just like Facebook" as one user said.

The new HTML 5 standard has the potential to improve the robustness of Internet and cloud based technologies in Africa, as it allows for offline data entry because browsers implementing this standard are now including a small database. The first version of such a "semi-online" feature was implemented in DHIS late August 2011. The user can now capture data offline by using the memory in the browser and "flush" the data (i.e. transfer to the server) when online. This is a very useful feature in Africa since Internet is not available everywhere and all the time. The following message was posted by a user after the new feature of offline data capture had been included:

> 2011-09-13
> *Hi, this is wow! I have realized that I can now work with a lot of*
> *easy without any interruptions from network fluctuations since*
> *some of us are in the interiors where we have lots of challenges*
> *with the network. This is so good, a big Thank you.........*

Offline data-use is another important optimization of DHIS2 for low bandwidth in remote areas: the ability to download data for off-line data analysis and use. A small "super lightweight DHIS2" application installed locally is used to download data from a local area and other areas specified by the user, including the indicators and aggregates generated by the system to a data mart, which is then used to generate Excel pivot tables used for data analysis. Reports, charts and maps are generated

when "online" and downloaded in PDF format and archived in the offline application. As the Excel pivot tables are not easy to update online regardless of bandwidth, the offline local data mart is actually representing an improvement on some functionalities when compared with the web browsing (see figure 3).
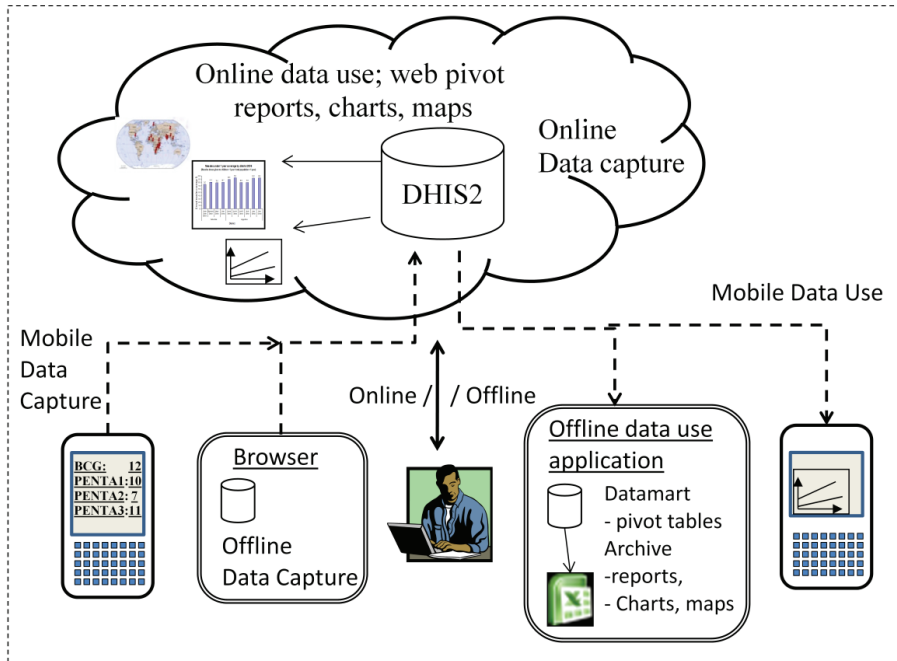

Figure 3: Semi-online DHIS2 design and implementation in Kenya.

Discussion

In this section we highlight and discuss the following four topics:

1. Health information in a community perspective: How communities can use HIS for their own development?

2. Design strategies: How to best include communities in participatory design strategies?

3. The technology dimension: Is modern Internet technology appropriate at community level in remote areas in developing countries?

4. The culture dimension: Are the HIS being developed culturally appropriate at the community level?

Health Information for community development

The case of Sierra Leone is, in the end, about improving health for communities throughout the country. This is done by improving access, quality, and use of health information, both for public health staff and for the communities themselves. The

public health system is there to serve community health, so strengthening their capacities to analyze the health situation and make appropriate action plans is in itself a way to use information technologies to improve community health. However, as the case shows, the technology can also be utilized to share data with stakeholders in the communities, such as paramount chiefs, civil society, and NGOs. For example, preparing data from neighbouring districts or chiefdoms, available from an integrated data warehouse, in league tables that are then shared widely with these stakeholders has been a powerful result from several districts in Sierra Leone. While the "owners" of the technology are the organized public health services, the information contained therein is shared beyond the domain of public servants, enabling the communities themselves to shape their response to their health challenges. The information system introduced in Sierra Leone thus contributed both indirectly and directly in enabling communities to improve their situation.

Furthermore, the case shows that the real benefit was linked to evaluating your own situation in comparison with others. In a context where information about your own situation is sparse, and knowledge about what it should be is even sparser, the availability of comparative data from other districts and chiefdoms can at least give a relative performance indicator. The league tables were especially strong carriers not only of information about the community's own situation, but how the community performed compared with others. The maternal and infant mortality rates in Sierra Leone are among the highest in the world, but there are domestic differences that may earlier not have been well acknowledged. Public health service coverage and utilization vary across the country, and by learning from best practises, while fostering some community competition, the league tables enabled the health staff and the communities they are serving to improve piecemeal, striving to achieve small results that have a big impact on the health status. For instance, the example from Western Area, where several measures where tried to improve the institutional delivery rate, was in direct response to the poor standing in the district league table. For this to be possible, the data relating to the community, be it district, chiefdom, or village level, must have something to be compared with. The value of the community data increases manifold when available *together* with data from other communities. The league tables and health information bulletins served both as carriers of information and in a normative way as guidance relating to what indicators were considered of national importance. Thus, the local levels could both get feedback on how they performed, and knowledge relating to how they were evaluated. The important point here is that isolated information on the individual communities is of less value than the connection to information on other communities. Information technology projects that have a community focus, then, should be wary about the power of transparency and linkages to other communities. While a singular "community system" would provide the community with its own health information, the real benefit comes when comparing one's own information on health status and available health services with information from other communities.

Communities' use of information to promote their own development, as illustrated by the case of Sierra Leone, is providing concrete experiences on how the WHO Primary Health Care approach may be achieved. Community participation in the development of the health services is highlighted in the following way in the Primary Health Care (PHC) concept Article VII, paragraph 4 and 5 in the Alma Ata declaration:

"Primary Health Care:

5. Requires and promotes maximum community and individual self-reliance and participation in the planning, organisation, operation and control of primary health care, making fullest use of local, national and other available resources; and to this end develops through appropriate education the ability of communities to participate;" (WHO 1978)

We may argue that without access to good information on the performance and availability of the local health services, local health status, and an overview of trends in other communities, "participation in the planning, organisation and control of the primary health care", as stated by the Alma Ata declaration, would not be possible.

Cultivation - Community based participatory design

In this section we will discuss how community participation in the design of information systems may be seen as part of, and incorporated in, the participatory design tradition.

In the last section we saw how community participation was an integral part of the WHO Primary Health Care approach; the community is seen as the key participant in the development of the health services for the community. Here we will look into whether such a strategy may also be applied to the communities participating in the development of the information system, which, again, should be regarded as an important pillar in the development of the health services in the community. Tracing the history of the participatory design tradition, we see that it has its origins in the progressive movements of the 60s and 70s, in ways somehow similar to the origin of the PHC movement. Participation for empowerment and social development were the slogans for both movements.

There are however some significant differences between the participatory design (PD) tradition as it has evolved over several decades in industrialised countries and the context of community development in Africa. First, while in the PD tradition, the workplace has been targeted as the arena for empowerment and action. In the context of the development of health services and improving health in developing countries, it is the community that is the arena for social and political development. Second, while the PD tradition was born out of a situation in the industrialised world where workers felt threatened by modern technology and feared joblosses, communities in developing countries are threatened by being sidelined by new technologies and being left out from development. This second issue, that is, how communities may be either sidelined or made to master new technologies will be discussed in the next section. Here we discuss the first issue: Focus on the community rather than the workplace.

As underlined by the Alma Ata declaration, the health services are there for the community and the community needs to take part in their development. When developing health information systems at the community level, two levels of users are important: health workers and the community. While the health workers are users of the systems in the traditional sense, as being defined in the PD literature, the community is the users of the health services and, as participants in the development, control and planning for improved health services, users of the information systems with the aims to pursue these goals. We thus need to extend the PD tradition to also include the community. Greenbaum and Madsen (1993) put forward three rationales for using participatory design approaches:

- a pragmatic perspective, a functional way to increase productivity;

- a theoretical perspective, a strategy to overcome the problem of lack of shared understanding between developers and users;

- a political perspective, a democratic strategy to give people the means to influence their own work place.

In addition to the three rationales that they suggested, a community perspective has been proposed as strategy to enhance both the community as well as to prepare technical development that goes beyond mimicking the first world (Braa 1996):

- a community perspective, extending the political perspective and aimed at empowering communities to control and master ICTs to their own advantage by pursuing their own social and political development.

In the Sierra Leone case we have seen that the formal community structures, the chiefdoms, are taking part in the development of the system as part of their strategy to mobilise resources, create awareness and to improve the health services in their own community.

An example from the case shows how the districts and chiefdoms took initiatives to improve the system, for example, by being instrumental in the development of data completeness reports and incorporating them in the league tables which enabled the chiefdoms to control and check their own data; a task the district team did not know how to measure by themselves. Such direct engagements and initiatives have been important in creating a sense of ownership to the system in the community, which again has lead to the development and dissemination of the health bulletins as a means for the formal community structures to communicate with and mobilise the wider community. Such dissemination of information from the HIS is important to develop further, both as a means for public health advocacy and as a vehicle for community participation. These bulletins may be regarded as first steps towards turning the HIS into a true interactive vehicle for wider community participation.

In Kenya, we have seen how direct and immediate access to own data through the Internet over the mobile network even at the most remote village level has created a significant level of local initiatives and participation in the further development of the system. Clearly, having direct access to your own data and being able to analyse and use it without having to rely on 'middle men', has both created a feeling of ownership of the system and commitment to participating in its further development. The development of the system in Kenya has from the start been driven by local initiatives seeking to release the potential on the ground. Even the fact that the system is based on the use of modems to connect tothe Internet over the mobile network, which is the most significant technical feature of the system, was not planned for. The new solution popped up through interaction on the ground, and changed the course of the entire national project. Chatting functionalities enabling users to communicate is another example of unplanned design features developed through interaction on the ground. Cultivation is the term we use to depict such an open user centred design and development strategy where the potential in the context is released through active participation in the design and development process. The cultivation approach has been important in engaging at the community level because it provides a practical way for the community to have real influence and to get results through their participation

Internet and ICT at the community level: Appropriate technology?

In the 70's and even later, the term appropriate technology was used in development aid circles to denote technology "simple" enough to be used in developing countries – which was a rather patronising attitude. In this section we will revisit the term and see whether "appropriate" can be given a new meaning in the age of the Internet and cloud computing.

When initiating the project in Sierra Leone, sustainability of hardware and software was a major concern. At that time, there were those arguing that computer technology was not appropriate for rural Sierra Leone. An initial survey showed that literally all computers where seriously affected by viruses. In order to address this problem a Linux based infrastructure was implemented in the districts; a computer without screen was used as a dedicated "no touch" Linux server running the DHIS software and accessed through wireless network by various users in the district headquarter by their browsers. This infrastructure turned out to be very successful, and indeed appropriate. Despite limited initial Linux knowledge, the trade-off was a running system without viruses. Early in the process, an additional smart technology was also tried: low powered 12 Volt computers running on batteries and, the plan was, solar power. This experiment, however, turned out to be not so "appropriate"; the low-powered server did not have sufficient capacity and speed, and users were not happy with screens and performance; various other technical problems put that pilot effort to a standstill.

In Sierra Leone, the Internet is not universally available across the country, a situation which is still similar in most parts of Africa. The norm when implementing country HIS in Africa has therefore been, as in Sierra Leone, until today (2011), to capture the data in stand-alone databases implemented in districts, hospitals and health facilities around the country, and to report data electronically by e-mail attachments or physically on a memory stick to the next level. Significant human capacity on databases, data management and system support is needed, in order to manage a national HIS based on numerous standalone database applications with fragile flows of data between them. Problems of data reporting, completeness and the maintenance of numerous standalone applications across the country make it very complicated. Building a web-based data warehouse on a central server, as is the norm in industrialized countries, and even using a cloud infrastructure, is much simpler technically and in terms of human capacity and needed support structures, for hardware, software and data and database management. Ironically, Africa would need more human capacity for support and maintenance when implementing a country HIS than would, say Norway, when implementing a similar system, because in Africa would need to maintain numerous standalone implementations and complicated flows of data, whereas in Norway only one central implementation would have to be maintained. Cloud based infrastructure using a central server with universal access would therefore be a very appropriate infrastructure in Africa. Based on the rapid increase in mobile coverage in Africa, new cables down both the East and the West coasts of Africa, the situation may be about to change.

The semi-online solutions developed in DHIS enabled by the new HTLM 5 standard which allows for offline data storage in the browser, has been successfully implemented in Kenya. This innovative technology is significantly improving the feasibility of web-based computing using another new technology: the cloud based infrastructure, even in rural remote communities in Africa. In Kenya also, mobile telephones are used to interact with the DHIS; data is reported from remote clinics to

the DHIS and feedback is sent from DHIS to the mobile. These examples of new and innovative technologies, including the local wireless network running on a dedicated Linux server in the districts in Sierra Leone, are all characterised by 1) being very appropriate for even rural communities in Sierra Leone, and 2) being very modern and even cutting edge. Therefore, the term appropriate technology for developing countries needs to be given a new and different meaning in the age of the Internet and cloud computing; to exaggerate a bit – the more "modern" and "cutting edge", the more appropriate the technology.

How can culturally appropriate systems be developed?

In the section above we concluded that modern Internet technology is appropriate at community level in developing countries. In this section we extend the notion of technology beyond the mere "technical", the artefacts and the "things", and see it as being rooted in knowledge and people through use and innovation (Fagerberg, 1994) in a socio-technical web (Kling, Scacchi 1982). Furthermore, information systems, such as the community based health information systems in Sierra Leone, are best understood as social systems (Braa, Sahay, 2012). Following these perspectives, 'cultivation' is well suited as a metaphor to describe the approach followed to develop relevant and socially and culturally appropriate information systems. The argument is that the particular components of the information system, such as hardware, software and paper-based data collection tools may be planted in a local setting, so that the seeds may be similar and context free, but local growing conditions, such as culture, languages and social conditions, are infinitely variable. The developing plant therefore needs to be tended and nurtured by the local community who will then develop a sense of ownership and commitment towards it. In this way the information system understood as a social socio-technical system will grow into place as an expression of the local culture and language. Cultivation, as an approach to information systems development, relies upon the development of local ownership and commitment. A bottom-up participatory design and development process is therefore crucial in helping to create such ownership.

The Sierra Leone case demonstrates that the community level HIS needs to be part of the larger national system in order to be able to analyse data about the local health situation as compared with national standards areas and the situation in other areas. Only by enabling the community to use the HIS to analyse their own situation within the larger context will it be possible to achieve the objective of the Alma Ata PHC declaration which calls for maximum community participation.

This means that while local empowerment, commitment and bottom-up processes are crucial, there is an equally important need for making national standards part of the community based HIS. When striving for equity between communities and regions in a country, national standards are needed to identify and target areas of need (Braa, Hedberg 2002). This may cause some tension between the local need for flexibility and national need for standards, which may be addressed through a hierarchy of standards where each level in the health system is free to define its own standards and information requirements as long as they adhere to the standards of the level above (ibid.).

Concluding remarks

This paper has looked at how community participation in both the development and use of health information systems has led to a situation where the communities themselves are taking active part in improving their health status. The main contributors to success in this regard have been identified as involving the communities in the development and use of the health information system, sharing data among communities in a transparent and mildly competitive manner, and, as the case from Kenya shows, using a mix of cloud computing and offline support to further facilitate the above points also for communities not regularly connected to the Internet.

It is clear from the case that communities are not just users of the information system, but they are also participating in its development and they are themselves shaping the way information is handled and used at the community level. Conceptualising information systems as social systems, cultivation is used as a metaphor to understand how culturally appropriate information systems may be developed through local commitment and bottom-up participatory processes.

At the technical level, the cases demonstrates that modern ICT and Internet technologies may indeed become appropriate technology even for rural communities in Africa.

The case of Sierra Leone shows that while the HIS needs to be based on local ownership and freedom to define its requirements, the system must also include the national standards in order to be useful in a wider national comparative perspective. This implies that community HIS need to be connected in a larger, national HIS and that routines for feedback and dissemination are in place. Our case shows how communities are leveraging the national integrated data warehouse in Sierra Leone to make local decisions, which would not be possible without the wider system.

References

Avison, D., Lau, F., Myers, M. & Nielsen, P.A. (1999). Action Research. Communications of the ACM 42: 94-97.

Bjerknes, G., Ehn, P., & Kyng, M. (Eds.) (1987). Computers and democracy: A Scandinavian challenge. Aldershot, UK: Avebury; Brookfield, VT: GowerBraa, J., Hanseth, O., Heywood A, Shaw, V. (2007). Developing health information system in developing countries: the flexible standards strategy. MIS Quarterly Vol 31 Special Issue August 2007.

Braa, J., & Hedberg, C. (2002). The struggle for developing District health information systems in South Africa. *The Information Society, 18*(3).

Braa, J., Monteiro, E., & Sahay, S. (2004). Networks of action: sustainable health information systems across developing countries. *Management Information Systems Quarterly, 28*(3).

Braa, J., Sahay, S. (2012). Integrated Health Infomration Architecture. Power to the Users. Maxwell Publishers, Delhi.

Braa J (1996) Community-based participatory design in the Third World. In Blomberg J, Kensing F, Dykstra-Erickson E (eds.): PDC'96: Proceedings of the

Participatory Design Conference. Computer Professionals for Social responsibility, USA, pp. 15-24.

Byrne, E & Sahay, Sundeep (2006). Community-based health information systems: implications for participation. *Information Technology for Development*. ISSN 0268-1102.

Checkland, P. and Holwell, S. (1998). Action Research: Its Nature and Validity. Systemic Practice and Action Research 11(1), 9- 21.

de Moor and De Cindio, eds. (2007). Special Issue: Community Informatics and Systems Design, *Journal of Community Informatics*, 3(1)

Fagerberg, J. (1994), `Technology and International Differences in Growth Rates', J*ournal of Economic Literature,* Vol. XXXII (September 1994), pp. 1147 – 1175.

Greenbaum, J., & Madsen, K. H. (1993). Small changes: Starting a participatory design process by giving participants a voice. In D. Schuler, & A. Namioka (Eds.), Participatory Design: Perspectives on Systems Design (pp. 289-298). Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Greenbaum, J., & Kyng, M. (Eds.) (1991). Design at work: Cooperative design of computer systems. Hillsdale, NJ

Heeks, R. (2002). Information Systems and Developing Countries: Failure, Success, and Local Improvisations. The Information Society, 18, 101-112.

HMN. (2005). What is HMN?   Retrieved september 20, 2011, from http://www.who.int/healthmetrics/about/whatishmn/en/index.html

HMN. (2008). The Health Metrics Network Framework.   Retrieved october 7, 2008, from http://www.who.int/entity/healthmetrics/documents/Rational_HIS_Capacity.pdf

Kling R, Scacchi W (1982): The Web of computing: Computer technology as social organisation, *Advances in computers*, Vol. 21, PP 1-90

Kimaro and Nhampossa (2005) Analyzing the problem of unsustainable health information systems in less-developed economies: Case studies from Tanzania and Mozambique, Information Technology for Development, 11, 3, pp. 273-298

Malecki, E. J. (1991), Technology and Economic Development: The Dynamics of Local, Regional and National Change, Longman Scientific & Technical, New York.

Midgley, A., Hall, A., Hartiman, M. & Narine, D. (eds.).   (1986), Community Participation, Social Development and the State, Methuan, London.

Sandberg Å. (Ed.) (1979), *Computers dividing man and work*, Swedish Center for working life, Demos project report no 13, Utbildningsproduktion, Malmø

Sahay, S., Miller, J., and Roode, D. (Eds.), Proceedings of the IFIP 9.4 Conference on Socio-Economic Impact of Computers in Developing Countries: Information Flows, Local Improvisation and Work Practices, Cape Town, South Africa, 2000

Susman, G., & Evered, R. (1978). An Assessment of the Scientific Merits of Action Research. Administrative Science Quarterly, 23(4), 582-603.

UNDP (2009) Human Development Report. Retrieved September 20, 2011, http://hdr.undp.org/en/reports/global/hdr2009/

WHO (1978) Declaration of Alma Ata, International Conference on Primary Health Care, Alma Ata, USSR, 6-12 September 1978, http://www.who.int/hpr/NPH/docs/declaration_almaata.pdf

WHO (2011) Keeping Promises, Measuring Results. Health Accountability Report Presented at World Health Assembly. Retrieved September 20, 2011, http://www.who.int/topics/millennium_development_goals/accountability_commission/PR_Commission_19May2011.pdf

VI

Scaling of Health Information Systems in a Global Context: Same, same, but different

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Abstract

Scaling of information systems is a field of research with growing importance. This paper presents the story of scaling of an artifact (called District Health Information Software – DHIS) and associated principles and practices around a health information system that has taken place over 15 years, both within and between multiple developing countries. Through the lens of the story of the artifact over its trajectory of development and implementation in multiple contexts and time, we develop insights that challenge traditional thinking around scaling. Scaling is not about constant gains and expansion, as is often assumed, but involves a dichotomy of losses and gains, associated with each step or translation in its process of movement. We draw upon Latour's insights on circulating references to analyze this dichotomy of loss and gains, conceptualizing the process as circulating translations. We contribute to the technology transfer literature in arguing that the process of transfer is not about a "parachuting" from point A to B, or a "design from nowhere" but it occurs in a series of small steps, where with each step new socio-technical configurations are created which not only shape subsequent steps, but also redefine the content of the artifact. In this way, we are in line with findings from the social studies of technology, but differ in that our artifact of study – software – is more "virtually immaterial" than the machines studied earlier. This property of software, coupled with growth of web-based and mobile infrastructure, allows ease of circulation across contexts, where it gets redefined and embedded at the same time at the interconnected levels of the global and local – a process we conceptualize as global scaling being "same, same, but different". We discuss both the characteristics of this process of global scaling, and the channels and mechanisms through which it takes place. Four overlapping conditions that shape this process include the software itself, the infrastructure, institutional practices, and ideas – this forms the basis for a general framework to understand global scaling of health information systems. Empirically, the story of DHIS is told from its birth in the mid-nineties in South Africa developed on a Microsoft platform to its transformation to a web-based platform, built using Java based open-source frameworks, and now moving through multiple countries. We focus on these dynamics primarily within India, Sierra Leone and Kenya.

Introduction

Scaling, or the process of expanding the scope, spread and size of an information system, is a topic which is gaining in importance in contemporary contexts. Amongst other things, this is fuelled by the demands of globalization that requires the same system to be spread to multiple contexts (Monteiro & Rolland, 2002). The same is also the case with health information systems (HIS), where global agencies like the World Health Organization (WHO) promote its use in multiple developing country contexts. The increasing use of open source applications for HIS (Braa & Sahay, 2012) which carries with it the potential for customization and reuse, heightens efforts to this process of expansion or scaling, both geographically and functionally.

In information systems research, studies have primarily focused on projects within local settings and described scaling to follow a "replication" logic, mimicking as in a natural system where the various branches have the same structure as the whole plant (Eoyang, 1996). Similarly, the technology transfer literature often describes the movement of technology across countries to also follow a replication logic in its movement from one context to another. Technology transfer is broadly concerned with the "same" system - System A is sent from place x to place y where the box is received, unpacked and A is installed there. However, within our perspective of global scaling, technology A when moved from place x to y, would retain some of the "sameness" but through the very process of movement across different socio-technical domains, will also acquire elements of "differences" – leading to the scaling process being *"same, same, but different"*. This represents a technology "translation" (as contrasted to transfer) process, exemplified by Akrich'(1992) study of how technology gets "translated" in every step of the movement process of a technology across countries.

Our analysis concerns "global scaling" of health information systems across multiple developing countries. This has two key points of departure from the Akrich work. While Akrich described the story of a forest pulping machine, our focus is on software, surely "less material" than machinery, a property we denote as "virtual immateriality". While this higher degree of immateriality enables easy transportability across contexts, it also makes it vulnerable to greater "interpretive flexibility" (Orlikowski 1992), as different social groups engage with the software. The second point of departure is that our analysis focuses on understanding scaling processes in global, implying multiple country contexts, and also within the country in different settings and spanning different domains of use. These points of departure make global scaling of (H)IS to be qualitatively different than technology transfer. While the latter focuses primarily on the dimension of geography or institutions, our analysis spans multiple dimensions such as system functionality, its inherent complexity, user maturity, and processes of learning and adaptation in new contexts (Braa, 1997; Sundeep Sahay & Walsham, 2006). The global dimension necessarily shifts the perspective of scaling from a bilateral movement from country A to B, to a networked view involving multiple locations at the same time, and also at different points of time.

The networked view allows for an analysis of scaling not just as a linear process of expansion and gain, but to also simultaneously examine processes of "loss" and the non-linearity. This arises through feedback and feed-forward mechanisms, from users to designers, or from local to global designers, which stimulate processes that may lead to non-linear and unpredictable movements. Furthermore, scaling is not treated as one large step of expansion and movement from point A to point B, described as "parachuting" (Braa & Sahay, 2012) or "design from

nowhere" (Suchman, 2002), but instead as consisting of a series of small steps or translations. Each such step involves creating new forms of socio-technical configurations (Latour, 1999), which also influence the content of the technology itself (Akrich 1992).

In HIS, global scaling is inevitable, as institutions such as the WHO and Health Metrics Network (HMN) have the mandate to circulate to global systems, standards, software, and best practices in different countries they partner with. In recent years, avian and swine flu have triggered world-wide responses, necessarily with global dimensions, including the HIS to monitor their spread and inform response based interventions. HIS thus needs to be designed in a manner that they scale globally, implying they are able to circulate from one context to another, while also simultaneously being well embedded in local contexts. Such movement is never friction-less, and influenced by various conditions such as culture (Lind, 1990; Nhampossa, 2005), infrastructure, human resources (Shaw, Mengiste, & Braa, 2007) and various others (Heeks, Mundy, & Salazar, 1999). Roger's classical "S" shaped curve of diffusion (Rogers, 1962) has been since critiqued that diffusion processes do not follow universal trajectories, and instead take various forms and shapes depending on the context (Nhampossa, 2005).

From a "global scaling" perspective, while geography is indeed fundamental, various other dimensions are scaled, including system functionality, user maturity, and political complexity (Sundeep Sahay & Walsham, 2006). A key argument explored in this paper, is that scaling does not lead only to differences, but also carried with it a significant degree of sameness. Our focus is on understanding how global scaling takes on a character that *is same, same but different,* and why this is the case. The research questions this paper focuses on include:

a. What are elements of sameness and difference that can be inferred during a process of global scaling of HIS?

b. Why is this the case, and how can this be best managed in order to have positive consequences of HIS scaling?

Empirically, the analysis is carried out within the framework of the Health Information Systems Programme (HISP), a research and development project being carried out since 1994 in multiple countries of Asia and Africa. Activities under HISP include the design, development and implementation of an open source HIS application called DHIS (District Health Information Software, hereafter DHIS). A key focus in this paper is on the artefact – DHIS - and the ideologies and practices that are embedded in its design and use. Given that, the "same" DHIS is being developed and used in multiple countries, it provides an interesting perspective on global scaling, on how the artifact circulates, and what remains same while simultaneously new inscriptions are developed. Geographically, we focus on three regions of the South – South Asia, West and East Africa for our empirical analysis. While in South Asia, there is the focus on India and the spread of DHIS to Bangladesh, and in West Africa it is Sierra Leone and Ghana, with interesting inter-linkages between these two regions through developments in the East African country of Kenya. This empirical design, sets up the analysis beautifully to understand how DHIS translates to being "same, same but different."

The rest of the paper is organized as follows. In the next section, we discuss related literature including on scaling and technology transfer. Taking the points of departure for our analysis as outlined above, we present a theoretical framework that helps to guide our analysis. The research methodology, basically involving the large scale multi-country action research called HISP is then described, followed by the case studies. Next, the cases are analyzed, within the perspective of same, same but different. Discussions and conclusions follow.

2. Global Scaling of IS/HIS.

2.1 Traditional perspectives: technology transfer and diffusion

Various strands of literature are relevant in understanding the progression of thinking in the conceptualization of scaling, and the perspective developed in this paper. Early thinking in this domain was informed largely by the technology transfer paradigm, dominant from the 1960s. Technology transfer refers to the process of transferring skills, knowledge, technologies, methods of manufacturing, products and services, and facilities among governments or universities, and other institutions to ensure that scientific and technological developments are scaled and made accessible to a wider range of users. The primary focus on "transfer" assumes a centre and a periphery from where to where is knowledge, products and know how moved. In the context of technology transfer involving countries, the core was then the developed, and periphery the developing countries. In the sixties, the dominant technology transferred related to agriculture and various forms of manufacturing machinery, while since the nineties, information technology has become a significant object of focus and transfer.

This model of centre-periphery movement was typified by Rogers' popularly used "S" shaped curve , which sought to explain how, why, and at what rate new ideas and technology spread through cultures (Rogers, 1962). Rogers proposed 4 main elements that influence the spread of a new idea: the innovation itself, communication channels, time, and a social system. The diffusion process, of how an innovation is communicated through certain channels over time amongst members of a social system, was described by Rogers to progress through 5 stages: knowledge, persuasion, decision, implementation, and confirmation.

 Rogers' ideas have also found significant application in the IS research domain through the Technology Acceptance Model (TAM) (Davis, 1989) and its subsequent extensions (Venkatesh & Davis, 2000; Venkatesh, Morris, Gordon, & Davis, 2003). The TAM models how users come to accept and use a technology, arguing that when users are presented with a new technology, two key factors influence their decision about how and when they will use it: perceived usefulness and perceived ease of use. While the former is defined as the "degree to which a person believes that using a particular system would enhance his or her job performance", the latter reflects the "the degree to which a person believes that using a particular system would be free from effort" (Davis, 1989).

While Rogers' ideas have been quite influential in the understanding of how innovations spread, and similarly the TAM in describing acceptance of new information systems, they have also been subject to criticism. For example, Nhampossa argues how the cognitive basis of these models tends to limit our understanding of the system (Nhampossa, 2005) in its

broader context. Furthermore, the assumption of a one way flow of an innovation, tends to rule out new ideas emerging from the periphery, and of it being treated as a relatively static event. This largely excludes the broader and multiple interactions taking place in context. Per Lind has argued how the promise of (information) technology transfer from the Western world to developing countries has not been materialized due to challenges that are cultural as well as technological (Lind, 1990). While we do not subscribe to Lind's extreme position that computer programs are a product of a developed culture, and as such, are not suited to the specific problems of Third World reality, we argue for an approach that emphasizes learning and innovation within a framework of "translation" rather than "transfer."

Braa, Monteiro, and Reinert argue for speaking of technology *learning* rather then *transfer*, as "technology is not just an isolated machinery or artefact, but involves the social and cultural context of use of a technical artefact" (Braa, Monteiro, & Reinert, 1995). Subsequently, Reinert has conducted an impressive analysis of technology transfer from an economic point of view, arguing that successful economies are based on industry protection that facilitates *learning* of technologies, i.e. that only by being given time for learning and adapting technology, can industries stand a chance of being sustainable in a competitive setting (Reinert, 2007). Evocative of the expression "teach a man to fish..", the core is that it is not the technology, the fishing gear, that feeds a man for a lifetime, but learning how to use it in his waters.

2.2 Reconceptualization of scaling: as translation

An alternative perspective to technology transfer, which we argue has interesting implications to study global scaling, is Akrich's (1992) notion of technology translation, describing the tale of the physical, economic, and institutional modifications taking place around the introduction of a Swedish forestry machine to Nicaraguan cotton farming. Through successive alterations to the technology, one small step at a time, it is slowly translated into a useful device for the local context, quite different from that originally used in Sweden and as intended to be used in Nicaragua. These translations not only affect the technology itself; it is a mutual alignment of the altered technology to a changing industry, in the end resulting in the development of a new economic niche; selling cotton stalk briquettes as fuel to local bakeries. The essence of technology translation then, as compared to transfer, is the contextual forces working upon the technology to alter it's materiality, its potential and eventual use.

Similarly, Nhampossa studied the introduction of a HIS developed originally in South Africa to Mozambique, and describes the translations that took place at different stages, for example the technology being first tested at the national level of the ministry, followed by its deployment to provinces, and then districts (Nhampossa, 2005). Like Akrich, Nhampossa too traces the translations involved at each of these stages, and how these lead to changes in the technology itself. He uses the example of the birth of the multi-language support in the HIS because of the demands of the local context to have the system in Portuguese. He argues that "technology is developed as a result of the interaction of culture (manner or way of thinking, talking and acting), context or environment (e.g. country, organization or department), work practices, and the material characteristics of the technology itself" (page 139). This translation

is not a one-off event, but characterized as a successive chain of smaller translations, each contributing to the coming together of different socio-technical configurations (Law, 1996).

Another important aspect in reconceptualizing technology transfer as translation is the higher degree of "interpretive flexibility" (Orlikowski, 1992) associated with information technology as contrasted with the more fixed materiality of technologies like machines and equipment. Interpretive flexibility implies the potential of the same technology being perceived by different social groups in varying ways leading to different and unexpected consequences. Barley described how the same CT scanners were interpreted differently by the radiologists and doctors in two hospitals in Massachusetts, leading to different consequences (Barley, 1986). Sahay and Robey similarly described different consequences of the same Geographic Information Systems (GIS) technology in two county government organizations in South Florida, and attributed these to how geographers and computer scientists interpreted the technology in varying ways in these two settings (S. Sahay & Robey, 1992). By virtue of its "virtual materiality", information systems can relatively easily circulate across different settings, thus becoming vulnerable to varying social constructions and associated translations. As a result, scaling processes tend to be non-linear, involving unanticipated consequences.

2.3 Our perspective on global scaling

 Firstly, we see scaling to involve change in a range of dimensions, including geography, functionality, user maturity (Sundeep Sahay & Walsham, 2006), and technical dimensions like data load and network distance (Bondi, 2000). Successful scaling, and the related concept of scalability, has often been attributed to more technological aspects, like architecture (Lemley & Lessig, 2001), generativity (Zittrain, 2006), and standards (Braa, Hanseth, Heywood, Mohammed, & Shaw, 2007; Monteiro & Rolland, 2002); including how standards need to be flexible to enable change. In recent times, there also has been a focus on the organizational aspects that shape scaling. For example, in a comparative study of Nigeria and Ethiopia, Shaw, et al. present a framework for analyzing scale in relation to organizational capacities in the health sector (Shaw et al., 2007). They propose a strategy of mindful innovation (Swanson & Ramiller, 2004), balancing available human resources, access to technology and the type and volume of data collected. An important aspect of our perspective on scaling as involving multiple dimensions, is the need to establish trade-offs between the ability and need to scale, as well as trade-offs related to the direction of scaling since expansion in one dimension can lead to losses in another (Latour, 1999).

Secondly, we emphasize non-linearity in the process of scaling, including the rather unexplored simultaneous dual process of loss and gain. As with language, any translation runs the risk of deviating from the original meaning. In Akrich's example, the modifications of the technology to handle cotton stalks instead of Swedish forestry waste signified a physical change that compromised the ability to function as intended back in Sweden. So while there is a gain in better suitability to the Nicaraguan context, at the same time there is a loss in terms of original functionality.

This gain/loss dichotomy has been beautifully illustrated by Latour, with his model of circulating references (Latour, 1999). He has looked at the sequential transformation of a set

of empirical data, in his case specimens of flora and soil samples from a Brazilian savannah, via coding in note-books, to academic papers. Latour identifies a chain of translations not unlike what is described by Akrich. Each step signifies a modification for a different use, in Latour's case; a methodological abstraction from a living piece of soil towards a coded piece of data to aid research. What Latour also notes, as shown in Figure 1, is the simultaneous loss that takes place in this movement. At each step of translation in his example (from left to right in the figure), what was particular about the soil sample was reduced, and what was general was amplified. There was a drift towards more universality, accompanied by a similar drift away from the locality. We find this model appropriate to study processes of global scaling, seen as involving consecutive steps, each representing a transformation from the local to the global, from the particularity of a node in the system, to the generality of the wider system. This process takes place over time and space. Latour depicts this process schematically as under.
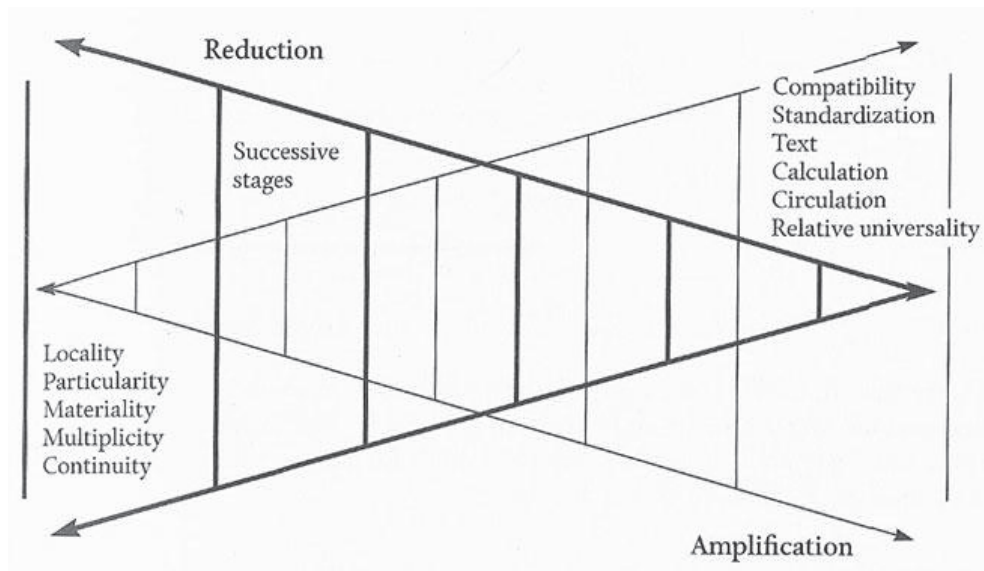

Figure 1 Circulating references. Each step reduces particularity and amplifies universality (Latour, 1999).

Bringing the pieces together: scaling as circulating translations.

As discussed above, we propose three key concepts to study global scaling. The first is on multi-dimensionality, emphasizing the various facets that scaling encompasses. The second concerns non-linearity, which brings our attention to the back and forth movement and the multi-linkages which accompanies scaling, and it is not just a push in one direction of growth and expansion. Thirdly, the concept of translation, which emphasizes how scaling takes place in small and incremental steps, and with each step there are new socio-technical configurations being formed, which not only shape the process of scaling, but also help to

redefine the constitutive base of the technology. We take these three concepts together to propose the notion of "circulating translations" to understand scaling. Like Latour, the notion of circulating emphasizes both a move forward, but always in relation or reference to what exists, what is left behind. The successive chain of translations, through learning, imply processes of gain and loss, which accumulates over time to depict an amplification of generality, and a simultaneous reduction of particularity. Going back to Akrich's example, the changes in Nicaragua goes perhaps unnoticed back in Sweden, but any supplier of the machine, or spare parts, could potentially extend his business by taking both implementations of the technology into account. The scaling from Sweden to Nicaragua amplifies the commonalities of the technology, the wider the scale, the stronger the emphasis on commonalities across the various actors.

The health sector, which is the focus of this study, presents a unique requirement around scaling of HIS. The primary health sector seeks to provide "universal" access to health care to the people, implying "all" must receive care. The implication of this for HIS is that they need to be able to register and provide data for all facilities and also individuals in the region covered. It does not help the manager of the immunization programme to know whether children within a pilot area of his district have got vaccines, he needs to know the status for all children in the region. The "scaling" problem is thus of "all or nothing." This of course has implications on the scaling strategy where loss and gain is on-going, and we need to try and ensure that gains are on-going, and that they outweigh the losses. The inherent nature of health information is to be dependent on a critical mass to be useful for management (Braa, 2005). Implications of this on scaling include the need to scale rapidly and extensive enough to achieve utility, in a context of constrained resources. Given the political and unpredictable nature of the health sector, protecting against losses is a non-trivial task, and requires a constant and on-going vigil. We illustrate these dynamics through the story of scaling of the DHIS artefact.

3. Research Methods:

This paper builds on research carried out within the Health Information Systems Programme (HISP) project since over more than a decade. HISP is an R&D network of health and IT, including various individuals and institutions (such as universities, government departments and ministries, NGOs etc), that have been involved in strengthening processes around the design, development, implementation and use of HIS in a number of countries in Africa and Asia. HISP was initiated in 1994 in South Africa, and today spreads over more than 25 countries. While the network, especially the research and funding related activities, are coordinated from the University of Oslo, increasingly a regional focus is being promoted including the creation and strengthening of nodes in HISP India (for South Asia), HISP West Africa (for the West African region) and HISP East Africa (for the East African region).

The framework: Action Research

The overall methodological framework for this research, and for the HISP network more broadly, has been of action research. While the flavor and form in which the action research is organized and carried out by different members and nodes of the network has a lot of

variations, some common design principles can be discerned as underlying the efforts. The first principle relates to the use of a participatory design form of research where the researcher is engaged with the change processes in an organization, actively collaborating with them to solve an accepted problem (Avison, Lau, Myers, & Nielsen, 1999; Checkland & Holwell, 1998). Such form of participatory action research holds that understanding social processes at play is best achieved by being engaged in processes related to the introduction of change related interventions and observing the effects (Baskerville, 1999; Baskerville & Wood-Harper; Davison, Martinsons, & Kock, 2004).

The origins of the HISP tradition of participatory action research can be traced back to the Scandinavian research projects that centred on industrial democracy, starting with the Norwegian Iron and Metal Workers Union project to look at planning, control and computerization from a trade union perspective in 1970 (Bødker, Ehn, Knudsen, Kyng, & Madsen, 1988). User-participation and emancipation stood central in these projects through the 70s and 80s. In HISP, this was also the point of entry for development of a new HIS in South Africa after the fall of apartheid (Braa & Hedberg, 2002). The participatory design principles were operationalized into approaches of rapid prototyping and real-life testing of the software DHIS, which has evolved over the years with a lot of inscribed user-focused knowledge. Participatory design has not only been a method for design and development within HISP, but has also served as an important object of research (Braa & Sahay, 2012).

Another principle underlying the action research approach has been of networks, which has provided the setting in which both the action and research components of the HISP initiative have been undertaken. In 2004, Braa, Monteiro, and Sahay articulated the *networks of action* approach, guiding the HISP initiative, as addressing the need to spread risk and increase sustainability of the networks. Key to this has been the circulation of key personnel, technology and knowledge between various nodes of the project. This helps to increase learning and basis for generalization by basing research on comparative cases rather than isolated instances (Braa, Monteiro, & Sahay, 2004). The point of departure for this articulation was earlier studies of action research having argued for the need to situate the action within networks rather than on singular units of isolated action research projects which did not create enough momentum and scale to attain sustainability. Therefore, the focus needed to be shifted "from single organizations and workplaces…to networks" (Engelstad & Gustavsen, 1993). This networked based approach tends to be more pragmatic and flexible towards understanding and managing processes of change in the research setting.

The empirical strategy followed in the analysis and interpretations of the cases is one of post-hoc interpretation and rationalization. All three of the authors have been engaged with the cases of DHIS scaling from one country to another, or even within a country, for more than 10 years each. They each have individualized and also collective experiences of processes of scaling of DHIS from when it started to now, more than 10 years on. One of the authors of the paper was the originators of the HISP network in 1994 in South Africa, and has been involved all along till today. The individual and collective reflections based on action research based empirical engagements with the processes of scaling have contributed to the interpretations reflected in the case study. A key focus of the case study has been the focus on the artifact –

DHIS – through whose lens the story is constructed. We describe the story of the artifact, how it has evolved over more than a decade, and over this period passed through many countries, and also many regions within a country, and also as a product through different levels of functionalities and maturity. This movement of scaling which we then describe concerns how the technology with its inscribed ideologies and practices, has moved over time, a process which we conceptualize as global scaling.

Our empirical story description builds on three cases of scaling; a) within and from India, to Bangladesh where also we span domains from health to food security, b) within and from Sierra Leone, to West Africa, representing a quantum leap in scale from a single country to a region including 15 countries; and c) within and from Kenya, to East Africa, with implications for both South Asia and West Africa. In each of these cases, the activities are still ongoing, starting in 1999 (India), 2007 (Sierra Leone), and 2011 (Kenya). Within these countries, the authors have had pivotal roles since the start, giving access to a longitudinal perspective on scaling processes presented in this case. Given the scope of the overall case, a complete overview of data collected spanning all these countries and years would be too extensive. However, we present our interpretations of data that has been recorded over time as a combination of personal notes, e-mails, official documents like data reporting forms and tendering documents, pictures, training material and exercises, research papers and presentations.

An interpretive perspective has informed this analysis, a tradition to which the three authors have subscribed to over the years. Since each of the authors have been embedded over long periods of time in the different cases (one in South Asia, the other in Sierra Leone and the third in East Africa), it has been of course difficult for each to be objective in their respective analysis. Further, there are many details of particular cases which are in the head of a particular author which the others do not really have access to. To help understand these gaps, the three of us have thus each tried to write the cases they were most involved with and pass it on to others who developed their interpretations wearing different research lenses. In addition, the other two researchers would provide inputs on the story to parts in which they have been members of the team. In September 2011, we held in our institution a seminar on theory building related to scaling. We wrote down three empirical cases on scaling, and three senior professors from the UK who were invited to the seminar as experts, provided their theoretical interpretation and rationale for the three cases. Through this process of trying to develop multiple interpretations, we have tried to piece together the different threads of the story of global scaling of a HIS artifact that has spanned nearly 15 years and has also touched upon more than 25 countries. We have necessarily needed to make design choices in terms of what to emphasize in the story and what parts we did not. This was necessarily a subjective process reflecting biases and pre-judgments of the authors of what they considered to be more pertinent to the understanding of the process of global scaling.

While this research methods section has not been written in the conventional manner giving descriptions of the number of interviews done and how documentation was carried out, we strongly believe the empirical base on which this story is based, represents one of the richest pieces of empirical work carried out in IS research. The overall story of DHIS and HISP has

covered now about 15 years, spread over 25 countries, and has been the basis of about 25 doctoral studies and more than 100 papers. The authors have been at the vantage point of having engaged with a number of these studies, empirical work, discussions, seminars and research presentations. The interpretations presented as a part of this case study represent a distillation of these different experiences, presented in a "top-down" manner, rather than a "bottom up" way in which details (eg number of interviews) of a particular study are detailed.

4. Case study: Tracking the DHIS

This case study tracks over time and space the movement of the open source DHIS application and the HISP, a global network that is developing and implementing the DHIS. While as a network, HISP is relatively diffused and fuzzy, the DHIS, however, is a material artifact with concrete implementations, and clear trajectories of its scaling across dimensions of technology, geography and time. Through the lens of the artifact, we see the inscribed public health practices, policies, architectural visions, and depict the networks and political compulsions driving the process. We focus our scaling analysis to the following dimensions:

1. Technological – to describe the growth of the DHIS through technological changes over time; from MS Access based standalone application to cloud computing.

2. Geographical – to trace how the DHIS and HISP activities have progressed over geography, from the start in South Africa in the 90's to India and from there to Bangladesh, and back to Africa; West Africa and East Africa. Given our focus on scaling within a global context, we also discuss how DHIS grows within a country; new functionalities gets developed which trigger interest also in other countries.

3. Institutional – this includes various formal and informal elements, such as the growth of ideology, legitimacy, ideas, political compulsions, new organizations, people, and related processes.

DHIS development has evolved over two versions. The first – DHIS v1- since 1997 by HISP in South Africa on MS Access. Since then the DHIS v1 has spread to multiple countries in Africa and Asia and it is still in use in South Africa. The second – DHIS v2 – building on the v1 data model is a modular web-based software package built with free and open source Java frameworks, developed since 2004 and implemented for the first time in India since 2006.

We present the case through five interconnected processes of technological development and geographical and political positioning, which represent junctures in the timeline of the history of DHIS at different level of scales. Table 1 provides an overview of these 5 stages:

Timeline	Key processes in developing the DHIS
1998 -: Start of DHIS South Africa	DHIS v1 developed by HISP in South Africa to support the post-apartheid integrated and decentralized health system. Focus on information for action, local use and a flexible meta data structure
2006 -: Web-based DHIS2 in India	DHIS v2 developed in Java based technologies and first implemented in Kerala, India, from where it scaled to 10-20 states 2008 – 2009 and to Bangladesh 2011. Political pressure have been important for both for scaling and de-scaling of DHIS in India

2008 -: DHIS2 in Sierra Leone, HMN and WAHO	DHIS2 implemented in Sierra Leone in West Africa in a high profile HMN project. Successes led more countries in the region to follow suit and the West Africa Health Organization to become a partner. Interoperability using SDMX-HD demonstrated.
2011 -: Cloud computing in Kenya	DHIS2 implemented based on cloud infrastructure and using modems to the Internet over the mobile network. First of ts kind in Africa. Ghana, Uganda, Rwanda follow suit. Offline data capture using storage in browser makes implementation easier in Africa.
2012 -: DHIS2 Tracker module in Ghana and Uganda	Tracker module integrating range of use cases from anonymous case based reporting (line listing ICD10 cases in Ghana) to tracking of beneficiaries supporting continuity of services; ANC, delivery, post natal, nutrition and immunization (Uganda).

Table: Timeline and key processes in the development of DHIS2

4.1. DHIS initiation in South Africa – "Information for decentralized action"

 HISP and the DHIS was born out of the post-apartheid South Africa and their struggle to overcome the wrongs of the past, including inequity of health services delivery between racial groups, and extreme fragmentation. HISP was initiated in South Africa in 1994 as a part of the new ANC government's reconstruction and development program (RDP), which emphasized a decentralized system of health districts including their supporting HIS. HISP started out as collaboration between, on the one hand, public health researchers and activists with background from the anti- apartheid struggle, and on the other hand, informatics researchers with background from the Scandinavian participatory design and action research tradition (see Braa, Hedberg, 2002, for a detailed presentation of HISP in South Africa).

DHIS v1 was developed and implemented first in pilot districts in the Cape Town area and then in two provinces of Western and Eastern Cape in 2008. The flexible DHIS combined with the HISP approach to integrate data from different programs through a shared essential data set linked to indicators proved successful. Other provinces followed suit and the DHIS became the country standard from 2001, providing DHIS and HISP with political legitimacy which has endured in South Africa to this date. DHIS inscribed a political approach with a clear focus on information that could be turned into action by focusing on clear targets for the health services and indicators to measure achievements. The key break with the past was to give users control over their own information, now located at their own desk.

DHIS was developed in period of constant changes in data requirements and organizational structures and boundaries, the old 'homelands' where merged into new provinces, districts where changed as were the borders between them. DHIS therefore had to be developed with a flexible meta data structure that could easily be changed and adapted to the continuously changing contexts of use. Changes in the metadata, such as new district boundaries, new facilities, or new data sets to be collected and indicators to be calculated, could easily be done through the user interface without programming intervention. In this way, being developed to serve the users' needs in a constantly changing environment –a worst case in terms of stability – DHIS developed into a flexible platform for developing applications and tools, enabling its configuration in multiple ways to suite a wide range of use contexts.

4.2. Web based DHIS2 and implementation in India – scaling in South Asia

DHIS2[1] was first implemented in Kerala, India in January 2006 by the HISP India team which had prior experience of working with DHIS v1. Since 2006, the DHIS2 has evolved into a robust application being implemented in several states in India and from 2010, also in Bangladesh. We start with the Indian account, and its spread further to Bangladesh.

Taking the DHIS 2 to the web and to the Indian sub continent

Re-developing DHIS as a modular web application represented a radical break in technologies as well as an over-emphasis on the new online communication platform, presenting formidable obstacles to the Indian technical team. While the core development took place in Oslo, customisation and implementation was in India. When DHIS v2 was first introduced, the HISP India team members, who had several years of experience with v1, found it hard to make it useable and to get the data out, as the database model was difficult to understand since it incorporated a database abstraction layer, requiring the use of a Java API instead of directly accessing the database as in v1. As a consequence, the Indian team chose to bypass the API in order to be able to obtain quick results and thereby providing "hard-coded" but well-performing reports.

In response to immediate user needs, the Indians implemented a number of innovative solutions for data analysis and presentation, such as the Dashboard module developed in collaboration with health managers, enabling graphical analysis of data and indicators in charts. This module became an important instrument for the scaling of the DHIS in India across multiple states as it was used as a key "sales argument" for DHIS when demonstrating to state health authorities. A GIS module was developed in collaboration with Vietnamese developers, giving further impetus for scaling in India. By providing good results on the ground, the Indian team managed to scale the DHIS to about 20 states in India during 2008-2010, making it as one the largest open source implementations in the developing world. However, post-2011, a politically driven process of de-scaling took place, which we describe later.

For quite some time, the Dashboard module developed locally by the Indian team could not be included in the global core code repository due to many local workarounds created, such as directly accessing the database. This caused many problems as global core developers could not help the Indian team with their installations, and the Indians could not upgrade to new DHIS versions, shutting of the sharing of new innovations. As the DHIS was implemented in other countries, similar local workarounds started to proliferate as add-ons to the core. With exponential growth in the user base, the need for synchronization of the local development with the global code base was constantly evolving. In order for local innovations to become shared globally, they need to be made more generic and integrated with the core code base. The Dashboard module, not shareable globally, illustrates the complex problems of scaling new functionalities and innovations across countries. It requires developing a shared understanding of both the user domain, together with the software development platform and

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[1] If not stated otherwise, all subsequent mentions of DHIS refers to DHIS version 2

architectural design which enables separating clearly between the global (core) and local modules, and the adding on of local modules and their subsequent generification and inclusion.

The approach to solve the lack of compatibility between the Indian and global DHIS development was to circulate developers, the Indian went for a few months to Oslo and core developers from Oslo went to India for considerable lengths of time. The Dashboard module was pair-reprogrammed and committed to the global repository during this period. Shortly after that, the Dashboard was used with significant success at meetings with WHO in Geneva, resulting in further scaling of the DHIS.

HISP and DHIS in India: Scaling as a response to a constant pressure to de-scale

HISP India, a not-for-profit NGO, is a small group of public health informatics people who have been since 2000 struggling to keep afloat as a small start-up outfit in a large country where the formal ministry dominates, and large vendors hold sway. Being proponents of open source software (DHIS) and bottom up decentralized capacity development, the HISP approach has been at odds with the Ministry's centralized structures, having to constantly struggle with the pressure to "de-scale".

HISP first came together as an informal group of interested people, supported by the HISP global initiative of Oslo, to initiate small HIS pilots in some clinics in the states of Karnataka and Andhra Pradesh. In early 2002, they got permission to work in Andhra State, in 12 field level clinics, after having made an approach to the Chief Minister, through his IT Advisor. Entry through the political rather than the health department channel, proved out to be problematic to HISP through out their stay of 5 years in the State, as they were always viewed as "outsiders" working in a trajectory incompatible with the Health department's scheme of things. Despite this continued resistance to their presence, HISP managed to work for 5 years, expanding first from 12 clinics to a full district and then on to multiple districts and also to the state capital. But this entire process of expansion always remained fragile and vulnerable, and finally then when in 2005, the political party in power was ruled out with the elections, the fragile thread which held HISP India with the state also snapped, and their contract was finally terminated.

Following this setback, HISP needed to urgently survive, as the 15-20 people in the team were without a job. Initial visits were made to Kerala, a state which was reputed as favoring open source software, and decentralized planning. In 2005, HISP was given permission to pilot efforts in one clinic in the capital district of Trivandrum. Coincidentally, around the same time, Oslo started the development of the open-source and web-based version of DHIS2. In early 2006, the first instance of this was released, which was then installed in one clinic in Kerala. By 2008 – 2009, this same DHIS had evolved with much new functionality added, and became the state standard for routine reporting. This scaling process was enabled through the implementation efforts of HISP India who signed a MoU agreement with the State. In 2010, the elections resulted in a new party being voted into power, leading to large changes in the health department. The period of the HISP MoU was also completed at this time, and the

project not extended. However, since the DHIS was well and truly embedded in the state, its use was not disturbed by the political shake up.

While the use of DHIS was being successfully evolved in Kerala, at least three other states (Gujarat, Jharkhand and Madhya Pradesh) invited HISP to start implementing DHIS in their respective sites. Implementation progressed to different stages, and in all cases was cut short by political or administrative issues. In Gujarat, from 2006 to 2008, under the guidance of an extremely visionary Commissioner, there was the very successful implementation of DHIS to all facilities in the state, and also the development of new innovative functionalities, such as the dashboard module and integration with GIS. However, with the transfer of the Commissioner, the new incumbent decided to scrap DHIS and start a new initiative. Similar political struggles halted the project half way through in Jharkhand, and in Madhya Pradesh, the pilot did not scale as the authorities behind the pilot had been moved out.

Around the same time in 2008, a national think tank (National Health Systems Resource Centre – NHSRC) was established in Delhi to provide technical assistance to the Ministry of Health on 6 areas, one of them being HIS. HISP India, because of its extensive state and sub-state level field experience, was invited by the NHSRC to serve as their technical support partner. The DHIS was selected by the NHSRC to be presented to the states as an open source solution that could be used at the state level, supported by HISP India, and covered through NHSRC central funds. This proposal was taken up positively by the states given DHIS's features of flexibility and analysis, and more than 20 states adapted DHIS.

However, the rapid uptake of DHIS was not taken positively by the Ministry, which wanted states to use the national web portal that they were promoting through a proprietary solution. In the initial model, the states using DHIS would do the local information processing in that, and also generate the required reports that needed to be submitted to the national web portal. This portal was capable initially of accepting district level data. However, as the Ministry soon realized the popularity for sub-district data processing, they initiated processes to build similar functionalities in the portal. These technical developments were accompanied with intensive national level efforts mandating states to change over from the DHIS to the portal for all their reporting. By 2012, only half the states continued with DHIS – the scaling of 2008-2009 was accompanied with an equally rapid de-scaling in 2010-2011.

From India to Bangladesh – regional and functional scaling

In 2008, a consultant from EPOS, a German group providing technical support to the Ministry of Health, Bangladesh, on a visit to India came to meet HISP India and the DHIS. This led to EPOS creating a MoU with HISP India to provide technical support in the development of a national data warehouse. This effort fed into the global Health Metrics Network's (HMN) framework of creating a national data warehouse. During the period 2008-2010, the MOU was successfully implemented, leading to the national ministry taking to decision to adopt DHIS nationally, a process ongoing in 2012.

In parallel, the Bangladesh FPMU (Food Programme Monitoring Unit) had problems with their system (being developed by Rome UN FAO) for management of food security and

nutrition and were scouting the web for firstly an assessment of their existing system, and also for alternative solutions. They selected the Oslo Professor also a part of HISP India to carry out this mission, and after about 6 months of analysis and discussion, the FPMU decided to try and customize DHIS as their system for food security. They were given confidence by the success of DHIS in the health ministry in Bangladesh. While the collection, management and presentation of statistical data in health and agriculture share many similarities, there are also key differences as the food security system is primarily a policy support tool and not a routine MIS as is the case in Health. The use cases are quite different and policy making in agriculture relies upon extensive statistical analysis, making it needed, for example, to feed data from DHIS into statistical packages. This development will obviously also be beneficial for scaling in the health sector, where statistical number crunching is important for epidemiological analysis.

The expansion of the DHIS into the agriculture sector illustrates that when a solution is flexible and useful in one context of use it can be used with relatively minor adjustments also in other and quite different contexts of use. The process of such expansion happens when users see similarities between different contexts of use and the potential transferability of the solution. The more is the use, learning and dissemination, the more likely for users to see such similarities and how the solution can be improved or adapted to new usages, i.e. innovations.

Summarizing the politics of scaling in India

The Indian case reflects significant scaling as a system has expanded from a single clinic to become one of the largest open source implementations in the public health sector of the developing world. Further, HISP India team has over the years developed expertise in different domains such as patient based hospital information systems, and MHealth and now the new domain of food security. The HISP India team has grown from 2 persons in 2000 to 70 in 2010, and also approached external Asian markets. Significant expansion has been accompanied with rapid drops within the country, contributed most often by political events. A key motivation in HISP India's actions for driving the scaling process has been related to survival, to be able to continue to pay the salaries of their existing staff, providing the impetus to enter new domains and geographical areas. While diversification contributes to sustainability it puts pressure as focus gets diluted to multiple areas. This is an ongoing dilemma the HISP team has to deal with, playing out in their strategies for scaling.

4.3. Implementation in Sierra Leone and working with HMN and WAHO

DHIS2 was first implemented in Africa in Sierra Leone, West Africa from early 2008 in a high profile HMN project where Sierra Leone was selected as a 'Wave one' pilot country for HIS strengthening. A situation analysis and strategic planning process was carried out during 2006-07, and the plan was to start implementing a central data repository according to the HMN Technical framework. HMN were searching for candidates to carry out the technical work, and DHIS was selected in June 2007. This process was buoyed by the positive results coming in from India after 18 months of efforts which helped to convince the Ministry in Sierra Leone and HMN to go for DHIS. Implementation started early 2008, and the DHIS2

team in Oslo was put under a lot of pressure to deliver according to advanced requirements from the HMN, making Sierra Leone the lead DHIS project for Oslo over a couple of years, until the HMN as such and its interest started to dwindle. Important in this storyline is that the project was widely regarded, and promoted by the HMN, as a success and best practice, which created significant regional interest with the West African Health Organisation (WAHO). The general sentiment was that if Sierra Leone, one of the poorest countries in the world and just coming out of a civil war, is able to implement a well functioning HIS; other countries could manage also. We describe intra-country scaling dynamics from Sierra Leone.

Sierra Leone – the first implementation of DHIS2 in Africa

Sierra Leone is a small country in West Africa, with approximately 5 million inhabitants, and only as recently as 2001 has come out of a decade-long civil war. Many international organizations have been present in the rebuilding efforts, and in 2006 Sierra Leone was selected by the HMN, a Geneva-based partnership with the WHO to strengthen their HIS based on a data warehouse approach - the HMN technical framework. Since the HMN were active in about 80 countries, their choice to use DHIS in their much focused pilot in Sierra Leone was a strong impetus for DHIS scaling, both as a software application and as a network of ideology, best practices and learning.

The rebuilding of health services after the civil war led to rapid growth of various health initiatives, but within a fragmented framework as various donors nurtured their own systems. Each health facility used about 15-20 different paper based reporting tools which were not harmonised with huge overlaps, leading to very poor data quality. The agreed way forward was to use DHIS to integrate the various data flows and data sources and thereby to provide an integrated framework for data collection, management and use. To deal with the institutional reluctance to change, a two-phased strategy was chosen. First, implement the existing fragmented data reporting forms in the DHIS and thereby convince the actors of the advantage of collaboration, and second, revise, harmonise and integrate the data reporting using the DHIS as a central data warehouse. A successful data warehousing strategy was implemented, where one data element in the database was related to a field in several data collection forms, thus doing "behind the scenes" integration. In January 2008, this integrated system was implemented, accompanied with intensive training, first in four pilot districts, and six months later in more districts. The district databases were then integrated in the national database, with data sometimes moving on memory sticks, and a rather complete national data set was available for analysis during the last half of 2008. The technical integration approach was accompanied with a strong participatory process where all stakeholders were included, contributing to the identification of problems and also the solutions. At the same time, through actually doing the integration, it was also documented how it was possible to achieve shared common data sets in a national repository. By January 2009, all stakeholders agreed on new harmonised shared data collection forms to be implemented from March/April 2009, and to implement the DHIS in all districts immediately in order not to lose momentum and data.

There is no power grid in Sierra Leone and the human resource and infrastructure situation are poor, including problems with computer viruses. The project applied two innovative approaches to address these constraints: Linux servers and low-voltage computers. All

districts were equipped with dedicated Linux servers and DHIS was accessed over Wifi giving protection from the virus problem. The Wifi was used by multiple users to both capture and access data using their web-browser. The setup with low-voltage computers was less successful due to problems of low capacity and frequent failures which required spare parts from the US. The low luminous screens were also not well received by the users. Given these technical problems, the project moved to normal computers.

Sierra Leone, HMN and WAHO: legitimating the DHIS and help further scaling

Interoperability was a central part of the data warehouse approach promoted by the HMN Technical Framework, providing the impetus in 2010 to initiate the new SDMX-HD protocol for statistical data exchange developed by the WHO. A pilot was set up in a clinic in Freetown where the medical record software OpenMRS was used for managing HIV/AIDS patients and aggregate data was sent to DHIS using the SDMX-HD.

The establishment of this interoperability, even though only at a test basis, promoted by HMN, led to regional interest in "the Sierra Leone architecture", with WAHO taking the initiative to include also the iHRIS application for human resource management, developed by the US Capacity plus project, in this architecture. These initiatives, together with the fact that many countries in the were in the process of introducing the DHIS and/or the iHRIS, led to the organisation of a workshop on training in both these applications in Accra, Ghana, September 2010. The WHO organised a 'Connectathon' meeting, which led to the official launch of the SDMX-HD standard. The participation of WAHO helped provide the impetus to the rest of the region. An assessment of the HIS in the region has been carried out and based on this a HIS policy and strategy document developed and endorsed by the health ministers annual meeting in 2012. Given that about half of the 15 countries in the region have already or are in the process of implementing the DHIS, the West African policy formulation will help to legitimise DHIS as a product, and, in the name of HISP, as an embodiment of knowledge and best practices.

In 2009, DHIS was implemented in the Gambia following the same approach as in Sierra Leone with standalone district instances of the software. This created the problem of the different installations becoming partly incompatible with the master version. We may summarise that the change in technology, from MS Office and Access to web based, had not brought any advantage as the Internet, although being developed in Gambia, was not yet being used. While Sierra Leone had significant funding available because of donor interest, Gambia was not resourced, seriously impeding scaling. The lesson from both countries was that it is challenging to implement and maintain national systems based on standalone instances. This learning was the prelude to the "use of the cloud infrastructure".

4.4. DHIS going online - Cloud infrastructure in Kenya

Influenced by the achievements of the DHIS as promoted by the HMN, the Ministry of Health in Kenya decided to use the DHIS in October the same year. While the decision was to implement a web based system, the national Internet connectivity was not seen as good enough to allow for a central server solution nationally. The plan was therefore to implement

standalone instances in districts and hospitals around the country, but a field visit to Machako in October 2010, a district and hospital not far from Nairobi, changed the course of action. Testing the DHIS online server in the information office, everything went well until a power cut left the line dead. As it was a hospital, the generator started and power came back, but the Internet was gone. The team was just about to conclude that Internet is still not there, when a staff suggested to use his "dongle", which worked fine, as mobile networks are not affected by power cuts. Immediately after this revelation, Internet modems were tested around the country, it worked, and the decision was taken to go for a central server solution, probably the first time for such a country-wide public sector project in Africa. However, the server in the Ministry of Health could not be used, as the connectivity was poor in the building and the server setup not reliable. As a temporary solution, therefore, a commercial server was rented – through a London based company, meaning cloud computing for real, although politically it was not seen as acceptable to locate national health data outside the country. The Coast province was selected as a pilot, and the system implemented in January 2011 to all districts and hospitals. The pilot was successful and the rest of the country was covered during April-October.

 All users were provided a modem and a budget for airtime. The network was working, but the bandwidth was limited many places, and the cost of airtime restricted the amount of time online. In order to address a multitude of problems, the DHIS lab was literally moved to Kenya; the lead developer and others took part in building a local team and to address numerous user requests in rapid prototyping cycles on site with the users. Working on an online server meant that changes made as responses to requests from users could be implemented for all users immediately or overnight, enabling a new and more direct way to conduct user-driven design and innovation. This would not have been possible with standalone instances. The central server and the Internet is changing this situation totally.

Three examples of such users-driven innovations: 1) the need for communication between developers and users both in the testing and exploration of new functionalities as well as more general user support led to the implementation of online messaging in the DHIS enabling users to communicate with the developers, and with each other. The messaging system developed following these requests have proven crucial in the countrywide deployment of the DHIS. 2) To be able to capture data and work on it offline was an important user request. Using the new HTML 5 standard, which is enabling more data storage in the browser, a "semi-online" feature was implemented in DHIS late August 2011. The user can now capture data offline by using the memory in the browser and transfer the data when online. 3) Offline data-use in a cloud based infrastructure is the other important feature needed to optimize the system in areas with poor Internet. A small "super lightweight DHIS" application installed locally is used to download specified data, which is then used to generate Excel pivot tables used for data analysis. This rapid national deployment has been made possible by the cloud based infrastructure on a central server approach, coupled with ongoing participatory innovation with new features added "while in full production".

4.5. Tracker in Uganda and Ghana – new ways of using DHIS

The successful "online" implementation in Kenya led other countries in the region, Rwanda, Uganda and Tanzania, to adopt similar approaches and it inspired Ghana back in West Africa to implement a fully online solution in 2012. In both Ghana and Uganda, the customization of the DHIS was initiated 2011 and implemented using central server and 'cloud infrastructure' during the first half of 2012. As in Kenya, the deployment in the two countries was carried out rapidly, with Ghana even a full 'switch-over' taking place during the month of April 2012. This was made possible because the new online system replaced and to some extent mimicked a standalone system used to report much of the same data.

The Ghana and Uganda projects are interesting because they were both taking up in their own way and further developing two different DHIS features addressing individual patient data first developed in India. The two features in question both capture data on individuals, but respond to very different use cases. While the first one represented a minimal requirement of an individual record system, anonymous non-trackable line listing of cases, the other represented more of a maximum requirement; the ability to track a pregnant mother through the services of ante natal care, delivery and post natal care and immunisation of the babies. A line-listing system had earlier been developed in India as a local ad-hoc prototype not incorporated in and aligned with the global DHIS core, meaning that it could not be shared globally. While compulsory registration and tracking of all pregnant mothers was introduced in India in 2009, unfortunately, due to politics in India mandating the use of a centralised government system, the development of the tracker module did not come very far. As additional requirements to the DHIS implementation in Uganda and Ghana, both these two features (line listing and tracker) from India were brought forward. While in Ghana, the requirement was to include a line listing module for individual anonymous cases following the ICD10 codes, in Uganda the requirement was to use the tracker in a project for continuous care from pregnancy through to delivery and post-natal care. In Ghana, rather than taking the prototype not well incorporated into the DHIS2, they implemented the functional specification using the tracker module by making a workaround. The registration of names and dismissing the tracking functionality where patients were assumed to pass through the stages of a health program, such as e.g. the immunization schedule. The use case in Uganda was very similar to the originally intended use in India and this project became the driver for further development on this module.

In a new conceptualization of the tracker, the use cases and solutions were now rather seen as a continuum where the Ghana anonymous one-off cases represented the low-end and the Uganda use-case represented the high-end of complexity. Both in Uganda and in Ghana, it was the large national DHIS project that provided the framework in which the further exploration of the tracker module could take place. The interesting issue here is that the circulation of HISP facilitators between India, Kenya, Ghana and Uganda enabled the merging of requirements, use cases and innovations into one comprehensive framework forming the basis for a generic module in the DHIS which can be localised and applied in other countries. Already, for example, learning from the more simple case based setup in Ghana, the module is being customized for reporting of morbidity and mortality cases using

the ICD10 codes in Kenya. Thus further illustrating how learning and movements of best practices are travelling in the network. Sometimes practices and solutions are carried from place to place as use cases, best practices and specifications, that is as ideas and text. The line listing prototype system developed in India illustrates movement as a use case and specification to Ghana where it is implemented anew, now including ICD10 codes. From Ghana the use case and solution moved to Kenya as a material artifact incorporated in the DHIS core code repository.

5. Case Analysis
Global scaling: One step back and two or many steps forward – cyclic development

Abstracting from the different experiences and stories described in the case study, we can see global scaling of an artefact like DHIS taking place at two inter-connected levels of the global (or "shared") and the local. A more general trajectory that can be abstracted is of a process where the DHIS starts to be introduced and embedded in a particular country context, and at the same time, the learning and innovations which such an embedding should give rise to, should feed back to the global and become part of the shared repository. The more these innovations are shared globally, the greater is the potential for the artefact to be introduced to new contexts both in terms of geography and functional areas – global scaling. Absence of local innovations, as we can say was the situation with the experiences of implementing DHIS in Cuba or Mozambique, or a non-responsive global development group, can impede global scaling processes.

Innovations are carried out as cyclic processes within and between two distinct levels of the DHIS software platform and the wider network of development and implementation. At the software level, the global 'core' application platform is being continuously evolved based on feedback from countries and users. At the next level, a country or use organization will then take this his empty 'shell' and populate it with meta data, and customize a local instance of the DHIS application, leading to a cyclic interplay between these two levels. Features are ideally developed locally as plug-ins to the global core which then enables the upgrade to new versions. In other cases, new requirements are so profound that the global shared core application needs to be further developed. In such a case, users feedback requirements to the global team shaping the 'roadmap' for development. The current deployment of DHIS for the new domain of food security in Bangladesh has raised the demand for new functionalities, such as for inferential statistics. This has led to the new demand in the roadmap of DHIS2 being integrated with an open source statistical language called R. For effective scaling, this integration should be carried out in a generic manner, to enable its use in other countries and feeding back to the use context of health.

This interactive innovative scaling process may thus be seen as a process of going one step ahead, that is to take the global application and develop a new local feature such as the dashboard in India, but then taking one step back and redevelop it as a global generic tool. Thereafter the development can take two or many steps ahead, if the dashboard can be made available for all DHIS users not only in India but also in other countries. In Latour's framework of loss and gain in the circulating reference, while there is gain through

innovations, there may be loss while making it general (India's loss in redoing the Dashboard), but gain as the general becomes more widely available. This is due to the double 'dimension' of the DHIS; it is both a local adaptation to a specific context and a generic tool which can be localized to multiple contexts. The DHIS is therefore not losing the local specifics in the process of being generalized, rather it is being enabled to become even better localized and adapted to the local context, in more sites. To paraphrase Latour's words; its gain, then loss, but then again double gains. Or one step back and then two or many steps forward. At any point in time, there are several concurrent steps being taken back and forward throughout the HISP network; local specific innovations that will in turn lead to a generalized re-make of the core software to allow other users to adopt the new features, leading to yet more innovation.

The DHIS2, as a software is thus both specific and generic - two properties. In this section, we present a discussion on both the characteristics of these two sets of interconnected processes, and also the mechanisms or drivers of change.

Trajectories, coincidences and unintended consequences

The trajectory of the DHIS as it is drawn up in this case story may appear arbitrary as a stone being kicked around at both the global and local levels, as it moves from South Africa to India and from there to West Africa, then to Kenya and East Africa, before it goes back to Ghana and then India. Within each of these countries there are similar sets of processes, such as between and within states in India or districts in Sierra Leone. Scaling is surely not a linear process, as it is often made out to be. Part of this confusing trajectory arises from our perspectives as story tellers and the case material which we selectively choose to present. However, coincidences and unintended effects also make up a big part of it. Coincidences may be of particular importance for a small and weak organization as the one you find around DHIS , as they are drifting as in open sea without the possibility to invest and ensemble strong partners for implementing 'marketing' strategies. Chance thus becomes of crucial importance over planned strategies. For example, the fact that the DHIS and HMN teams happened to be in Sierra Leone at the same time was a chance event with led to significant scaling implications. There was an unintended match here between two sets of processes – HMN's search for a technical data warehouse solution and the maturing of DHIS in India. This match became a major driver of the DHIS scaling processes. In the past, these coincidences have also had adverse implications, like in Ethiopia and Mozambique, where HISP India got into "David and Goliath" kind of battles against an international aid agency, and were 'thrown' out due to political pressure. But these cases, as failures more generally, are difficult to account for because they do not materialize and history is 'written by the victors', at least those who are left to tell the story.

Politics as the driver of scaling, de-scaling and then sometimes re-scaling

Political legitimacy, or lack thereof, are key issues driving scaling processes of both the DHIS as an artifact and the HISP as a network including concrete legal entities such as HISP India. HISP India, since its inception in 2000, have been engaged with political conditions arising from state requirements, large vendors, and the federal-state relationships were the former

mandates centralized systems. From 2009, when DHIS was introduced in about 25 states because of a visionary bureaucrat, it was de-scaled to 10 states as the federal level mandated the use of a different, national system. However, in 2012, states were finding it increasingly difficult to use the centralized system for their local analysis, and started to develop bilateral agreements with HISP India for using DHIS. A process of re-scaling was initiated, as DHIS gained ground to about 15 states, and also started to establish its presence in Bangladesh and also in new domains of Food Security. The pressures to de-scale catalyzed HISP India to innovate and stand up to the scaling challenge. As a result, HISP India has survived and is therefore able to tell the story, while in Ethiopia and Mozambique where years of effort were spent only for HISP to be thrown out, the story is fading, existing only as memory traces in some of the HISP members who were then present – a decade ago. The de-scaling did not give rise to a re-scaling, at least within the framework of a decade, but we don't rule out future possibilities. As the case of Sierra Leone demonstrates, political support is a key driver, especially when it's legitimacy is derived from global entities like HMN. But political support on its own cannot sustain scaling, and it is only garnered from being able to respond to user needs, and finding acceptance in the "local" context. In Sierra Leone, it was a significant achievement to be able to join all stakeholders in a process to revise and integrate the previously fragmented data reporting coming from multiple sources using the DHIS as the data warehouse. Success in this process helped to convince both local stakeholders and regional authorities (WAHO) to support DHIS as the broad integration approach. The erosion of the HMN as a global force indeed slowed down efforts of global scaling, but the DHIS could be said to have reach a stage of "irreversibility" to be able to have a life of its own even without this global impetus. The legitimacy in the region now comes as much from association with WAHO as from HMN.

It is difficult to describe a case which ended long ago and it is only natural that the stories told are from 'surviving' cases, like the success in West Africa, or the ongoing (last 15 years) successful story of the DHISv1 in South Africa, and the struggles of India. What must be emphasized is that in all these surviving cases, political standing and legitimacy have accumulated, and the greater the survival and success, the more political legitimacy is obtained. This is an important ingredient for scaling at both levels of local and global.

User driven innovations: cause and effect of scaling

We take a practical approach to understand innovation – from a user perspective of being able to do existing work more effectively, and to carry out new tasks with the innovation. Essentially, it implies providing solutions to support demands from users. In the early days of the DHIS in India we saw how several solutions, such as the Dashboard being developed to provide users with their data at "a push of a button". The struggle to give users direct access to their own data has been a driver of innovations in the DHIS since early days in South Africa, where specially designed Excel pivot tables were used as the tool to present data. In Kenya, the development of providing end-users access to their own data has led to both online access to tools to visualize and use your data in an offline mode. All these developments have been driven by user needs and involved a close process of user participation. Technical developments, such as the implementation of the DHIS on a central server, has both created

the need for and also facilitated the spread of the innovation. The server has facilitated the cycle of interaction between the users, their expression of needs, its action by the development team, and its spreading back to the user community. Such a cycle would have been very difficult if not impossible to implement in a standalone mode of deployment. In Kenya, users in multiple locations could test out new functionality 'live' once installed at the server. New functionalities, bug-fixing and other improvements can then be carried out 'on the fly' or overnight. The online messaging implemented in DHIS enabling users and developers to communicate and feed back to each other, represent yet another innovation enhancing such user participation.

An important aspect of our perspective is that innovations scale only when they circulate and are "transferable" across multiple contexts of use – from the local to the global. While the Indian dashboard was a success in India, because of the hard-coded nature of its design, it could not be shared and integrated with the global repository. It ultimately "died" and was replaced by the data visualizer created by the global team, by design made for multiple contexts. Scaling depends on rapid innovations of new features and functionalities and generator of such innovations. As the software is introduced to new countries and use-areas, it will have to change, adapt and provide new and improved solutions, else it will de-scale and perish. Stability is never a given, and without an ongoing process of creating innovations, and leveraging innovations from shared to local contexts, global scaling will not take place.

The process of scaling is thus bringing the software at the 'bleeding edge' of development where different user groups are constantly challenging the possibility given by the constantly changing and developing web-technologies. The case of Kenya challenges the status quo "of Africa not being ready for online 'cloud computing'"(WHO, 2012), and new solutions based on the mobile network and modems have emerged. Arguably, implementing DHIS on cloud infrastructure in Kenya and providing country wide online access through modems over the mobile network represents a case of massive 'leapfrogging' – first a whole country, and very soon the whole continent of Africa. This infrastructure has enabled the DHIS to be rolled out in Kenya and covered the whole country in less than 6 months, and Ghana has switched over from offline to online modus during one month. These examples are changing the course of history, as it has mobilized several other African countries to follow the same route. Infrastructure-driven innovations have mobilized user innovations and scaling.

The online deployment of DHIS in Africa represented 'overnight' a change from a large number of installations, one for each district office, hospital or other use sites, to only one installation in the 'cloud'. In Kenya the physical server and installation was in fact in London. What does this mean for the materiality of the software that is being scaled? We see that the ease of scaling has drastically improved with the diminishing of the physical materiality. The 'materiality' linked to local hardware, software versioning and maintenance is replaced by a much simpler maintenance of computer hardware which can be accessed by any computer in the network. This reconfiguration has implications on competence, with users requiring much less technical competence as compared to the higher competence needed to maintain the central server.

Summarizing case analysis: what is being scaled at the level of ideas and principles?

DHIS2 scaling involves the circulation of a range of 'things', from concrete organizations such as HISP India to more abstract principles such as the HMN technical framework. Two sets of health information principles are key to the DHIS story: 1) the principles of information for action and local management developed by the HISP South Africa; and, 2) the HIS architecture principles as a part of the HMN Technical Framework. DHIS scaling has involved the circulation of these principles, such as in Sierra Leone where the HMN framework was materialized into a concrete implementation on the ground. This materialization was quite fundamental as the original conceptual architecture had a clear 'Western' bias and assumed a computerized environment where all data were available in digital format. This was translated to the reality in Sierra Leone and other countries in Africa where data sources were paper based, and required data warehousing principles to be significantly amended. Where, for example the Western data warehouse architecture prescribes 'Extract, Transform and Load' digital data, the African translation will include harmonization of paper based sources and organizational measures and procedures and technical solutions for capturing data from paper based forms. This learning was abstracted, refined and turned into concrete principles and written up as, for example, in the WAHO HIS policy document covering 16 countries.

The other ideology or set of principles of 'information for action' and 'local empowerment' represents a broader ideology of 'decentralised management' which has been translated into design inscriptions in the DHIS, such as the principles of essential data and the use of indicators rather than raw data. User friendly ways to analyse and present information using maps and graphs represent another line of software features enabling local use of information. Local empowerment is more generally pursued through the flexible metadata structure making it easy to modify and extend the system locally. We have seen that local users in rural Kenya are excited by the fact that they can access their own data, and compare it with neighboring facilities and districts – or country wide - online using their modem to the Internet over the mobile network, literally at any time and from anywhere. Before DHIS, this data was barely available at all and only in paper based annual reports.

Abstracting from these stories, we see global scaling, at the inter-connected levels of the global (or shared) ad local, to be influenced broadly by 4 sets of inter-connected conditions of infrastructure, software, institutional practices and ideas. We synthesize this learning into a model for global scaling in the following Discussion section.

Discussion

Discussions: Global scaling - Same, Same but different

After the analysis presented in the previous section, at a higher level of abstraction and generalization, we discuss the theoretical implications of our findings with respect to the phenomenon of global scaling of HIS. By following the trajectory of the DHIS artifact for over 15 years, we bring in a strong temporal perspective into the analysis of this process of scaling. We take a view on scaling that is similar to how the Buddhists see reincarnation:

taking a candle to light another candle, so that the flame of the old burns on in the new. Similarly, we see that even though the DHIS which was originally born in South Africa as a standalone, Access based system, has now been transformed into a Java based web application being used in multiple contexts, there are elements of the "old" which " live on with the "new". Thus as global scaling takes place, we see there are elements both of sameness and difference with respect to what was left behind – as Latour would describe this as a "circulating reference." We conceptualize this process as "circulating translation" as the movement of the artifact over the years takes place in many small steps or translations, and at each step we see "same, same, but different."

To help unpack the above dynamics around the process of circulating translations, we start by providing an overall schematic of our theoretical conceptualization of global scaling, and then discuss that.
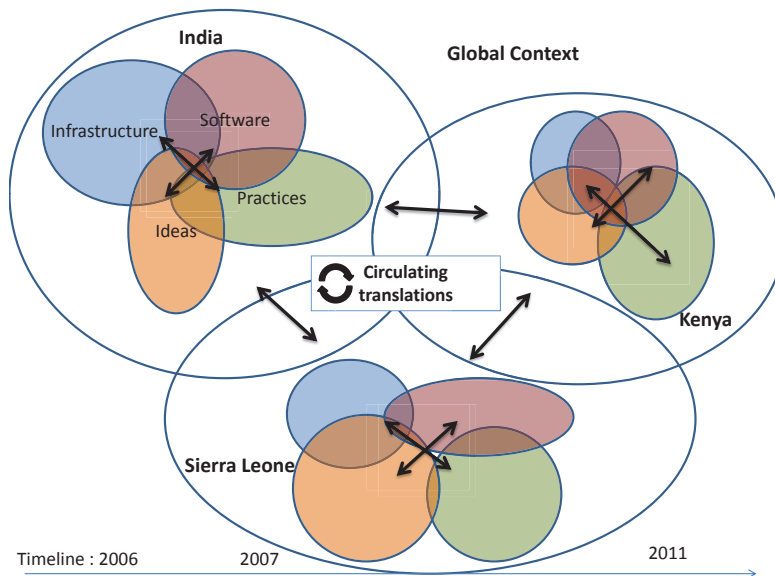

Figure 1: Theoretical conceptualization of global scaling of HIS.

The figure is composed of the following components:

1. ***Four key dimensions*** of global scaling including infrastructure, software, practices, and ideas. These dimensions reflect diminishing degrees of "immateriality" – while infrastructure is most material, ideas are least so. In that continuum are software and practices. The four dimensions are described:

    Infrastructure: With this we think of the physical artefacts - networks, power supply, computers, bandwidth, and other physical elements.
    Software: an artefact, but different from "traditional" technological artefacts like machines in that it represents a form of "virtual immateriality", which enables its relative ease in circulation as compared to physical artefacts like machines.

Practices: Patterns of action, routines, institutions, skills and knowledge that constitute how people carry out their everyday work. For example, the routines of how data is captured, registered and transmitted, or practices of supervision.
Ideas: The underlying ideologies, logics and philosophies underlying practices. Important in the HIS field are perspectives on the role of information, centralized vs. decentralized decision making, perspectives on open source software, and wider social acceptance of accountability and transparency.

2. *Intra-context dynamics* – which we term as "interaction effects" refers to how these four dimensions mutually influence or not each other. Within a context, while in our example, relates to countries (India, Sierra Leone etc), they could very well involve provinces or districts within a country, or different health programs within a particular health system. Interaction effects, for example, could represent how improvements in infrastructure can change how software is designed and applied, and the practices and ideas surrounding this. Our case describes how the "discovery" of the application of mobile internet in Kenya, helped to revolutionize the entire implementation process bringing in new practices.

3. *Inter-context dynamics* – which we term as "constellation effects" representing how different contexts, including its constellation of the four dimensions, influence each other. For example, how new software functionalities developed in India, in addition to redefining interaction effects within its context, also influenced software use in Kenya and Sierra Leone – constellation effects – with each of them also triggering respective interaction effects in their local settings.

The above defined interaction and constellation effects take place in contexts of respective countries and the global respectively. We argue that these taken together create *"circulating translations"* implying that changes or translations within or across countries take place in small steps, and with each is associated a simultaneous process of gain and loss, every move forward points to something left behind – scaling is about a circulating translation. We illustrate this with two examples:

1. The translation from stand alone deployment of DHIS to increasing degrees of the "cloud".

2. The birth of the "information for action" ideology in South Africa, and its steady dissipation over the years.

Example 1 to Illustrate the model: Translations from standalone to increasing degrees of the "cloud":

Microsoft Office was the defacto standard of available infrastructure in post-apartheid South Africa, shaping the decision of DHIS v1 to be developed as a standalone system on Access platform. The development was shaped by strong ideology and ideas related to "empowerment of the coal face" and participatory design (Braa and Hedberg 2002). Practices of participatory design implied a strong involvement of public health practitioners (nurses and

doctors) in shaping the development trajectory of DHIS, and led to strong inscriptions of "information for action" in the software. The rapid uptake of the software led to the DHIS becoming a national standard in South Africa by 2001, and its proliferation to all facilities – "physically installed" in the computers there. The interaction effects between hardware, software, practices and ideas were clearly evident.

In 2004, when the DHIS2 development was initiated on Java platform, the DHIS v1 was taken as the basis for requirement – ensuring "the old lives on in the new". However, the sameness was tempered with a great deal of difference as the development platform, methodology and practices changed – going for more distributed development – and very different software development practices. The new software approach had implications on the infrastructure (server based deployment), and different practices for training, such as strengthening capacities in server administration. The ideas too were influenced, as participatory design took on a new form, and driven more significantly by the technologists than the public health people as was the case in South Africa. The DHIS2 developed and deployed for the first time in India had constellation effects in Sierra Leone, where through the HMN, the DHIS2 was introduced. However, there were rather different interaction effects there, as the absence of a power grid and supply in Sierra Leone meant that local district level systems had to be deployed. The HMN placed the DHIS2 within a different ideology – ie of an integrated technical framework being promoted from Geneva, giving it a global dimension.

When DHIS2 was later introduced in Kenya, a way was found to achieve the first real online deployment using mobile modems and the cellular network. This had significant implications on the management and logistics of the system, as it also solved the problems of keeping tens and hundreds of database deployments in sync. The work on the software to allow this to function even when temporarily offline opened up possibilities of use in yet other countries, with Ghana adopting the same setup. Coming full circle, with the software translated in Kenya within the new platform, the new developments (for example, the introduction of messaging services) are now coming back to India and Sierra Leone. This reflects our point about the back and forth movement that is necessarily inherent in global scaling.

Even as the DHIS2 evolved, and moved to multiple countries, in South Africa, where it all began, they have not yet been able to make the transition to DHIS2. The existing installed base – both materially (its physical installations) and ideologically ("Africa is not ready for the Web") – have impeded this transition. Maybe there is a loss there? However, in the DHIS2 network more broadly, there is a significant loss in terms of the public health driven information for action agenda, as the technologists hold more sway. We discuss this loss and gain in our next example.

Example 2: The birth of the "information for action" ideology in South Africa, and its steady dissipation over the years

A driving force from the very start of HISP was "information for action", giving primacy to public health management needs over technical ones. South Africa successfully, through a long and political process, established this with a minimum, essential health data set, and a strong focus on regular data analysis for decentralized evaluation and action planning. Only

what was needed for regular management should be covered by the system, data needed for "peripheral" activities should not clog the papers, computers, charts and minds of the health staff. The focus was on "essential" and not "useful to know" or "useless to know" data.

Through a cycle of translations, we can track how this concept has taken more of a background position in other countries. Firstly, post 2005, the informatics people at Oslo became responsible for defining the trajectory of the artifact, naturally making the public health inputs relatively marginal. The interaction effects between the four identified dimensions quickly started to erode the information for action concept in countries like Cuba and Tajikistan, where it found little room in the centralized, socialist environments. DHIS was largely instead translated to serve the existing ideological paradigm. Furthermore, in many of the countries – example Cuba, Tajikistan, India – the statisticians dominated in the respective national ministries of health. They favored the ideology of "more data is better" (Lewis and Sahay 2011) helping to further erode the focus on local action. The introduction of powerful servers into the introduction lifted constraints on data handling, encouraging more and more data to be sent to the national level, making local action an increasingly difficult task.

In various other countries, the primary focus was to focus data supply to the information needs of the international donors. The notion of "essential data" was thus transformed from what was required for local action to that what was going out of the country, with implications for continued money flows. This shift had implications on practices around training, as material started to be developed on "how to make reports for donor X". Finally, the centralization of the software development to Oslo, geographically and culturally distant from local contexts of use, reduced the regular and intimate interaction of the developers with the end-users including the doctors and nurses as was the case in South Africa. While the information for action paradigm was well known by core HISP members, it was not so well understood and practiced by the second generation HISP members, where the technical focus was greater. It was not any longer what drove data management improvement, to the degree it had in South Africa.

Lately this concept has faced some force from changing constellations originating in the global context. With increased attention on measuring effects of aid (declarations, HMN) and pay-for-performance schemes, the focus is again on actionable information, albeit in a top-down manner. With the constellation and interaction effects again towards global and national information use, information for action has been translated towards a hybridization of its earlier phases.

Conclusions

We have in this paper described the scaling of software and best practices between several countries, and within these countries. This paper contributes to move forward our thinking in the domains of scaling and technology transfer. The process of circulation is described as being non-linear, with gains and losses, taking place in small steps and involving an ongoing redefinition of socio-technical configuration. Such a conceptualization can inform our thinking of scaling and technology transfer, for HIS particularly, and information systems more generally.

References:

Avison, D., Lau, F., Myers, M. D., & Nielsen, P. A. (1999). Action Research. *Communications of the ACM, 42*(1), 94-97.

Barley, S. R. (1986). Technology as an Occasion for Structuring: Evidence from Observations of CT Scanners and the Social Order of Radiology Departments. *Administrative Science Quarterly, 31*, 78-108.

Baskerville, R. L. (1999). Investigating information systems with action research. *Communications of the AIS, 2*(3es), 4.

Baskerville, R. L., & Wood-Harper, A. T. A Critical Perspective on Action Research as a Method for Information Systems Research In M. D. Myers & D. Avison (Eds.), *Qualitative Research in Information Systems* (pp. 129-145): Sage Publications.

Bondi, A. B. (2000). *Characteristics of Scalability and Their Impact on Performance.* Paper presented at the WOSP 2000.

Braa, J. (1997). *Use and Design of Information Technology in Third World Contexts with a focus on the Health Sector, Case Studies from Mongolia and South Africa.* PhD, University of Oslo, Oslo.

Braa, J. (2005). A data warehouse approach can manage multiple data sets. *Bulletin of the World Health Organization, 83*, 638-639.

Braa, J., Hanseth, O., Heywood, A., Mohammed, W., & Shaw, V. (2007). Developing health information systems in developing countries: The flexible standards strategy. [Article]. *MIS Quarterly, 31*(2), 381-402.

Braa, J., & Hedberg, C. (2002). The Struggle for District-Based Health Information Systems in South Africa. *The Information Society, 18*, 113-127.

Braa, J., Monteiro, E., & Reinert, E. (1995). Technology transfer vs. technological learning: IT-infrastructure and health care in developing countries. *IT for Development, 6*(1), 15-23.

Braa, J., Monteiro, E., & Sahay, S. (2004). Networks of Action: Sustainable Health Information Systems Across Developing Countries. *MIS Quarterly, 28*(3), 337-362.

Braa, J., & Sahay, S. (2012). *Integrated Health Information Architecture: Power to the Users*. New Delhi: Matrix Publishers.

Bødker, S., Ehn, P., Knudsen, J. L., Kyng, M., & Madsen, K. (1988). *Computer support for cooperative design (invited paper)*. Paper presented at the Proceedings of the 1988 ACM conference on Computer-supported cooperative work, Portland, Oregon, United States.

Checkland, P., & Holwell, S. (1998). Action Research: Its Nature and Validity. *Systemic Practice and Action Research, 11*(1), 9-21. doi: 10.1023/A:1022908820784

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 319-340.

Davison, R., Martinsons, M., & Kock, N. (2004). Principles of canonical action research. *Information systems journal, 14*(1), 65-86.

Engelstad, P. H., & Gustavsen, B. (1993). Swedish Network Development for Implementing National Work Reform Strategy. *Human Relations, 46*(2), 219-248. doi: 10.1177/001872679304600205

Eoyang, G. H. (1996). Complex? Yes! Adaptive? Well, Maybe... *Interactions, 3*, 31.

Heeks, R., Mundy, D., & Salazar, A. (1999). Why Health Care Information Systems Succeed or Fail *Information Systems for Public Sector Management*. Manchester: Institute for Development Policy and Management.

Latour, B. (1999). *Pandora's Hope, Essays on the Reality of Science Studies*. Cambridge, Massachusetts: Harvard University Press.

Law, J. (1996). Traduction/Trahison: Notes on ANT. Retrieved from http://www.lancs.ac.uk/fass/sociology/papers/law-traduction-trahison.pdf

Lemley, M., & Lessig, L. (2001). *The End of End-to-End: Preserving the Architecture of the Internet in the Broadband Era*. Working Paper No. 207. Stanford Law School, John M. Olin Program in Law and Economics.

Lind, P. (1990). *Computerization in Developing Countries: Model and Reality*: Routledge.

Monteiro, E., & Rolland, K. H. (2002). Balancing the Local and the Global in Infrastructural Information Systems. *The Information Society, 18*, 87-100.

Nhampossa, J. L. (2005). *RE-THINKING TECHNOLOGY TRANSFER AS TECHNOLOGY TRANSLATION: A CASE STUDY OF HEALTH INFORMATION SYSTEMS IN MOZAMBIQUE.* Doctor Scientarum, University of Oslo, Oslo.

Orlikowski, W. (1992). The Duality of Technology: Rethinking the Concept of Technology in Organizations. *Organization Science, 3*(3), 398-427.

Reinert, E. (2007). *How Rich Countries Got Rich ... and Why Poor Countries Stay Poor*. London: Constable.

Rogers, E. M. (1962). *Diffusion of innovations*: Free Press of Glencoe.

Sahay, S., & Robey, D. (1992). *Social Construction of Geographic Information Systems: Some Preliminary Impressions*. Paper presented at the ICIS.

Sahay, S., & Walsham, G. (2006). Scaling of health information systems in India: Challenges and approaches. *Information Technology for Development, 12*(3), 185-200. doi: 10.1002/itdj.20041

Shaw, V., Mengiste, S., & Braa, J. (2007). *Scaling of Health Information Systems in Nigeria and Ethiopia: Considering the options.* Paper presented at the IFIP 9.4, Sao Paulo.

Suchman, L. (2002). Located accountabilities in technology production. *Scandinavian Journal of Information Systems, 14*(2).

Swanson, E. B., & Ramiller, N. C. (2004). Innovating mindfully with technology. *MIS Quarterly, 28*(4), 553-583.

Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science, 46*(2), 186-204. doi: 10.1287/mnsc.46.2.186.11926

Venkatesh, V., Morris, M. G., Gordon, B. D., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly, 27*(3), 425-478.

WHO. (2012). Measuring the impact of e-health. *Bulletin of the World Health Organization, 90*(5), 326-327. doi: 10.2471/BLT.12.020512

Zittrain, J. (2006). The Generative Internet. *University of Oxford Faculty of Law Legal Studies Research Paper Series,* (28 2006), 1974-2040. Retrieved from http://www.harvardlawreview.org/issues/119/may06/zittrain.pdf