

From technology for information to information for local action: the role of participatory networks from case studies in India

By

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Abbreviation and Acronyms used

AIHS – Academy for International Health Studies
AIIMS – All India Institute of Medical Sciences
ANC – Ante Natal Care
ANM – Auxiliary Nurse Midwife
BCG – Bacillus Calmette-Guerin
BCT – Bhoruka Charitable Trust
CA – Chartered Accountant
CEmOC – Comprehensive Emergency Obstetric Care
CHC – Community Health Centre
CM&HO – Chief Medical and Health Officer
CMO – Chief Medical Officer
CRHSP – Comprehensive Rural Health Services Project
DFID – Department of International Development
DGHS – Directorate General of Health Services
DHIS2 – District Health Information Software Version 2
DHS – District Health Society
DM& HO – District Medical and Health Officer
DMO – District Medical Officer
DMS – Dashboard Monitoring System
DoHFW – Department of Health and Family Welfare
DPM – District Program Manager
DPMU – District Program Management Unit
DPT – Diphtheria, pertussis, tetanus
ENT – Ear, Nose & Throat
FHIMS – Family Health Information Management System
FRU – First Referral Unit
GDP – Gross Domestic Product
GIS – Geographic Information System
GOI – Government of India
GPRS – General Packet Radio Service
HIS – Health Information System
HIS – Heath Information System
HISP – Health Information Systems Programme
HISP India – Health Information Systems Programme, India
HIV/ADS – Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome
HMIS – Health Management Information System
IAS – Indian Administrative Service
ICT – Information Communication Technology
IDSP – Integrated Disease Surveillance Programme
IEC – Information Education and Communication
IFI – Department of Informatics
IHC – India Health Care

IPD – In Patient Department
IPHS – Indian Public Health Standard
IS – Information System
IT – Information Technology
JHI – Junior Health Inspector
JPHN – Junior Public Health Nurse
LAN – Local Area Network
LHV – Lady Health Visitor
M&E – Monitoring and Evaluation
MBA – Master in Business Administration
MCHS – Maternal and Child Health System
MDG – Millennium Development Goal
MIS – Management Information System
MoHFW – Ministry of Health and Family Welfare
MOU – Memorandum of Understanding
MPHS – Multi-Purpose Household Survey
NGO – Non Government Organization
NHSRC – National Health Systems Resource Centre
NLEP – National Leprosy Eradication Programme
NORAD – Norwegian Agency for Development Cooperation
NRHM – National Rural Health Mission
NVBCP – National Vector Borne Control Programme
OMR – Optical Marker Reader
OPD – Out Patient Department
PD – Participatory Design
PDA – Personal Digital Assistant
PHC – Primary Health Centre
RCH – Reproductive Child Health
RIMS – Routine Information Monitoring System
RNTCP – Revised National TB Control Programme
SC – Sub-Centre
SDA – Symptom Diagnosis and Action
SDMX-HD – Statistical Data and Metadata Exchange-Health Domain
SMS – Short Message Service
SPMU – State Program Management Unit
TB – Tuberculosis
TCS – Tata Consultancy Services
TT – Tetanus Toxoide
UIO – University of Oslo
USAID – United States Agency for International Development
WHO – World Health Organization
WITFOR – World Information Technology Forum

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Abstract

A common research finding from various studies of health information system in developing countries is that data collected is generally not used for supporting local action. As a result, large amounts of investments being made into computer based health information systems have not realized their promised potential. While various researchers have tried to identify the reasons behind this limited use of information for local action in different contexts, far less is known about what can be done to address this situation. This thesis presents an action research study in the Indian public health system, focusing on the question of how information use for local action can be strengthened, so technology is not seen as an end in itself but a means to generate relevant information.

Theoretically, two sets of concepts provide the foundation to this thesis. The first concerns *metis* concerning local knowledge related to the domains of technology, the application area of public health, and the manner it is situated within particular contexts of implementation and use. *Metis* is used as a concept to understand local knowledge, and is a concept proposed by James Scott (1998) from Political Science in the context of large state level systems geared towards managing different aspects of population-based systems such as related to cadastral mapping or identification systems. The distinguishing aspect of *metis* is its focus on the practical value that local knowledge provides in solving complex field level problems, rather than on its abstract, theoretical and universal benefits. In this thesis, the concept of *metis* helps to focus on understanding the concrete aspects of local knowledge (related to technology and public health) and the practical benefits that provides towards strengthening the use of

information for local action.

The second concept is of *participatory networks* (Puri et. al. 2009) which helps to understand how local knowledge of the implementation and use context is understood, articulated and fed into systems development process in order that it is inscribed in the design of the application. Participatory design has its origins in the principles of participatory design drawn particularly from the Scandinavian tradition, but expanded by drawing upon the notion of “networks of action” (Braa et al 2004). Participatory networks then represents a concept of how local knowledge from multiple concepts of implementation and use, can be inter-linked with processes of systems development conceptualized as a broader process of socio-cultural change. Addressing multiple contexts of implementation and use enables the sharing and learning across different nodes of the participatory network, vital to address the crucial challenge of the scale of HIS (Shaw 2009).

Taken together, metis and participatory helps us to understand and also in shaping processes of system development, at both the country and global levels. While metis helps to focus on the constitutive aspect of the participatory network, while its link with processes of system development draws attention to the instrumental aspect of participatory networks.

Empirically, the thesis is grounded within the framework of the Health Information Systems Programme (HISP) initiative, ongoing in India since 2000 in which I have been intimately involved from the very beginning. My thesis focuses on the story, post 2008, when HISP India became an important part in the national arena, being involved in the redesign efforts of the national Health

Management Information System (HMIS). The research design was multi-level (including the national level of the Monitoring and Evaluation division of the Ministry of Health, and two states of Kerala and Tamil Nadu) and longitudinal (2008-2011), wherein I was engaged with and studied the establishment of participatory networks and supported its growth. The action efforts involved data collection through multiple means of interviews, observation, and focused action during efforts of conducting training programmes, carrying out system prototyping exercises, making situation analysis studies, and numerous methods of interactions involving presentations, evaluation reports, informal meetings and discussions, and email and mobile phone-based communication.

The theoretical contributions can be summarized to include the following:

1. Understanding the constitutive aspect of the participatory networks through local knowledge - metis – related to technology and public health and the functional benefits it provides;
2. Understanding the instrumental aspect of participatory networks including the role of their initiation, and the mechanisms through which they grow (or not);
3. How metis and participatory networks helps in understanding system development processes; and,
3. Understanding the impediments that exist in the use of information for local action.

Three key practical contributions have been developed in this thesis:

1. An approach to capacity building based on the focus on metis;
2. Guidelines to support system design and development, based on the focus of promoting information for use for local action;

3. Practical approaches towards the development of participatory networks.

The findings from the thesis have more general implications, such that the general framework of multiple knowledge domains understood through metis could be useful for researchers in other contexts. While this thesis focused on local knowledge related to technology and public health domains in the Indian context, other settings would have different specifications of local knowledge which would need to be empirically investigated. The notion of participatory network as useful to address the problem of scale provides a general concept, while the mechanisms of their growth would be different in other contexts.

Chapter 1 : Introduction

1.1 RESEARCH QUEST

Health Information Systems (HIS) in developing countries has traditionally been criticized for being upward focused (reporting to the Central ministry) and not effective in supporting local action and decision making (Aanestad et. al. 2005, Smith et al 2008, Wilson et al. 1988; WHO 1994, 1999; Braa et al. 1997; Mukama 2003). Braa et al (2007) expressed that nearly three decades of efforts in various developing countries have still not been able to readdress this situation, except for a few like South Africa and Thailand. In India too, despite the stated national agenda of decentralization, integration and promotion of evidence based decision making, the tendencies of centralization and upward reporting dominate, and seem like a brick wall to penetrate.

A commonly adopted strategy to support decentralization, integration and promotion of the use of information has been to implement computer based HIS. Despite the potential of such technological solutions in terms of storing, processing and retrieving large amount of data at various levels of the health administrative hierarchy, technologies often tend to become a tool in the hands of the decision makers. They only aim to enhance and reinforce the existing culture of upward reporting and centralized control. Emphasis is laid on technology as a tool that can solve the prevailing information challenge, i.e. seeing technology as an end in itself. This became evident in the question asked by a District Hospital In-charge and the response received from an officer in-charge of Monitoring and Evaluation (M & E), at the Central level

during a national level workshop in India in 2009 in which I had participated:

“As per the new initiative of using biometrics for improving hospital performance by monitoring daily attendance of the hospital staff, we have noticed that all the hospital staff is present at the hospital on time. However we also noticed that doctors are spending their time in the canteen instead of their allocated wards, nurses in the accounts department instead of IPD wards and registration clerks in the OPD ward instead of the front office. Is there any technology intervention that can prevent this?” [District Hospital In-charge]

“Yes, sure! We can use web-cams at all the stations to monitor if the staff is at their allocated place or not.” [Officer in-charge of M&E, Central level]

The aim should have been to improve hospital performance, which could be achieved through analyzing indicators such as patients seen per doctor, bed occupancy rate, and patient satisfaction rates. But the focus was instead on the technology as a solution in itself. Similarly, Raghvendra and Sahay (2006) argue:

“As a part of various health reform efforts, including that of HIS, ICTs are being actively introduced by international agencies, national and local government. But quite often the focus of such efforts is primarily on the means (computerization) rather than the end of what needs to be achieved: strengthening information support for health management” (pp.267-268).

Raghvendra and Sahay argue that the introduction of ICTs in the

development of HIS is not necessarily the silver bullet that solves the problem of efficiency of the health services. Rather, the critical issues to be addressed in the implementation of HIS are social and organizational and not solely technical.

Working for more than a decade with different aspects of HIS design, development and implementation at multiple levels – from community to the national level in India - I argue that technology should be viewed as an artifact that can only enable the generation of information. Through human intervention this needs to be converted to relevant action aimed at improving public health. Building such a perspective towards technology has significant system design and development implications. How can they support *initiating action* and not just *data reporting*? Enabling this “use of information for local action” shift from the dominant tendencies of centralization and upward reporting, will thus require to firstly understand what the action needs are, and how these can be translated to system design? (Braa et al 2004).

As a system’s developer under training, the focus of my thesis is specifically related to the domain of system’s development, how it can be organized and improved to help in strengthening information use for local action. A key facet of this is the process of “participation” which concerns how the domain of system development tries to understand the implementation and use context. It further inscribes this understanding into the systems design and development processes. The domain of participatory design globally (for example, Gregory, 2003, Asaro, 2000), and in Scandinavia in particular (Bratteteig, 2004), has had a long tradition of trying to address this issue, including the development of methods and techniques to carry out participatory design.

Building from this tradition, and expanding it with the notion of “networks of action” (Braa et al 2004) that seeks to enable the development of HIS with specific emphasis on issues of scale, I developed the concept of “participatory networks” as a fundamental notion in this thesis. Participatory network therefore is a concept that helps to understand the process of interaction of the implementation and use context seen through the primary lens of “local knowledge” with system development related activities.

The thesis describes my practical and theoretical knowledge within the framework of the global HISP (Health Information Systems Programme) action research initiative, and contributes towards enabling of the above described shift in India. A primary challenge addressed in this research is to understand “how technical system can be better designed so as not to be seen as an end in itself, and how it is treated as an enabler to generate relevant information, that can be used by health functionaries at different levels, to strengthen local action?”

Addressing the above challenge, I believe, is of fundamental importance as governments of various developing countries are reaching out to ICT based solutions in order to try and address the pressing public health problems like increasing rates of HIV/AIDS and vaccine preventable diseases, alarming rates of maternal and infant mortalities, nutritional related challenges, and new forms of epidemics like Bird Flu and Mad Cow disease. The challenge of managing these problems is magnified by the large scale of resources required as compared to what is available. These resources are in the form of man power, infrastructure, funds and medical facilities etc. Addressing these challenges is deeply implicated in the relation between knowledge domains related to

public health, technology and the context of implementation. I would like to illustrate this relationship with the help of two practical examples:

1. An important public health problem that many developing countries are grappling with is that of maternal mortality, implying the death of a mother either during her pregnancy, delivery, or within six weeks following the delivery. While many factors contribute to maternal deaths, an important factor is the access these pregnant mothers have to essential obstetric care services. In the fight against maternal mortality, information and the surrounding health information systems can play an important role in identifying problematic areas. An appropriate system design in this case would be one that enables pregnant women to have easy and quick access to the nearest obstetric care services. A map or a spreadsheet can be designed to provide detailed information to decision makers about the number of pregnancy cases in an area and the obstetric care services available in that region. This will guide them to take necessary steps for improving lack of adequate medical facilities, such as strengthening of outreach services or the provision of medical care through mobile units.
2. Fighting HIV/AIDS is another crucial problem for the public health systems in many developing countries. A key concern here is the transmission of the virus from pregnant women to children. In the public health systems, for example in India, the departments dealing with antenatal care and HIV/AIDS treatment are separate and independent

units, involving varying funding agencies, resources, and supporting information systems. As a result of these independent units, it becomes quite difficult to ensure that all women who come for antenatal care to the primary health care system are also subjected to HIV/AIDS testing and follow up care. Information systems can play a crucial role to establish and monitor the linkage between these two sets of services, and how efficiently referral processes can be operated.

In both the examples given above, well designed information systems can play a crucial role to help support health care officials design appropriate action plans to try and address these problems. *Technology can help process raw data to generate information.* While information is necessary, it can never be viewed as sufficient to make improvements in the delivery of health services. The information should be translated into relevant knowledge, i.e. information be analyzed and action to be taken accordingly by the decision makers. The consequences of these actions can then be evaluated and used to revise the information needs. This translation from data to information and then knowledge is not taking place effectively in the health services of most developing countries. By and large, the health information systems are limited to gathering data, with very limited translation of the large amounts of data being collected (Lippeveld & Sauerborn 2000).

For system development to allow the translations to be done is a complex task, given that different kinds of knowledge and understandings come into play. For example knowledge related to the **application domain** (e.g. the public health related knowledge of what contributes to maternal deaths), the **technology domain**

(of how appropriate computer based information systems can be designed and developed), and the **implementation context** (work practices of the health staff who ultimately have to use the system to support their everyday activities). Some other examples in this regard are listed below:

- a. Understanding how appropriate software tools can be developed to analyze data quality, and information practices that can act on the analysis. If the validation analysis carried out by the software highlights the violations, then it is the supervisor's responsibility to check these violations and take action.
- b. Understanding how health indicators for a district can be displayed on a GIS map, and building the capacity of the district manager to conduct spatial analysis.
- c. Understanding the kind of analysis which a field nurse must carry out, such as comparing her monthly achievement with the targets, and explaining to her how the map can help her to plan her monthly tasks.

All these different examples require combining understandings and knowledge around technology, the application domain and the context of implementation. Balancing between the domains of technology, application and implementation becomes key to effectively integrate information into decision making processes. Based on the problem domain (public health) and local context, one of the main tasks for the information systems designers is to develop appropriate technological solutions. It should enable the generation of relevant information for users to effectively use it towards local action. This cycle of using knowledge about the problem domain and context for building appropriate technology,

to generate relevant information, which can be drawn upon by users to try and address the needs of problem domain, is reflected in the title of this thesis: “From technology for information, to information for local action”. This cycle, representing the interaction between the technology and the application domain is enabled through participatory design processes (Bratteteig, 2004, Bjerknes and Bratteteig, 1995), and needs to be effectively managed to contribute to effective systems development.

The research focuses on system development at two levels:-

- The first is about the participatory design processes it seeks to understand local knowledge related to the technical context and the application domain of public health, within the context of implementation in which the systems are to be used.
- The second level is related to the scaling of these participatory processes. It focuses on how knowledge gained from different participatory design processes and from multiple contexts can feed into a common pool of knowledge. This knowledge further supports a more “global” level of system development, based on what I call a *participatory network*, so that the improvements achieved can be for the larger user community. This thesis seeks to engage with these challenges in the Indian context which provides the setting for a large scale implementation of DHIS 2 (District Health Information Software Version 2), and national and global system development groups based in Oslo around DHIS2.

1.2 RELATED RESEARCH

The critical role of HIS in strengthening public health systems has been known for some time now (Lippeveld, Sauerborn & Bodart, 2000, Bodvala 2002), but the outcomes have been described as grossly inadequate (Lippeveld, Foltz & Mohouri 1992, WHO 1987).

In most developing countries, HIS has been unsuccessful because:-

1. It was considered irrelevant.
2. The data gathered was of poor quality (Murthy & Patel 1988, Nordberg 1988, Frere 1987).
3. It was fragmented by multiple vertical programs (Monterio 2003, Chilundo and Aanestad 2003, Kimaro and Nhampossa 2005).
4. There was a lack of timely reporting.
5. Information primarily served the needs of the higher levels of administration (Braa 2001, Sahay 2001, Feldman & March 1981, Haga 2001), and
6. Poor use of information (Sapirie 2001).

As a consequence, HIS is typically data led, rather than action led (Sandiford et al, 1992). The undoubted potential of ICT has not translated to practical benefits on the ground (Heeks, Mundy & Salazar 2000) for various reasons, including inadequacies in both computer based (Nhampossa 2004) and physical infrastructure (Mosse & Nielsen 2004), limited human resource capacity both in number and skill (Chilundo 2004), overburdened health staff (Mosse & Sahay 2003) and limited encouragement given to use information for local action (Opit 1987, Quarishy & Gregory 2005).

These various studies have highlighted the problems of information not being used effectively, and the underlying reasons for the same. Minimal effort has been made about “what can we do

about these problems?” My focus therefore relates to the system development process. It specifically deals with how knowledge about the technical and application domains can be enabled through participatory design processes, and its linkages with system development at national and global levels.

To develop theoretical understanding of this identified problem, I would focus on three sets of issues:

- a. **Knowledge** - specifically to understand the nature of local knowledge related to technical and application domains. It can help provide a strong foundation for systems development of relevant solutions, geared towards supporting local action.
- b. **Participatory design processes** - how they can be organized, managed and scaled to build stronger inter-linkages between the domains of local knowledge and system development.
- c. **Systems development** - based on HISP approaches, related to principles of development in context, and the use of prototyping processes.

For the first, I would draw primarily on the concept “**metis**” (i.e. “a wide array of practical skills and acquired intelligence in responding to a constantly changing natural and human environment.” [Cass R. Sunstein, *More is Less*, in *The New Republic*, at 37 (May 18, 1998)]) by James Scott. This helps understand local knowledge - both technical and public health which are identified to be useful for enabling local action.

For the second, I would draw upon an understanding of the Scandinavian tradition of participatory design, how it has been

adapted and redefined under the Health Information System Programme (HISP). The notion of *participatory network* is developed from inspiration by the HISP network of action (Braa et al 2004), to describe participatory processes focusing on understanding, using and circulating local knowledge in the network as defined above. HISP, which provides the framework for my empirical investigation, is now introduced.

1.3 RESEARCH SETTINGS

Supporting universal and free primary health care for all is the goal of the National Health Policy of India (Gupta & Chen 1996). To provide integrated preventive, promotional, curative and rehabilitative services for the entire rural population, Community Health Centres (CHCs), Primary Health Centers (PHCs), and Sub-centers (SCs) were established in India as the peripheral institutions (Ragavendra & Sahay 2007). The health department staff in these institutions prepare huge amount of data on a weekly, monthly, quarterly and annual basis. This data is transmitted to the national level through the intermediate levels of the district and the state to meet the internal needs of the bureaucracy and their informational dependencies on International Aid Agencies (Sahay 2001). The flow of data is largely unidirectional with limited attention given to providing constructive feedback to the peripheral health department staff to strengthen their work processes. Acknowledging this limitation of the existing HIS, the Indian Prime Minister during the launch of the National Rural Health Mission (NRHM) in 2005 said:

“... The monitoring systems have to become outward towards the community and not upward towards the bureaucracy. For example, so far the health information we have in our country through the

National Family Health Services Reports, is seen at State and Central levels and hardly ever at district and below district levels. If information is to lead to action, it should be available and used at the local level.”(April 12, 2005)

It is within the ongoing efforts of the NRHM to reform the country health systems, including the HMIS (Health Management Information System) that my research is located. The empirical setting is provided by the action research efforts of HISP, India, which is part of a broader global research and development network – HISP- initiated by the University of Oslo in 1994. It is now ongoing in various countries in Africa (Ethiopia, South Africa, Tanzania, Malawi, Botswana, Nigeria etc.) and Asia (India, Bangladesh, Sri Lanka and Vietnam).

HISP India is a not-for-profit organization which aims to develop sustainable computer-based HIS to support the public health departments of various Indian states. The aim is to support district/state management and enable them to conduct local analysis and action through the introduction of a free and open source software called DHIS 2 (District Health Information Software – Version 2). A key strategy of HISP is to strengthen the capacity of the health staff at all levels, with a key focus on the field workers, to eventually assume independent ownership of managing their information processing needs and to be able to use information to support their everyday activities.

At the national level, HISP India has a partnership agreement with the National Health Systems Resource Centre (NHSRC) which has been established as a technical support agency for the NRHM in various areas including HMIS. NHSRC works with the Monitoring

and Evaluation (M & E) Division of the National Ministry of Health, and also the division managers for various health programs (such as Child Health and Maternal Health) to help strengthen the information systems. Invited by NHSRC, HISP India has been engaged with various processes of reform including re-definition of the data sets for different vendors, formulation of indicators, system design, development and implementation reflecting these changing information needs. The broader objective is to try and support the Central ministry towards bringing about a paradigm shift in functioning. Instead of receiving large amounts of data which remains largely unused, the decision makers will be able to obtain limited, relevant and processed data which can be easily subjected to information analysis to conduct relevant and timely action.

HISP's tasks in India were initiated in the state of Andhra Pradesh in 2000 (Sahay & Walsham 2005). Over the years it has gradually expanded in different degrees to nearly 20 other states. These states are not only widely dispersed across the country, but also inherently possess different languages, socio-economic dynamics, extensively varying cultural settings, and sharply contrasting ICT capabilities and applications.

As a Ph.D student since 2008, and HISP team member, I have been actively participating in HIS related activities over the last decade. It has provided me with a deeper understanding of the relevance and importance of socio-cultural contexts, in which computerized HIS are being developed and institutionalized. The field experience has helped me gain valuable insights into the working of HIS in different health facilities, including the challenges of infrastructure, capacity, analytical skills, culture and others. These insights have

been crucial in understanding issues of local knowledge, system development and participatory design.

Further, I have played an active role in mediating between the understanding from the field, and the processes of systems development at two levels. At the national level in India, the development team has been engaged in various activities related to adopting global releases of DHIS 2, carrying out local customizations, and also building their own modules and functionalities that are urgently required.

At the global level in Oslo, the core development of DHIS 2 is taking place based on global requirements, including that of India. Therefore, my role also consists of “getting the Indian requirements heard in Oslo,” and then working with their developments (testing, customization) to take it back to the field sites in India. Through this experience of participating in multiple states and activities, I have contributed to an evolution of HISP India to a stage where inputs from them are also valued at the national level, for reforming and redesigning of the systems.

The research methodology adopted in this thesis doesn't follow the traditional action research methods. The material gathered for the research is through active participation in various actions as I have been involved in the process of design, development and implementation of HIS in India. Having worked in this domain for over a decade, my key motivation lies in seeing how information can contribute to improving public health practice and health outcomes. The research is inspired by the HISP philosophy of “building collaborative networks of action” (Braa et al 2004), aimed at creating mechanisms by which collaborative activities can be developed and circulated through the network. Learning from

multiple sites and settings is undoubtedly more effective than single site pilots. Data collection, again by the nature of the research resembling a longitudinal and deep lived experience, has involved much more than can be formally documented in the details of number of interviews and meetings.

In the field, I have been engaged in collecting various forms of qualitative and quantitative data. Some of these have included: situation analysis studies, open interviews, meetings, discussions and presentations, conducting training programmes, troubleshooting problems, participatory observation, analysis of documents and forms, system prototyping, and electronic communication, at both the national and global levels, and conversations both with HISP members and state level officials. Quantitative data has involved the analysis of routine data of different states, for both data quality and health status. Given the multiplicity of data collection methods, the intensity and continuous nature of engagement, data recording has taken place through multiple means such as my diary, e-mails, formal evaluation reports, and photographs. In the methods chapter, I will further elaborate upon the details of data collection and also of data analysis.

1.4 RESEARCH QUESTIONS

In India, as also in many other developing countries, public health problems are rising and accumulating, and therefore the urgency to address them is heightened. This has led many governments and donor agencies to invest large sums of money into the purchase of ICTs and undertake efforts to develop HIS supported by ICTs (Ragevandra & Sahay 2007). As has been pointed out by various researchers (e.g. Braa & Hedberg 2000) these efforts have

not yielded practical benefits of generating appropriate information that is used by users in designing and implementing improvements in health care delivery.

Research studies were carried out to understand why the potential of ICT based HIS remains underutilized. Some factors identified are inadequate infrastructure, human resources capacity, politics, structures of bureaucracy and various others. While these studies have been very crucial in sensitizing us to issues of importance, the challenge of system development has not been adequately considered. It sensitively seeks to understand knowledge especially seen beyond a technical ICT focus...

Going beyond the technical, I argue that aspects of the domain of public health (the knowledge of which the ICTs are trying to inscribe in the systems), and the context in which the systems are being implemented and used, should also be considered. These then provide key inputs to the system development, a process enabled and scaled through participatory design. A key focus then is on how to develop appropriate systems which will enable a shift, and technology is seen as a means to generate information to enable local action and not an end in itself. Based on this background, the research questions addressed in this thesis are as follows:

- (i) How interaction of knowledge in the domains of public health and technology, within a particular context shapes system development processes?
- (ii) How participatory design processes can be organized to enable a constructive interaction between the above mentioned knowledge domains and system development? How can these processes be effectively

scaled?

- (iii) How can capacities of users be developed, to support effective use of technological solution towards generation of relevant information and to strengthen local action?

Answers to the above research questions will provide contribution in two domains,

1. To system developers engaged both at the national and global levels. The specific input is with respect to an understanding of knowledge of the technical and public health domains, within a particular implementation context that needs to be sensitively inscribed into system development process.
2. To implementing agencies such as HISP India, on how to organize participatory design processes to strengthen system development at national and global level.

1.5 EXPECTED CONTRIBUTIONS

As per my research quest outlined in the theoretical perspective and research questions, the contributions expected from this thesis are identified as follows:

- An integrated *participatory network* perspective on the interaction between local knowledge, participatory design and systems development.
- An understanding of how technical systems can be designed with knowledge, that can enable use of information for local action, including addressing factors that impede this process.

- Identify strategies towards strengthening participatory design processes, and their scaling.
- Practical strategies to build capacities for health information users in order to strengthen local action.

1.6 STRUCTURE OF THESIS

The rest of this thesis is organized as follows:-

- In chapter 2, an overview of my theoretical approach is presented. It focuses on Scandinavian tradition of participatory design, local knowledge concerning public health, technology domains situated in a particular context, and, system development processes specifically. Also focuses on their inter-linkages with participatory design processes.
- Chapter 3 is about my research context where the empirical work for the thesis has been carried out. Background information on the problems faced by the Indian public health system and the role of NRHM with respect to HIS are described. Further, I have described the structure and functioning of the National, State and District health administration in India, to help the reader better understand the context. I have also provided an orientation to the problems faced by the primary healthcare system and its constituent institutions.
- In Chapter 4, the research approach and various methods adopted for collection of empirical data are described, followed by an elaboration of the research scope including the time line and its extent. The chapter concludes with a section on the process of analysis of the empirical data collected.

- Chapter (5) describes the different conference and journal papers that have been included in this thesis and how they relate to the research questions. The papers themselves are placed as Annexure 1-6 of this thesis.
- In Chapter 6 called Discussions, I discuss the implications of the theoretical ideas related to local knowledge, participatory design and systems development.
- In Chapter 7 the implications and contributions of the research are presented. It describes key theoretical and practical contributions.
- Finally Chapter 8 consists of brief concluding remarks.

Chapter 2 : Theoretical Overview

The aim of this chapter is to discuss related research that helps to complete my quest towards understanding the nature of participatory networks. Also to know how it facilitates the interaction between the implementation and use context, viewed primarily through the lens of local knowledge, with activities related to systems development. The particularities of the empirical context, namely the public health related domain, the developing country setting, and the system development taking place within a globally distributed north-south network, are taken into consideration while articulating an initial theoretical perspective that helps to conceptualize my research questions. It is subsequently refined based on the empirical analysis described in chapters 6 and 7.

2.1 OVERVIEW

The theoretical foundation of the thesis is related to the following three domains:

- 1) **Knowledge** - local knowledge concerning the domains of technology and public health, situated in a particular implementation and use context. While the use context refers specifically to the conditions around the user that enable the use of information (such as skill levels), implementation concerns the broader conditions reflecting work practices, organizational resources, hierarchical relationships and infrastructure situation.
- 2) **Participatory networks**, with a focus on the Scandinavian participatory design tradition within which the HISP efforts

are situated. And to learn how this has been expanded, drawing upon the networks of action idea, in order for it to reflect the particularities of the empirical setting of the thesis.

- 3) **System development**, with a focus on its inter-linkages between processes of participatory networks and local knowledge.

These different aspects of theory are first discussed, and subsequently pulled together with a figure to reflect the initial theoretical model forming this thesis.

2.2 IMPLEMENTATION AND USE CONTEXT: THE ROLE OF LOCAL KNOWLEDGE

The context of implementation and use of the HIS is understood through the everyday practices of the users of the system and even other actors such as the doctors, who use the informational outputs of the system, and how those are shaped by the context – institutional, social, cultural and political (Kling et al 2000). The practice based theorists argue that these practices are implicated in knowledge – how activities are understood, carried out, and revised over time (Blackler, 1995; Thompson and Walsham, 2004). A key focus thus in this thesis is on knowledge, especially related to local knowledge. My emphasis is on peripheral level health department staff comprising primarily of field level nurses and medical doctors, engaged in practically providing medical care. Understanding their knowledge, what exists, how it needs to be nurtured with respect to HIS, form the key focus of this thesis.

Due to the nature of the goals of my research, knowledge is a key object of analysis to understand the implementation and use context. The study of knowledge by itself is not unique in IS

studies. It is because in contemporary times it is deemed as a strategic resource in organizations, and a continuous quest is its thoughtful management and application which is expected to improve the competitive and technological edge of organizations, in terms of their productivity and profitability (Schultze and Leidner 2002). There have been numerous debates both in the IS and management research arenas over what knowledge is and how it may be created, gathered, applied and shared meaningfully across diverse contexts, including geographical boundaries (Walsham 2005), and also professional divisions of academics and practitioners (Rynes et al. 2001). However, this problem of knowledge and its blending has not been an active object of study in the domain of public health informatics settings, especially in developing countries.

“What is knowledge” has been articulated variously. For example being stated as “abstract, universal, impartial and rational,” is to be stand-alone and essentially truthful in ancient Western philosophy (Coakes 2004, p. 408). Knowledge is often viewed as a commodity, emphasizing that it exists prior to and is independent of the knowing subject, thereby ignoring the practice-based aspect of knowledge and how this is created and distributed in the act of appropriation (Walsham 2001, Yakhlef 2002). A contrary viewpoint emphasizes that knowledge is socially constructed, being context specific and situated in practice (von Krogh 2002; Suchman 2002).

During the last two decades or so, knowledge management has been a key arena of IS research (Alavi & Leidner’s 2001), gaining initial popularity with the work of Nonaka and his colleagues (Nonaka 1991, 1994; Nonaka & Takeuchi 1995). Nonaka (1994) has described two types of knowledge – ‘explicit’ and ‘tacit’. He argued

that tacit knowledge may be captured and converted into an explicit and sharable form in organizational contexts. He presented a model to make tacit knowledge explicit, and for it to be drawn upon from one context for reuse in another setting. Based on this perspective, knowledge tends to be treated as being practically synonymous with data collected, information created, disseminated and embedded in products, services and systems. A contrary view, inspired by Polanyi (1966), has been that tacit knowledge by definition is tacit, and cannot be made explicit, and is internalized in individuals arising from their “in-dwelling” (Thompson & Walsham 2004). Often, people may not even be consciously aware of the tacit knowledge they possess, since it is deeply resident in the mind of an individual, making it largely “inaccessible” for managerial capturing and codification (von Krogh 2002). Way before these contemporary debates, Peter Drucker (1969) had argued that when workers leave a company, they take their knowledge with them, irrespective of how much they may have documented and shared it. Obviously, there are limits to “knowledge management.”

The commoditized view of knowledge has attracted many critiques (Brown & Duguid 2001; Orlikowski 2002), emerging from communities of practice (Wenger, McDermott & Snyder 2002), and being practice-based (Suchman 2002).

1. Boland and Tenkasi (1995) emphasized the multiplicity of knowledge disciplines arising from “perspective making” by various groups of experts.
2. While Wenger (2000) also similarly stated that multiple occurrences of knowledge held by individuals and communities become embedded in social learning systems.
3. Walsham (2001) has argued for more human-centered

approaches, emphasizing the distributed and multiple nature of knowledge (Blackler et al. 2000).

4. Nicholson and Sahay (2004), in the context of offshoring of software development, have argued about the deeply embedded nature of knowledge which cannot be seamlessly circulated across time, space and cultural boundaries.

These arguments exemplify why, even though there may be some explicit parts of knowledge (such as a System Requirement Specification document) that could be relatively coded easily and transferred across continents, there will also be its tacit components. For example, how meaning is inscribed to these documents which represent large outputs of embedded social, cultural and institutional processes.

Based on the various critiques and debates over the commoditized perspective of knowledge, and my interest in seeing how information can be used for local action, my theoretical basis takes as a point of departure, a practice-based conceptualization of knowledge. This perspective seeks to understand how people follow work routines in everyday organizational life, imbibing key learning, innovations, and how members communicate and negotiate knowledge across and within communities.

Gheradi (2000) explains these notions through the example of a carpenter hammering a nail. It brings forth the relationship between subject, object, the context and knowledge. She emphasizes an emergent identity centered on the idea of practice by people who have knowledge in their heads, and which is appropriated and transmitted through mental processes. In this way, Gheradi and others have tried to work through the dichotomies of mind-body, thought-action, and individual-

organization. In a similar vein, Yanow's (2000) perspective on the location of learning, describes how learning is accomplished through multidimensional forms of knowledge that animate social practices, both cognitive and cultural. It further describes the processes through which practices are reinforced and transformed with time.

While most existing studies around knowledge and their critiques derive from business organizations, there are additional issues to be considered in the context of public health informatics, which is the focus of this thesis. For example, since this context involves a community (not a business) setting made up of people who develop social bonds through shared traditions, language and identity, **knowledge can be viewed as being socially distributed and entrenched in collective actions of members** (Von Krogh 2002; Wenger 2000). Diseases and their interventions have their specific logic of rationality and materiality (Chilundo and Aanestad, 2005), which need to be reflected in the supporting HIS. For example, a HIS for reporting on communicable diseases would need to cater to a daily reporting system, than a monthly reporting one required for pregnancies and immunization. What data to report on, when, how this is processed, interpreted and acted upon, and the supporting role of artifacts and technologies, all represent multiple aspects of knowledge.

To help theoretically conceptualize such "local knowledge," I would like to draw upon the interesting notion of "metis" articulated by James Scott (1998). "Metis" is a concept from ancient Greek that is often translated into English as "cunning" or "cunning intelligence". Broadly, metis represents a wide array of practical skills and acquired intelligence in responding to a constantly

changing nature and human environment. All human activities require a considerable degree of metis, but some activities require far more, for instance acquired knowledge of how to sail, drive a car or ride a bicycle. Metis is knowledge that cannot be reduced only to formula based instructions, because the environment in which it is exercised is complex and non-repeatable and formal procedures of rational decision making are impossible to apply.

The word metis contrasts with another Greek term “techne” which represents the formulaic instructions or knowledge and practice. It can be reduced to instructions, prescribed, and imitated by those even without a deep understanding. Scott argues that when scientific knowledge is imposed upon complex environments like societies or agricultural practices, it is almost always inefficient. However, the opposite focus on metis almost always yields positive results, and its value lies in the functional benefits it provides to practice rather than as theoretical or abstract knowledge. Scott argues that metis is being systematically destroyed by the state as they seek to impose scientific knowledge. He writes:

“It would be a serious error to believe that the destruction of metis was merely the inadvertent and necessary by-product of economic progress. The destruction of metis and its replacement by standardized formulas legible only from the center is virtually inscribed in the activities of both the state and large-scale bureaucratic capitalism. As a ‘project’, it is object of constant initiative which are never entirely successful, for no form of production or social life can be made to work by formulas alone - that is, without metis. The logic animating the project, however, is one of control and appropriation. Local knowledge, because it is dispersed and relatively autonomous, is all by un-appropriable. The reduction or, more utopian still, the elimination of metis and

the local control it entails are preconditions, in the case of the state, of administrative order and fiscal appropriation and, in the case of the large capitalist firm, of worker discipline and profit.”
(pp.335)

As another aspect of my theoretical lens, I will next discuss participatory networks, and how that evolves from the tradition of participatory design and its relation to local knowledge.

2.3 PARTICIPATORY NETWORKS

The notion of participatory networks as developed in this thesis builds upon and expands the principles of Participatory design especially that developed within the Scandinavian tradition. Participatory design can be seen as a process of understanding user needs and knowledge that feeds into systems development processes. While participatory design can be seen as taking place in particular time-space contexts (like an organizational setting), the notion of *participatory network* can be conceptualized as the inter-linking of these multiple processes of participatory design across various contexts, so as to enable sharing and learning in a larger prospect.

In relation to knowledge, the concept of *metis* has been articulated above as a lens to understand local knowledge in the context of public HIS. Given the focus of *metis* on local or practical knowledge, a key challenge of its use is scaling its relevance to broader settings, and not just confining to the local. Large initiatives of implementing ICT interventions in the health care sector often tend to work well in pilot settings that cover a small area, which have a definite timeline, and are supported by an external implementation agency. However, these projects tend to

die when this external support is withdrawn or the scope of the project is scaled up to wider areas or extended in time (Shediac-Rizkallah and Bone 1998). So, how can metis which may be relevant in a small, local setting, play out in larger situations of the public health system, is a key challenge to understand in this thesis.

To approach the above challenge, I would draw upon Braa et al's (2004) notion of "networks of action" which specifically seeks to address the related challenges of the scale of HIS's sustainability. Networks of action is inspired by the ideas of Elden and Chisholm (1993) that action (such as related to participatory software development and capacity building) should be situated within networks rather than in singular units. This is because local interventions always need to be part of a larger network for enabling them to endure over time and space. Establishing networks helps to create opportunities for sharing of experiences, knowledge, technology and values between the various nodes of the network. Applied to the theoretical perspective in this thesis, the challenge is how "metis" can be made constitutive of these networks of action. And how capacity for action can be created which can make metis local and relevant in a network that is inherently global.

While metis represents local knowledge around the context of the everyday world of the health worker, the challenge to the IS designer like me is twofold:-

- a) how can this local knowledge or metis be inscribed in the system? and
- b) how can this inscribed metis better support user action through appropriate information support in both local and

broader settings, especially related to systems development.

The concept of *participatory networks* helps to focus on the collaborative action aimed at the development, use and circulation of local knowledge in broader networks. This is relevant to the HIS development and implementation. Participatory networks are seen as the 'enabling mechanism' for the generation, articulation, combining and sharing between the different nodes of network. For example, how can knowledge about public health, which is normally restricted to medical doctors, be articulated in a way that can be understood by the community of software developers and administrators?

Similarly, contextual knowledge related to one geographical area needs to be understood in a way that its context-free aspects can be translated to make it relevant and applied to other settings as well (Puri & Sahay 2003). This kind of networking of knowledge necessarily requires linking of micro level and local knowledge – *metis* - with that of the other participating communities of systems developers and users. The participatory network concept helps to theoretically understand the challenge, and how it may be practically resolved (Tellioglu and Wagner 1999).

The concept of participatory network builds upon an extensive tradition of literature on participatory design in IS research, and seeks to extend this within the context primarily of HISP related research. During the last four decades or so, research on IS design has emphasized the importance of active user participation in various facets of system design, development and use. This body of research has increasingly argued that IS should be viewed as

situated in socio-technical heterogeneous networks (Walsham, Symons, & Waema, 1988) rather than being primarily technical (Lyytinen & Klein, 1985).

These arguments have helped in shifting the focus from a predominant technical orientation of systems developers situated in a computer science tradition, to include and actively recognize the needs, aspirations and expertise of users (Byrne and Sahay, 2007). The rationale behind this shift is the recognition that it is ethically and morally right for workers to be involved in the development of systems. This will develop their professional lives and an understanding that repeated failure of traditional technical approaches can potentially be overcome through the use of participatory design based approaches (**Ibid**). This shift from a techno-centric to a socio-technical heterogeneous network helps to enhance sensitivity to the social context of IS design and places a greater emphasis on enabling user participation (Mumford 1993; Puri et al 2009).

Participatory research in IS has primarily emanated from organizational settings in the West (Gregory, 2003; livari, 2007) and been shaped by their societal context (Asaro, 2000, Kanungo, 2004). For example, in Scandinavia, participatory approaches thrived because of the homogenous and open nature of society, high literacy and living standards, the tradition of cooperation in research, well developed modern infrastructure, social democratic polity, and an influential trade union. All these positively contributed to the introduction of technology, and the intensive use of computers in the workplace (livari & Lyytinen 1998).

The nature of participatory design also varied in countries. Britain

largely adopted a socio-technical approach (Mumford 1993) with a focus on autonomy in work groups through power sharing, joint responsibility and multiple leadership roles (Asaro, 2000). In contrast, in the United States the aim was primarily to support different prototyping and business process re-engineering efforts, by creating more efficient and effective organizational and business practices (Puri, 2003). The empirical context of HIS in developing countries, as has been argued by different researchers (such as Byrne and Sahay, 2007; Puri, 2003; Puri et al 2009), represents a very different setting than those in which participatory design research has evolved.

To understand these differences, these researchers have explored and discussed the relevance of two streams of participatory design, one from development theory focusing on social development ends, and the other relating to IS design and development. In the context of ICT and development projects including the health domain, these researchers have argued towards combining the understanding from both these streams to have more meaningful health systems and also broader developmental outcomes. The empirical focus of this thesis has focused primarily on participatory processes related to the IS and HIS domains not considering broader development processes. While this narrow ambit is indeed a limitation of thesis, it is so used because the focus of this research is on HISs being used primarily in health facilities by health department staff rather than in community settings.

The early participatory design literature was important in shifting the focus of system design from a primarily technical to a socio-technical one, and in emphasizing the role of the user. Some examples of this include Kensing and Bloomberg's (1998)

identification of three key issues related to participatory design: politics of design; the nature of participation; and, methods, tools and techniques for carrying out design projects. Various empirical studies have been carried out with such a focus towards participatory design (such as Bjerknes and Bratteteig, 1995; Beck, 1996, Greenbaum, 1995). Iivari & Lyytinen (1998, p. 167) have argued that IS design methodologies tend to be an “offspring of their time, reflecting for example dominant research trends and theories of that time.” In the same vein, Dahlbom (2003) has argued that with the service sector becoming more dominant, “a new agenda of action research will have to be developed as new large scale projects with trade unions and public agencies are waiting to be initiated, involving both users of information technology, and, more importantly, consumers as well, in a consumer oriented approach to services” (ibid., p. 105).

System development in this tradition has emphasized the role of user participation (Gjerull 2006), under the assumption that system users are considered experts in their own work and their knowledge is fundamental in building relevant systems. This will invoke minimum resistance. The form and degree of involvement may vary, as does the degree of actual influence and power. User participation aims to increase workplace democracy by giving the members of an organization the right to participate in making decisions that are likely to affect their work.

Despite the significant gains made through this body of research, they have come under critique for the use of extreme manpower intensive techniques, primary focus on processes rather than the output and how that is integrated to broader use and institutional settings. Therefore they are usually been restricted in scale, are

scattered and isolated (Staring 2011).

Further, these approaches have been criticized for presuming a limited, rather homogenous user group which often fails to make a major impact (ibid) when put into practice. Puri et al (2009) emphasizes that participatory design should be seen as necessary but not sufficient in itself to ensure the success of IS. It requires contextualization to local settings, but also to more macro processes such as those arising out of globalization and the increasing role of private entities in public health.

In the next section, research related to participatory design in developing countries is discussed to highlight some of the particularities of the setting, which requires the contextualization of participatory design approaches as argued by Puri et al (2009).

2.4 PARTICIPATORY DESIGN IN DEVELOPING COUNTRIES

While the participatory design tradition has been widely recognized, and has become an increasingly mainstream part of IS design and development in the West, its formal acceptance in developing countries is still underway (Avgerou 2002; Heeks 2006). As highlighted by various researchers such as Kensing and Bloomberg (1998); Puri et al (2004); Byrne and Sahay (2007); Engelstad and Gustavsen (1993); Titlestad et al (2009), this tradition of study has primarily emphasized interventions in singular units or few work places or on a small scale, rather than focusing on larger scale networks. This is what has been identified as urgently needed in developing country contexts.

Participatory processes in developing countries often tend to be

inhibited by rigid bureaucratic structures (Avgerou & Land, 1992) where traditional methods don't adequately work. User participation in the Western context is supported by skilled users, and other enabling particularities of the social, cultural and political settings (Kyng 1995, Heeks 1999). Whereas in developing countries there are existing inhibiting factors, such as lack of quality ICT education, poor infrastructure, and a top down centralized view of IS (Walsham et al., 1988; Sahay 2001). Following Lamb and Kling (2003), the notion of the user too in developing countries needs to be re-conceptualized reflecting "meaningful and productive relations between those charged with technology design and those who must live with its consequences" (Kensing & Blomberg, 1998, p. 172). Suchman (1994) describes that a lot of technology projects in developing countries have an approach of "design from nowhere" , i.e. systems are developed in the West by designers who have little understanding of the context of use. Suchman argues that this is deeply implicated in issues of power and control. Heeks (2002) has described this as the "design-reality" gap contributing significantly to system failures.

HIS in developing countries need to be endowed with characteristics such as supporting large scale networks. Participatory design approaches therefore need further contextualization, and some research that has focused on this issue is discussed.

2.5 PARTICIPATORY DESIGN IN HIS

Participation towards IS design, development and use in the health sector, raises its own particular challenges. Given the involvement of various donor agencies, the nature of diseases, geographical

spread of outreach services, typically weak ICT related capacity of the institutions and health staff, heterogeneity with respect to user types and needs, administrative levels, and uneven distribution of infrastructure and resources, all increase the challenges of using participatory design approaches. While researchers (Lippeveld & Sauerborn, 2000; WITFOR, 2003; Braa & Blobel, 2003) have argued that locally focused participation and commitment in the development and running of HIS, are key issues in the delivery and management of health services, which is currently not the case in most developing countries. This is due to poor systems and procedures of information handling, lack of local use of information, poor feedback and the fragmentation of the reporting system into numerous sub-systems controlled by specific health programmes (Titlestad et al, 2009).

Non-optimal working of HIS in developing countries often arises from the organizational and social issues. These issues are being inadequately addressed in implementation, such as the fragmented nature of systems, heterogeneity of user needs, and centralized administrative control. These conditions raise an urgent need to examine the issue of participation, not as being something stand-alone and organizationally confined, but with respect to networks involving the multiplicity of actors, technologies and various institutional practices in their diverse socio-political contexts (Puri et al 2009).

Other two important issues towards participation are, the need to enable decentralized approaches and structures as opposed to centralized ones, and to support the inclusion of large number of peripheral institutions and districts raising the important issue of scale (Titlestad et al 2009). How these issues have been discussed

in the HISP network, which also is the framework for my research, is now discussed ahead.

2.6 PARTICIPATORY DESIGN WITHIN THE HISP NETWORK

The HISP network can be described as a global research, development and action network around HIS, based on creating north-south collaborations. HISP was born out of the anti-apartheid movement, through the effort of a few as a bottom-up project, in South Africa in 1994/95 in four pilot districts, in and around Cape Town. It has now gradually spread out to cover the entire country (Braa and Sahay 2011, Kimaro and Titlestad 2008).

The initial HISP researchers coming from Oslo had their source of inspiration from the principles of Scandinavian participatory design tradition, related to user employment and workplace democracy. This was very well received in post-apartheid South Africa, where the focus was on restoring democracy within the health care system, through process of decentralization and user empowerment. However, when these techniques were taken to other countries such as Cuba and India, various challenges were observed as the participatory methods were not adequately contextualized. Further, new challenges kept emerging such as different technologies, rising level of user expectations, and the changing face of infrastructure. These issues needed reform and extension of participatory design approaches, which Braa and Sahay (2011) have described in three phases of evolution of the HISP network.

- A. **HISP and “Traditional Participatory Design” (1994-2000):** This was the initiation phase of HISP in South Africa

where it was developed as an action research project. This was done in collaboration between researchers from the public health domain and the Scandinavian participatory design tradition, aiming at developing district based HIS. In this phase, a rapid prototyping was adopted, in cooperation with users, towards the development of DHIS v 1 software.

Participatory approaches used during this development not only helped in getting the requirements right, but also supported the development of a generic software solution which could be adapted to the ever changing health context. Using the DHIS software as a prototyping tool, essential data sets and data standards for primary health care data were developed. Participation in developing the DHIS software helped in getting the data model right. The use of DHIS as a participatory design tool for prototyping helped in getting the wider HIS right, such as building essential data sets and defining the flow of information in a district based system. Participatory design was also adopted towards cultivation of processes related to decentralization, and local user empowerment in terms of control, access and use of locally collected information. These dimensions of using participatory design towards the development of the software, HIS and user empowerment were characterized as key lessons from this phase with respect to participatory design.

- B. **HISP and “Networking Participatory Design” (2000-2005):** As an approach to building institutionalized capacity to support HIS design and implementation, this phase of HISP evolution focused majorly on developing education

programs (including Ph.D and Masters) based at, or coordinated from the University of Oslo. Students of these programs were oriented to the field of participatory design, and through practice became the major HISP advocates. They developed smaller participatory design projects in many countries such as Cuba, India, and Mozambique. However, while engaging in action in these widely different contexts (from Scandinavia and also South Africa), HISP researchers learnt the important lesson that **“context matters”** and participatory design methods need to be sensitively contextualized and be broad based. Scandinavian tradition of participatory design focused on local empowerment and was very well received in post-apartheid South Africa. But such concepts were largely foreign in the cultural contexts of Cuba and India, which thrived on centralization, due to reasons of legacies of Soviet statistics based planning and British bureaucracy respectively.

The other learning was in acknowledging the limited capacities that existed in developing countries towards public HIS and participatory processes. To address these challenges and limitations, the network of action framework was conceptualized. It focused on creating mechanisms through which collaborative activities, such as related to software development, conducting research and training, and promoting information use, could be developed and circulated through the network. The nature of action was broader than just the design, but also focused on larger issues such as fund raising and carrying out political advocacy. The action thus required to be carried out at multiple levels from

that of the international donor to the national ministries, and the district and sub-district level users.

- C. ***HISP and “Web-based Participatory Design” (2005-2010):*** This phase of re-contextualization of participatory design comes from the move towards web-based technologies. These technologies had implications on the nature of systems developed, the changing role and knowledge of developers and users, and the nature of their relations. During the first phase of HISP initiation in South Africa, DHIS development went through an intensive three year evolutionary participatory design process. During this period iterative design processes of testing prototypes were carried out in close collaboration with users. While this iterative design process produced a close fit with local field requirements, the system itself accumulated rigidities and a disordered architecture overall. This proved to be problematic when DHIS was subsequently introduced in other counties such as Mozambique and Ethiopia (Nhampossa, 2005; Lagebo and Mekonnen, 2005). To address this situation, the project embarked on a full remodeling of the database with internationalization embedded in the model, but retaining the same technology (MS Access). In this process, the developers were confined to Cape Town, and even users elsewhere in other countries. This entailed extensive travelling of project staff, supplemented by numerous e-mail communications, which contributed to the development of the new internationalized version of DHIS v 1.4, there was a strong participatory process carried out between the developers in Cape Town and implementation teams in Botswana and Zanzibar.

Around the same time, requirements for moving to an internet enabled web-based platform was mounting up and it thus triggered the development of DHIS-2 in 2004, under the leadership of University of Oslo. A stack of “bleeding edge” Java-based technologies were adopted with an aim of establishing and strengthening distributed development activities, involving participants from a number of countries (such as India, Vietnam and Ethiopia), in order to bring software development closer to the context of use. However, re-implementation of DHIS as a modular web application was done with a new technological framework, and over emphasis on the on-line communication platform. But it presented a formidable obstacle in terms of knowledge of the existing technical staff at various sites. While it took over a year and half to deploy the first version of DHIS-2 in Kerala, which lacked much of the important and required functionality, yet the system improved significantly through early use in India and Vietnam, and later also in Sierra Leone. Over the years, use and development of DHIS-2 increased significantly. While DHIS-2 in India became part of National Rural Health Mission’s (NRHM) approach for strengthening state health systems, the Health Metrics Network chose to use DHIS-2 in their country pilot plan for integrated HIS in Sierra Leone. The explicit change from stand-alone to networked web-based application and use of open source technologies allowed countries to technically adopt systems with limited prior preparation. Whereas in the earlier HISP phase it was typically time and resource intensive, as it started from a “small bottom.”

With this shift from locally focused participatory design approaches to include the network dimension increased the scale of operations, such as the whole country or a whole region, the use of open

source technologies helped to change the landscape of who participates and how.

Looking at the future now, Braa and Sahay (2011) identify further challenges to participatory design arising from the move to architectures, and the important role of integration in this regard. Such architectures bring in different dimensions of standardization, inter-operability, and inclusion of other systems such as in-patient care, and human resources for HIS. These have inherently different knowledge requirements as compared to routine HIS, which was the focus of the early HISP systems.

The move to architectures, also bring in new institutional actors such as WHO that are promoting such architectures and building standards (such as SDMX.HD) for data exchange, and also other open source development communities. Participatory design approaches thus need to accommodate a larger heterogeneity of technologies and actors, to address which, Braa and Sahay (2011) argue for an approach of keeping management needs for decision making as a central focus, across different systems, health programmes and management levels. They identify three levels of the architecture to include user based information needs, software applications, and data exchange. Participatory design approaches require to build an understanding of what are the management needs for information at multiple levels (eg. national, state or district) and health programmes (say TB or HIV/AIDS), and then analyze from which system or part of the architecture the information will feed in. While this approach helps to provide information of a greater granularity that individual users need, it places additional knowledge demands on the implementing staff to be capable to understand at a deep level the nature of decision

making, information requirements and the supporting system that provides this. Such an approach is different from the traditional ones, where the focus of understanding was on existing work practices and how computers could help automate what could be so done. These shifts in what is done and how, entails quite different approaches to participatory design and their scaling in networks.

The architecture approach raises significantly the complexity of knowledge with respect to the domain of software applications. It's because now there are multiple systems that exist, which need to interact seamlessly with each other. This raises the need for both system architects and HIS implementers to mediate not only between the users and user organizations but also with the application software developers and architects. A key challenge identified by Braa and Sahay (2011) with respect to this context is described as follows:

A paradox which PD will need to grapple with is “how to address the challenge of increasing distance of the user from the software and system, because of greater complexity as the need for more comprehensive health systems understanding also is magnified by the architecture arrangement?” (pp. 19)

This paradox, I seek to try and conceptualize and understand through the notion of participatory networks. Such networks emphasize the following distinctive features:

1. The implementation and use contexts are multiple and spanning different levels, systems and geographical areas.

2. Architectures are developed through multiple teams, responsible for different pieces, being fundamentally and geographically distributed from each other, and also from the context of use.
3. The knowledge requirements to be addressed through these networks are multiple and complex, and qualitatively different from the times of stand-alone and isolated systems.

The above sections focused on highlighting the issues of content – local knowledge – which systems developers need to understand. Participatory approaches allow this communication of understanding of the implementation and use context to take place with respect to the systems development activities. This will now be discussed. Though the vast subject area of the systems development field is acknowledged, the focus here is on outlining some key perspectives, and identifying this where my research quest is located.

2.7 PERSPECTIVES ON SYSTEMS DEVELOPMENT

Systems development approaches have moved a long way, since the early thinking, based on technological determinism where systems development was seen as a controllable process. It had clearly demarcated phases (Kling et al 2000), each being dependent on an earlier one (Rose 2002) and based on predefined requirements. This linear approach was inscribed in models such as lifecycle or waterfall (Sommerville 1989). Major critiques have been carried out of such linear models of systems development, which have also contributed to the development of methods based on prototyping (Bødker and Grønbæk 1991), agile development (Johannesen and Ellingsen 2009) and others, based on

assumptions that analysis and design cannot be separated from their social contexts (Hirschheim et al 1995), and that system development should be taken as a process of multidimensional social change:

"Cultural, social, political and moral aspects.....that pertain to the choice, development, implementation and evaluation of computerized information systems". (Lyytinen 1987 pp-4)

In Scandinavia, system development research places emphasis on the technical and non-technical conditions and their interplay (Bratteteig 2003). Further, system development is presented as a professional work process where guidelines, techniques and concepts for addressing the non-technical matters are embedded as a part of the education of the professional system developer.

Brattateig (2003) categorizes research on systems development to represent the following perspectives:

- i) **A construction process:** emphasizes the construction of information technology, method, techniques and approaches to building technical systems. Mathiassen (1981) describes these constructional aspects to make system development different from other social, organization and human change processes. Construction is concerned with the engineering part of systems development, involving the building of a working computing machine according to pre-specified specifications.
- ii) **An organization change process:** This perspective emphasizes that computer based information systems are always situated in an organizational context focusing on use as work. This perspective believes that design needs to be rooted in the work of the users, in the organization and

designing, for change requires knowledge about work practices and the organization. The organizational changes concerned with systems development include the introduction of a computer system, training users and redefinition of various work practices and culture.

- iii) **Political process:** This aspect of system development is concerned with who decides what the problem is, and thus what the solution should be. The basic assumption here is that information technology is not neutral and there are different perspectives in society, sometimes representing conflicting interests. The emphasis here is towards understanding the effect of power and politics towards system development and its effects.
- iv) **Work process:** This aspect deals with the technical work of system analysis, design, programming and testing to plan and organize the conduct of the technical work, which is shaped by both the technical content as well as contextual factors.
- v) **Multi-perceptivity:** This aspect emphasizes that system development is a multi-disciplinary work process involving technical, social, organizational, psychological, managerial, economical, cultural, political knowledge and skills. While most system development research and literature emphasizes the construction of computer-based technology, however building a technical system is only one of the many processes in play. System developments involve the interplay between multiple processes which is crucial for creating real changes. Multi-perceptivity emphasizes that system development is a complex process that can be and should be understood from a number of perspectives

(Nygaard 1986, Nygaard & Sørgaard 1985, Thoresen 1984).

The HISP tradition to system development, which is my inspiration in this thesis represents largely a multi-perspective approach, which takes place largely in-context, and in close interaction with use. Further, building from the prototyping tradition, HISP believes in creating rapid versions of improved systems based on user feedback. How and about what this feedback is obtained, are facets related to participatory design.

The nature of system development is unique in that it is carried out in distributed and global environments, based on north-south-south networks. Unlike global outsourcing projects, where the south builds software for the north (Sahay, Krishna and Nicholson 2003), in HISP the south is engaged in building systems for solving their own problems in the south. This has implications on knowledge, as it is expected that people from a local setting will best understand their own context. However, various local developments need a global coordination, which in the HISP case is provided by Oslo. The open source domain also brings in opportunities for engaging more developers, but at the same time brings in challenges of building capacity, and retaining it from the lure of the private sector for promising developers. The system development challenge which I address in this thesis concerns the interplay between local knowledge and participatory networks, and how this is interlinked with system development processes at both the local and global levels.

2.8 SUMMARY OF THE THEORETICAL PERSPECTIVE INFORMING THIS THESIS

The above discussions on the three facets of local knowledge,

participatory networks, and systems development, help to provide the foundations for my theoretical exploration. The implementation and use context is understood through local knowledge, related to both the technology and public health domains. In a particular context, participatory design links this understanding of local knowledge with systems development that takes place at both the national and global levels.

The notion of participatory network which is at the core of the thesis, seeks to link multiple contexts of participatory design processes - from use to systems development. Systems development takes place in networks, with two hubs - national (India in my case) and global (Oslo). Development also has two distinct thrusts. The first is the core development which is taking place in Oslo. The second is what takes place at the national level, involving both customizations and a limited degree of core work. The coordination and sharing of such activities within the network, and its link with participatory design and participatory network processes becomes a core quest of this thesis.

After having presented this initial theoretical stance, I will return to elaborating on this theoretical perspective and discussing it in chapters 6 and 7 where I present the discussions and contributions respectively from this thesis.

Chapter 3 : Research Context

This chapter sketches the empirical context of this research. The chapter is divided into two segments. The first focuses on describing the background and structure of Indian health system, starting from the organization structure at the national level all the way down to the peripheral health institutions. The second focuses on describing some of the efforts towards Health Management Information System (HMIS), reforms at the state and national levels in India. This description helps to put my research in the institutional context in which it is situated, with a particular focus on the HMIS.

3.1 BACKGROUND: AN OVERVIEW OF THE INDIAN PUBLIC HEALTH SYSTEM

In India, the healthcare system aims at universal health care led by constituent states and union territories. The Indian National Health Policy was last formulated in 1983 and updated in 2002 (NHP 2002). Over the last few decades, India has registered significant progress in improving various health related parameters such as life expectancy at birth, reducing mortality due to malaria, as well as reducing infant and material mortality (NRHM 2005). It has the largest number of medical colleges in the world and produces the most numbers of doctors in the developing world, many of whom migrate to other countries. The country is equipped with state-of-the-art, high-tech hospitals which compare with the best in the world, and attract 'medical tourists' from many developed countries which reflects the high and cost effective standard of medical skills and expertise available. It has been reported that

India is the fourth largest producer and exporter of drugs in the world (Jan Swasthya Abhiyan 2006).

Despite the existence of such remarkable healthcare statistics, a high proportion of the population especially in rural areas, continues to suffer and die from preventable diseases, pregnancy and child birth related complications as well as malnutrition. Non-communicable diseases such as cardio-vascular diseases, cancer, blindness, mental illness, and diseases caused due to tobacco have created a heavy burden on the already over- stretched health care system in the country. Premature morbidity and mortality from chronic diseases contribute to the loss of significant economic and human resources in the country. The large disparities across India places the burden of these adverse conditions mostly on the poor, scheduled castes and tribes especially those who live in the rural areas of the country. Mukherjee (2010) describes the availability of recognized medical practitioners in rural areas to be 27 per 100,000 population whereas in the urban areas it is 155 per 100,000 population. She describes 84 per cent of hospitals in India to be sited in urban areas which accounts for roughly 35 per cent of the population. Public spending on preventive health services has historically been given a low priority in the country in relation to curative health as a whole. Indian public spending on health per capita is amongst one of the lowest in the world, whereas its proportion of private spending on health is one of the highest (NRHM 2005), making India a “**country of contradictions**” (AIHS 2008). According to a UNAIDS (2010) report, an estimated 2.4 million people in the country are living with HIV/AIDS, a condition which has the potential to undermine the health and developmental gains India has made since its independence.

As the deadline set by Millennium Declaration of the United Nations for achieving Millennium Development Goals (MDGs) by 2015 approaches, India, like many other developing countries, finds itself in a complex mélange of successes and failures, speed and sluggishness, against a backdrop of great expectations. While India has reported strong economic growth and made some progress toward the MDGs in domains of poverty and education, performance on the health care goals lags significantly. There is a continuous decline in mortality rate below five years of age(USMR), infant mortality(IMR) and maternal mortality rates(MMR) since 1990, and India is likely to fall short of achieving all these indicators by 28, 20 and 26 per cent points respectively (MDG-India 2009).

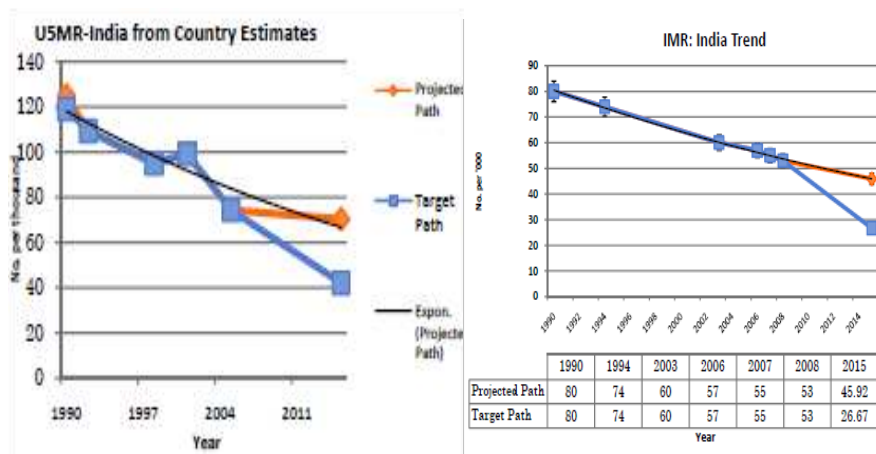


Figure 3-1: Trend of Under five Mortality Rate and Infant Mortality Rate, India. (source: MDG India 2009)

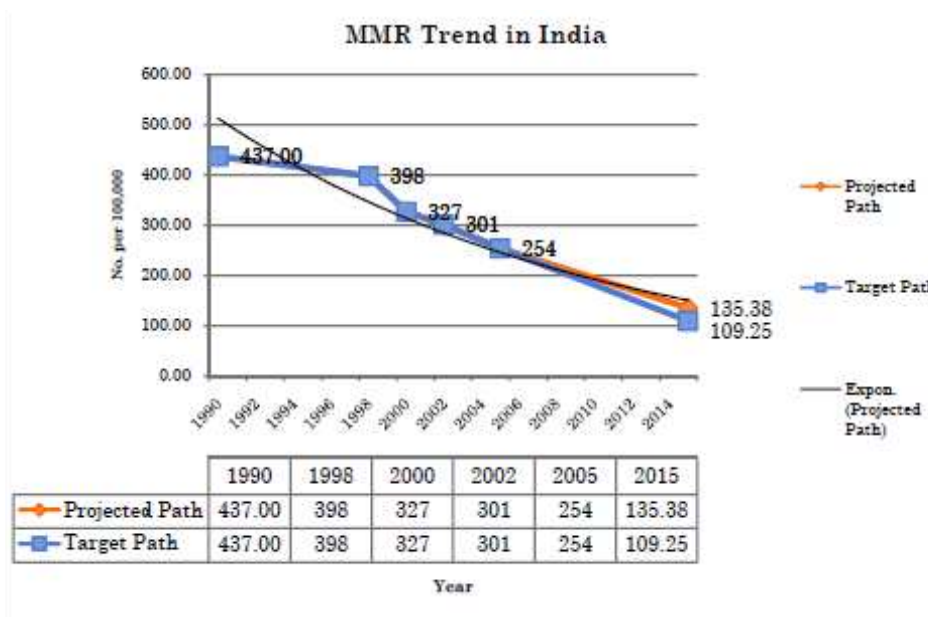


Figure 3-2: Trend of Maternal Mortality Rate, India. (Source: MDG India 2009)

Given these challenges along with their scope and magnitude, it is universally agreed that for the Indian health system to focus on narrowly defined projects is inadequate, and there is an urgent need to transform the public health system as a whole into an accountable, accessible and affordable system of quality services, leading to the birth of the National Rural Health Mission (NRHM 2005). Amongst the priority areas identified for reform by the NRHM is the national HMIS, which will be the focus of this thesis.

3.1.1 National Rural Health Mission (NRHM):

The office of the Prime Minister of India launched the National Rural Health Mission (NRHM) in 2005. The thrust of the Mission is on establishing fully functional, community owned, decentralized health delivery systems with inter sectoral convergence at all

levels, to ensure simultaneous action on a wide range of determinants of health. The NRHM is expected to bring about dramatic improvements in the health system by undertaking architectural corrections within a health systems framework (rather than a disease or programme specific framework) and promote policies that strengthen public health management and service delivery in the country. The Mission proposes a shift from narrowly defined schemes to focus on developing a fully functional health system at all levels from village to district. The Mission aims to increase public expenditure on health sector from 0.9 per cent to 2-3 per cent of the Gross Domestic Product (GDP), with an improved arrangement for community financing and risk pooling.

Amongst the fourteen targets identified by the NRHM for bringing about architectural corrections, effective integration of health concerns through decentralized management at the districts and the HMIS are identified as key goals. A key focus is to overcome the limitations of the existing national HMIS, which is geared largely towards upward reporting for compiling statistics, and create a greater action-led and community focused system.

To help strengthen technical support to NRHM, 700 consultants (with Masters in Business Administration (MBA) degree), and Chartered Accountants (CA) have been appointed to the state/district level programme management units. A National Health System Resource Centre (NHSRC) has been set up at the national level to serve as an apex body for technical assistance, dissemination and for functioning as a center for excellence for facilitating the center and states in programme management. This resource center, which is envisaged as an agency to pool technical assistance from all International Development Partners, is expected to develop

more coherent responses to central and state requests for technical assistance so as to help improve service delivery in the health sector in general. A similar resource center has been set up in north east India, and more are expected to be set up in other regions and states, so as to enable the growth of innovation and new technical skills to develop in the health system (NRHM 2005).

To support the programme management needs of NRHM and Reproductive Child Health (RCH)-II, State Program Management Units (SPMU) have been established in states which act as the Secretariat to the State Health Mission¹ and State Society². This unit, which is headed by an Executive Director/Mission Director, is responsible for the overall state level planning and monitoring for NRHM, management of flexi pool funds allocated, initiation of health sector reforms and supporting of continuous process improvements. Consultants recruited under this unit are expected to improve the performance levels of the public health infrastructure and functionaries to make the system more responsive and transparent. The SPMU consist of four positions which are the State Programme Manager, State Finance Manager, State Account Manager and State Data Officer. This technical pool would be accessed by all programmes under NRHM for providing

¹The NRHM would function under the overall guidance of the State Health Mission headed by the Chief Minister of the State. The mission is responsible to provide health system oversight, consideration of policy matters related with health sector, review of progress in implementation of NRHM, inter-sectoral coordination and advocacy measure required to promote NRHM visibility.

² State Health Society serves in an additional and technical capacity to the Department of Health and Family Welfare for the Implementation of NRHM in the State. It headed by a governing body chaired by Chief Secretary/Development Commissioner and an executive committee chaired by Principle Secretary/ Secretary, Family Welfare.

programme support related to logistics, financial management, Management Information System (MIS), tracking of funds, etc.

At the district level, on the lines of the state health mission, district level health missions have been established headed by the Zila Parishad³ as Chairperson, District Collector⁴ as Co-chairperson and Chief Medical Officer as the Mission Director. Integrated District Health Societies have been established where all the existing societies and vertical support structures are expected to be merged in the District Health Societies (DHS). This society is responsible for planning and managing all the health and family welfare programmes in the district, both in the rural as well as urban areas. One of the main tasks of the DHS is to ensure inter-sectoral convergence and integrated planning that includes - providing the platform where the three arms of governance at the district level (Zilla Parishad, Urban Local Bodies, District health administration) would coordinate health issues. The DHS is headed by the District Program Manager (DPM) who plays a key role in setting up and operationalizing the DHS secretariat. Along with the DPM, two additional posts have been created including Finance/Account Manager and Data Assistant (NRHM 2005).

The creation of such additional support units have contributed to positive results in some states but in others they have created their own island of operations. One of the key activities of SPMU and District Program Management Unit (DPMU) is the strengthening of HMIS at the state level by integrating all the

³ Zila Parishad is a local government body at the district level, looks after the administration of rural area

⁴ District Collector: is of Indian Administrative Service cadre appointed by central government and is directly or indirectly in-charge of entire governance of a district.

program specific data collected under the Health and Family Welfare Department. This unit is also responsible for reporting data to the central level through the national web-portal application implemented by Statistical Division under Ministry of Health & Family Welfare. The process of data reporting through the web-portal requires the data to be entered at the district level by district staff - after it has been scrutinized by the SPMU - before it is forwarded to the central level. This responsibility at the district and state levels rests with the DPMU and SPMU respectively.

In some states, the SPMU operates as a vertical information system, where the data collected by the DPMU is sent to the SPMU without horizontal coordination with the other health program divisions. The District Medical Officer (DMO), also known as the Chief Medical Officer (CMO) in some states, is responsible for implementing all health programmes and monitoring the health status throughout the district. The newly created DPMU was intended to help the DMO/CMO in their planning and monitoring activities. But the data tends to be collected and transmitted from the DPMU to SPMU without adequate coordination from the CMO of the district. In some states, the DPMU has a separate office and structure, with relatively well endowed resources, established away from the CMO's office, which makes coordination of activities difficult. As both the CMO and DPM come from different domains - medical and business respectively- finding a common ground for communication is often difficult. While the DPM sees the CMOs with limited capacity in administration of funds and resources, the CMOs view the DPMs as non-medical personnel who cannot administer health programmes. Since the DPMs are contractual staff, their long term allegiance to the department is also under question. An outcome of this confusion is that the data provided by the SPMUs is very differ-

ent in format and content, than what the different program division managers tend to have. Efforts to close this gap have proved to be problematic till date in various states.

This background information on NRHM helps to provide an understanding of the current focus of efforts for reform which are underway, including with respect to that of the HMIS. This newly created mission structure is expected to work in harmony with the historically existing health structure (from the national, state, district to sub-district levels), a relationship which I try to briefly outline in the next section. Sketching out this broad structure and hierarchy of the health system helps in understanding the different linkages across these levels, and how the HIS relates to these different levels. It also helps to understand the complexity of its relation with the NRHM.

3.1.2 National Level

Issues of health comes under the purview of the Ministry of Health and Family Welfare (MoHFW), which is instrumental and responsible for the implementation of various health programmes, prevention and control of major communicable diseases, and promotion of traditional and indigenous systems of medicines, at the state level. Keeping in view the federal nature of the Indian Constitution, the areas of operation have been divided between the Union government and the various state governments. Even though public health, hospitals, and sanitation fall under the domain of state items described under the Seventh Schedule of the Indian Constitution's exhaustive list, the items having a wider ramification at the national level, like population control and family welfare, medical education, prevention of food adulteration, quality control

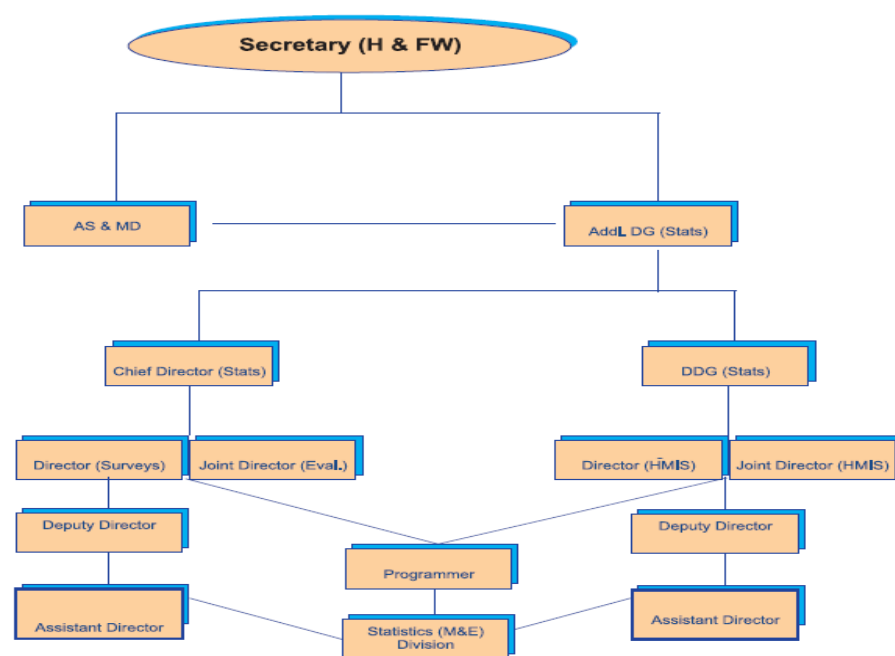
in the manufacture of drugs, are included in the concurrent list under the joint responsibility of the Union and State governments (DoHFW 2009).

The MoHFW is headed by Union Minister of Health and Family Welfare who is assisted by Ministers of State for Health and Family Welfare. The MoHFW comprises of a Department of Health and Family Welfare, Department of AYUSH (for traditional medicine), Department of Health Research and Department of AIDS Control, each of which is headed by a Secretary of the Government of India (GOI). Secretary of GOI, is the highest rank in the department belonging to Indian Administrative Service (IAS) which is the administrative civil service of the Government of the Republic of India. At the national level, the NRHM has a Mission Director also from the IAS, who reports to the Secretary of Health. As the structure itself articulates, there are inherent problems associated with shifts of government which often implies a change of the Secretary in GOI. During the course of my Ph.D research, I saw at least three different Secretaries of Health & Family Welfare change in the Central Ministry, each with different backgrounds, understandings and agenda towards HMIS.

The Directorate General of Health Services (DGHS) is an attached office to the Department of Health and Family Welfare, responsible for rendering technical advice on all medical and public health matters and for the implementation of various health schemes in the country. The Division of Statistics helps in perspective planning, monitoring and evaluation of the performance of various family welfare programmes and also coordinates demographic research under the Department of Health and Family Welfare along with 14 other divisions such as Maternal Health, Child Health, IEC

(Information Education and Communication) and Rural Health, etc. My research was mainly situated within the Department of Health & Family Welfare (DoHFW).

Given the different departments under the MoHFW, the HMIS is required to produce various program specific reports. To meet these reporting needs over the years, different departments have built and implemented various Information Communication Technology (ICT) solutions for their respective departments. For example, under the Universal Immunization Programme, the Routine Immunization Monitoring Systems (RIMS) software with support from the World Health Organization (WHO) has been developed and implemented throughout the country to collect immunization data. Routine Information Monitoring System (RIMS) is a web-based application built on Microsoft platform that supplies data to an online portal for central consolidation. A large part of data relating to immunization is also collected under the Family Welfare Program. All this data originates from the same peripheral institutions which also need to fill overlapping data in different forms so that they travel separately to different programmes/departments at the national level. The NRHM has recognized the urgent need for convergence of these different reporting systems, and various reform efforts are underway. Organogram of Department of Health and Family Welfare is depicted below.



AS & MD: Additional Secretary & Mission Director; Addl DG: Additional Director General; Stats: Statistics; HMIS: Health Management Information system; M&E: Monitory & Evaluation

Figure 3-3: Organogram of Department of Health and Family Welfare, India. (source: DoHFW 2009)

3.1.3 State Level

The health structure at the state level to some extent resembles the national structure, but with comparatively smaller departments/divisions. As the Union Ministry of Health & Family Welfare heads the national health system, at the State level, the Minister of Health along with a Secretariat which is under the charge of a Secretary or Commissioner (Health and Family Welfare) heads the State Department of Health & Family Welfare. Similarly at the national level there is a state level Mission Director for the NRHM who reports to the State Health Secretary, and is responsible for the implementation of various programmes. As the technical

wing, the State Directorate of Health Services is an office attached to the State Department of Health and Family Welfare which is headed by a Director of Health Services. The area of Medical Education is integrated with the Directorate of Health Services at the state level, and has a separate identity as the Directorate of Medical Education and Research. This Directorate is under the charge of the Director of Medical Education who reports to the Health Secretary or Commissioner of the State. Some states have created separate posts of Director of Ayurveda and Director of Homeopathy (both popular forms of traditional medicine) with a fair degree of autonomy in their day to day work, although they still fall under the Directorate of Health Services of the State (WHO 2002). Organogram depicting the health service structure in two states Kerala and Tamil Nadu are portrayed below.

ORGANISATIONAL SET UP AROGYAKERALAM

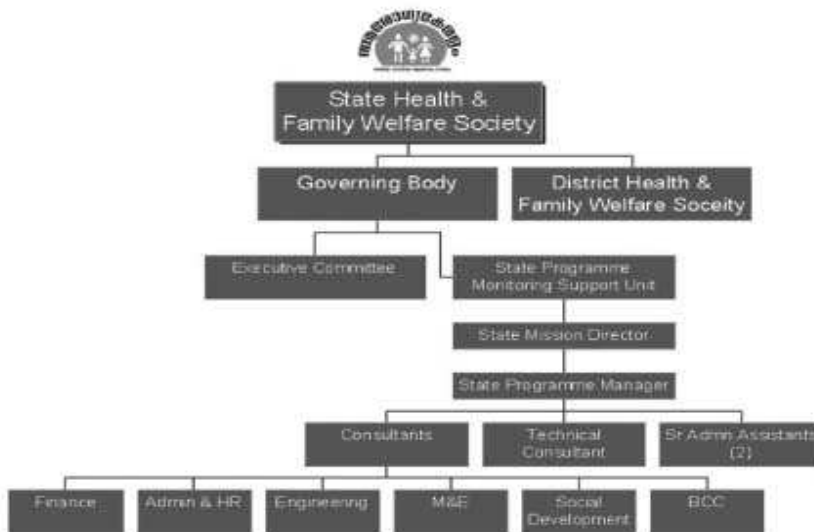


Figure 3-4: Organisational set up of State Health & Family Welfare in Kerala State. (Source mohfw.nic.in)

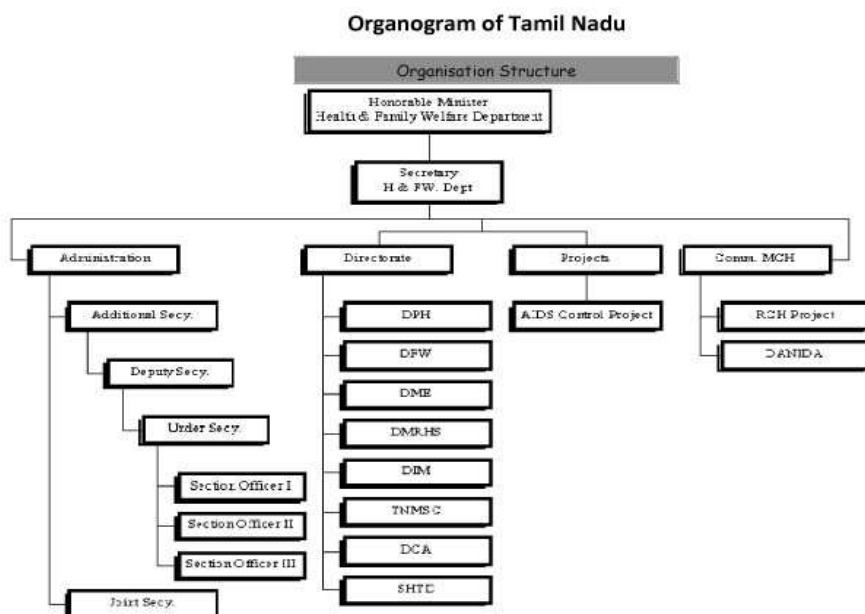


Figure 3-5: Organisational Set up of State Health & Family Welfare in Tamil Nadu State. (Source tnhealth.org)

While in the organizational structure of State Health and Family Welfare, a technical post for IT has been incorporated but in practice such skills are limited. This raises serious issues of inadequate support especially given that various state health departments, often with support from donors, have initiated multiple ICT projects, sometimes quite ambitious, complex and uncoordinated. When the state initiatives are seen in context of the additional systems that have been initiated through the national level, the picture becomes much more complex and uncoordinated. As ICT solutions are taking on a more prominent and central role in the reform efforts of the states, it is increasingly being realized that there must be a stronger and more coordinated IT department. However, establishing such structures are never easy, given the rigid procedures for procurement and recruitment.

3.1.4 District Level

At the District Level, there is the Chief Medical and Health Officer (CM & HO) or District Medical and Health Officer (DM & HO), popularly known as CMO or DMO who is the overall in-charge of the Health and Family Welfare programmes in the district, with responsibilities for implementing both the national and state programmes. In larger states like Madhya Pradesh and Uttar Pradesh, regional structures have been created, and the district serves as the link unit between the region and the state on one side, and the peripheral health facilities on the other. The DMO in the district is assisted by various line managers responsible for different health programmes such as Leprosy, Malaria, Tuberculosis, and Disease Surveillance. These officers are responsible for implementing and reporting on their particular health programmes to the State and National levels (WHO 2002). The District Program Management Unit structure established under the NRHM, is expected to coordinate with these different line departments for their HMIS reports and consolidate them at one point. Institutionally, this coordination is complex, and leads to problems in data quality and ownership. The new structures under NRHM are better endowed with resources, and thus often at odds with the traditional structures organized under the lines of health programmes.

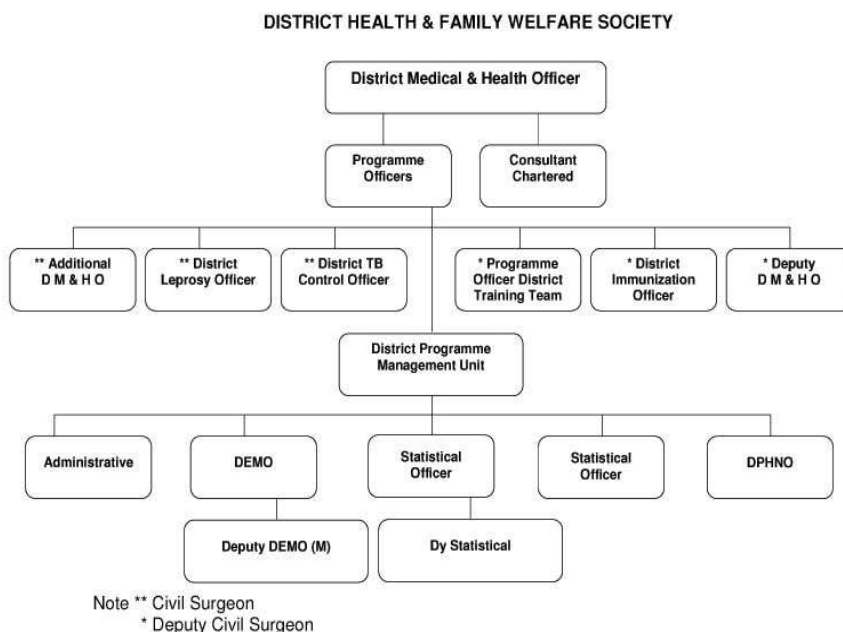


Figure 3-6: Organogram of District Health & Family Welfare Society, Andhra Pradesh

Information received from the state level in the form of policy guidelines and operational plans at the District health office is transmitted to the peripheral institutions. By doing so, the district acts as a manager, responsible for various issues of general, organizational and administrative kind in relation to the management of health services (DoHFW 2009). Ideally, the district health office should not only transmit the operational plans to the peripheral institutions, but also add on specific issues that are relevant to that district. But due to strict and rigid guidelines from the higher administration and lack of capacity in integrating local plans into predefined policies, such local initiatives are restricted. On the other hand, the district is also responsible for various programmes, each with their individual reporting requirements and data collection needs. For example, the TB program deals directly

with their programme specific TB units which are set up for catering to 100,000 of the population. These units are usually established under a Primary Health Centre (PHC) and collect their data separately on a quarterly basis, while other data has a monthly periodicity.

3.1.5 Peripheral Health Institutions

The field implementation of various national and state programmes takes place through the primary health care system, which represents the foundation of the rural health care system. The primary health care infrastructure in rural areas has been developed as a three tier system based on various established population norms. . The figure below provides an overview of peripheral health institutions, its coverage, services provided and staffing at sub district (Block) level.

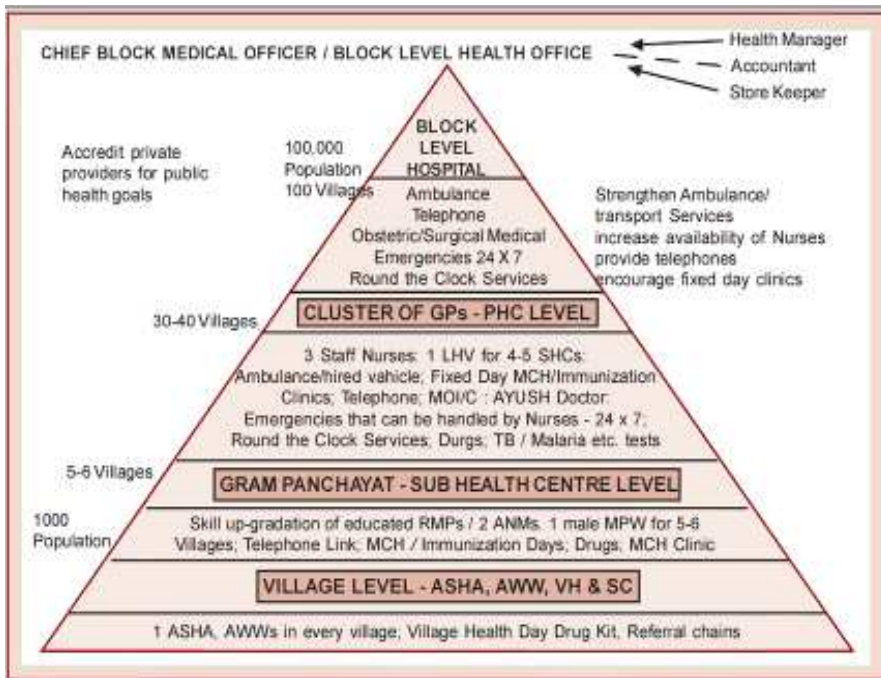


Figure 3-7: Overview of peripheral health institution. (Source NRHM Mission Document)

a. The Sub-Centre (SC)

As a first contact point between the primary health care system and the community, the success of national and state programmes are dependent on the effectiveness of the Sub-Centre. A Sub-Centre serves as an outreach center catering to the health needs of a population of 5,000 in plains and 3,000 in hilly or tribal areas. These norms are however not usually followed by Sub-Centers in many states catering to larger populations of even 10,000 - 15,000. A Sub-Centre is managed by one female health worker commonly known as the Auxiliary Nurse Midwife (ANM) and a male health worker commonly known as Multi-Purpose Health Worker (Male) (IPHS-SC 2006). Different states may term the health worker differently such as the Junior Public Health Nurse (JPHN) for ANMs

and Junior Health Inspector (JHI) for the male health worker in Kerala.

ANMs typically have high school qualifications (10th Standard) and further receive nurses' training program for one and half years. There are 336 ANM schools in the country with an annual admission capacity of approximately 13,000. The Sub-Centre staff are supervised by the Lady Health Visitor (LHV) and Health Assistant (Male) who are located at the Primary Health Centre (PHC). Each supervisor has five to seven Sub-Centers under their line of control which are under the administrative jurisdiction of a PHC. A senior ANM with five years of experience is given six months of promotional training program prior to becoming a LHV (Lady Health Visitor). Given the background and education qualifications of the ANM and their extremely heavy and geographically dispersed work load, their capacity building towards ICT and information support is a challenging task. Despite this fact, in ten years of my interactions with ANMs across different states, I have found them to be very passionate and enthusiastic about learning new technologies, something which is not often seen amongst the medical fraternity at the higher levels.

Apart from providing outreach services, ANMs are expected to record and report vital events related to births and deaths particularly of mothers and infants, to the health authorities in her area. Further, ANMs are expected to maintain multiple registers in their facility from which they aggregate their achievements or services provided for the period, and further send reports up to the PHCs. The registers typically maintained in the Sub-Centre are listed below.

Register to be maintained at Sub-Centre

1. Eligible Couple Register including details on contraception: Eligible Couples are defined in India as married women in the reproductive age group of 15-45 years.
2. Maternal and Child Health Registers:
 - a. Antenatal, intra-natal & postnatal
 - b. Under five register
 - i. Immunization
 - ii. Growth monitoring
3. Birth & Death Register
4. Drugs Register
5. Equipment-furniture & other accessories Register
6. Passive surveillance register for malaria cases
7. Register for records pertaining to Janni Suraksha Yojana
8. Register for maintenance of accounts including untied funds
9. Register for water quality & sanitation
10. Minor ailments register
11. Records/register as per various National Health Programme guidelines such as
 - a. National Leprosy Eradication Programme- NLEP
 - b. Revised National TB Control Programme-RNTCP

Box 3-1: Registers to be maintained at Sub-Centre (source IPHS-SC 2006)

These enormous lists of registers which have to be maintained at the Sub-Center are not only lengthy but also bulky in size to carry on field visits. As a consequence, most ANMs carry a small dairy where they record all their activities during their field visits and subsequently transfer this data to their respective registers. Due to the massive work load of the ANMs, registers are often not updated on a timely basis. In many states, new registers are not given to the ANMs on time. As a result these registers, which are the foundation of the entire HMIS in the country, become the weakest link in the entire information chain. While new initiatives seek to bring in technologies like Personal Digital Assistant (PDA) and

mobile phones, the primary registers continue to be neglected.



Figure 3-8: Health Worker explaining the translation of data from dairy to register

b. Primary Health Centre (PHC)

A first port of call to a qualified doctor is the Primary Health Centre (PHC), which is expected to cover a population of about 30,000 in plains and 20,000 in hilly, tribal or difficult areas. A PHC facility typically has 4-6 indoor or observation beds, serves as a referral unit for 5-7 Sub-Centers and also refers out cases to higher public health institutions. As per the guidelines of Indian Public Health Standard (IPHS), a PHC is expected to have fourteen paramedical staff; however in reality most of them are under staffed. And quite often, the medical doctors are additionally assigned to other PHCs to cover for vacant positions, and many even run their private clinics, leading to neglect of patients from their catchment areas. Typically, medical officers are overworked, seeing almost 100 to 200 outpatients every day.

The Lady Health Visitor (LHV) is the female supervisor at the PHC,

and supervises 5-7 ANMs from the Sub-Centers assigned to the PHC. Supervision includes the scrutiny of records maintained by the ANM. She reviews the monthly aggregated reports received from the ANMs and consolidates them to be finally approved by the medical officer of the PHC before sending it to the next higher level of the block. Often, CMOs are reluctant to spend time examining these reports, and one of them told me during an interview: *“I am interested in saving lives of people not doing paper work”*. Most PHCs are poorly placed in terms of infrastructure, including power supply, running water, and drugs. Computers and supporting infrastructure, thus often take a back seat in the absence of these more critical resources.



Figure 3-9:A rural PHC and its scarcity of drug availability

c. Community Health Centre (CHC)

The Community Health Centre constitutes the secondary level of the health care, and is designed to provide referral health care for cases from the primary level, needing specialist care, and additionally those patients that approach the center directly. Under

each CHC, there are 4-5 PHCs catering to a population of 120,000 in plains, and 80,000 in tribal and hilly areas. A CHC facility is 30-bedded with a minimum of four medical doctors providing specialist care in medicine, obstetrics, gynecology, surgery and pediatrics. These norms are however rarely operational.

CHC usually acts as a block (sub-district) headquarter, and with respect to the HMIS, it serves as the point of consolidation of all reports from the PHCs and SCs under it. However, in some states like Gujarat, CHC acts as Fist Referral Unit (FRU) with no PHC or SC attached to it. They compile their monthly service delivery report and transmit it to block head quarter where all the data (including PHC, SC and CHC) for that particular block is consolidated. These consolidated reports are then submitted to the district headquarters. In most states, this level of the block also provides the first point of computerization, although some of the advanced states like Kerala and Tamil Nadu have computers at the PHCs also. Under the NRHM, most of the states have established a Block Management Unit, consisting of a block coordinator and a data assistant. This cell is responsible for information processing, primarily limited to data entry and in some cases even data validation.



Figure 3-10: CHC and its patient load on drug distribution

d. District Hospital

The district hospital refers to hospital at the secondary referral level, responsible for a district of a defined geographical area. It plays an essential role in operationalizing the delivery of curative, preventive and promotive healthcare services to both the urban and the rural population in the district. As the size of a district, in India, varies from 30,000 to 30,00,000 (Census 2001), norms for district hospitals are graded from Grade I to IV as per the number of beds in the hospital (I being more than 500 beds and IV being 100 or less than 100). The reports received from district hospitals about their performance and district statistics tends to be incomplete, considering the significant level of primary care services they provide.

In states like Tamilnadu, district hospital and sub-district hospital (Taluk hospital) report to the Directorate of Medial and Rural Health Services, whereas other peripheral institution such as PHC, CHC

and SC report to Directorate of Family Welfare. Getting an overall district or block performance is difficult as these two directorates have limited scope of data sharing.

The Table below summarizes the essential services and expected norms in different facility types at the peripheral level.

<i>Facility Type</i>	
Sub-Centre	<p><i>Population norm:</i> 5000 in plain/non-hilly areas & 3000 in tribal/hilly areas.</p> <p><i>Expected key staff:</i> one female and one male health worker.</p> <p><i>Expected key services:</i> Outreach services related to immunization, antenatal, natal and postnatal care, prevention of malnutrition and common childhood diseases, family planning services and counseling. Implementation of various national health programmes.</p> <p><i>Existing facilities:</i> 146,036 (as on March 2008)</p>
Primary Health Centre	<p><i>Population norm:</i> in plain/non-hilly areas 30,000 & 20,000 in tribal/hilly areas.</p> <p><i>Expected key staff:</i> One Medical Doctor, fourteen paramedical and other staff.</p> <p><i>Expected key services:</i> Outpatient, inpatient and referral services, maternal & child health care including family planning, nutrition services, school health, basic laboratory services, selected surgical services, prevention and control of locally endemic diseases like malaria, kalaazar (black fever), JE.</p> <p><i>Existing facilities:</i> 23,458 (as on March 2008)</p>
Community Health Centre	<p><i>Population norm:</i> 120,000 in plain/non-hilly areas & 80,000 in tribal/hilly areas.</p> <p><i>Expected key staff:</i> General surgeon, physician, obstetrician and gynecologist, pediatrician</p>

District Hospital	<p><i>Expected key services:</i> Care of routine and emergency cases in surgery and medicine, 24 hours delivery services including normal and assisted deliveries, essential and emergency obstetric care, new born care, essential laboratory services, referral (transport) services.</p> <p><i>Existing facilities:</i> 4,276 (as on March 2008)</p> <p><i>Population norm:</i> 2-5 million</p> <p><i>Expected key staff:</i> Surgeons, physicians, obstetrician and gynecologist, pediatrics, orthopedic surgeon, ophthalmologist, anesthetists, ENT (Ear, nose & throat), specialists and dentists.</p> <p><i>Expected key services:</i> comprehensive secondary health care (specialist and referral services), epidemic control and disaster preparedness, services under various national health and family welfare programmes.</p> <p><i>Existing facilities:</i> 617 (as on 2008)</p>
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Table 3-1: Facility type and its key services details

By providing an overview of service details at each level of the health administration hierarchy and the associated reporting related issues, I have tried to sketch out the challenging context in which the HMIS reform efforts are placed. Challenges are multi-faceted related to infrastructure, work load, resources, and institutional fragmentation. There is also a general sense of apathy towards the reporting function, which is seen as a burden to meet the needs of the higher levels, but not something useful for local action.

3.2 EFFORTS TOWARDS HMIS REFORMS

This section describes some prior efforts, made towards strengthening HMIS that have taken place in the country. A problem in carrying out this exercise is the absence of documented evaluations of such efforts. This also raises a larger question of accountability and responsibility towards such efforts. Often, initiatives are started by Health Secretaries who lead the health department, and before the project is completed they are transferred to another department. The new incumbent then tends to start a new effort, little remains in memory of the earlier effort and this pattern is repeated.

To develop this section, I have relied on some published reports, and also drawn upon from some of the experiences gained by HISP India, during their ten years of working with various HMIS projects in different states in the country.

3.2.1 HMIS Reform Under Donor Initiative

In various health reform efforts, including of HIS, ICT solutions are being actively introduced by international agencies, national and state governments, medical institutes in their model sites to enhance the efficiency of administration and improve delivery of healthcare services. Various ICT solutions such as web-based systems, Geographic Information System (GIS), telemedicine, mobile and handheld devices, name based and electronic medical records have been initiated in different locations. Successes achieved through these various efforts, involving huge costs, have been limited and largely not justifying the costs incurred. . Various donor agencies such as The World Bank, DFID (Department for Interna-

tional Development), USAID (United States Agency for International Development), NORAD (Norwegian Agency for Development Cooperation) have funded these various efforts in their larger health systems strengthening initiatives, in which most often HMIS is an integral component. For example the World Bank, since 1990 have funded 15 such major projects, and engaged EPOS Health India Pvt. Ltd. to evaluate these projects. The table below summarizes these projects.

State	Start Date	Total Budget (in Million USD)	Budget of HMIS in the project (in Million USD)	% allocated for HMIS
Uttar Pradesh	2000	4780.7	77.25	1.61
Uttaranchal	2001	---	10.83	NA
Orissa	1998	82.36	9.06	11
Rajasthan	2004	15.92	19.97	19
Maharashtra	1999	137.6	12.4	9
Andhra Pradesh	1995	136.39	4.10	3
Karnataka	1996	78.32	9.32	11.9
Tamil Nadu	2005	131.5	25.61	19.5

Table 3-2: State wise HMIS budget overview

In these projects, various ICT solutions such as web-based system in Maharashtra, GIS in Karnataka, financial management system & personal information system in UP, optical mark reader in Tamilnadu, use of handheld devices (PDA) in Andhra Pradesh, were incorporated as part of the HMIS reform efforts.

The EPOS study reported that only partial success was achieved on some projects, but most fell short of achievement when examined for scalability and sustainability. The reasons for these poor outcomes were largely attributed to changing requirements, poor ca-

capacity of technological development and penetration, changing state leadership leading to change in the aims and support for the project. In some of the states like Orissa, Rajasthan and Uttaran-chal, which had limited exposure to ICT infrastructure during the project period, the focus was limited to strengthening of the manual HMIS rather than on developing ICT interventions. Based on their analysis, EPOS Health India listed out a set of recommendations towards institutional strengthening of HMIS efforts in the country, which is summarized in the table below.

Major Recommendations:

1. Formulation of a National Health Information Policy to provide rules, regulations, norms and standards regarding data collection, processing, generation, access, dissemination and security of health information.
2. HMIS component should be treated as specific and strategic programme objective with dedicated budgets & monitored through specific milestones.
3. Horizontal learning from the experiences of other states should be encouraged and promoted through specific integrated dissemination mechanisms, It should start with programme conceptualization all the way through to the implementation and operations phases of a new programme.
4. The principle of reusability of assets should be introduced in the programme-planning phase.
5. Integration of information from all programmers under HMIS and inclusion of the private sector should be designed and considered as a strategic objective and results area.
6. Proactive leadership is required for establishing an IT environment; and strategic importance given to data and information management is as vital as its use as a basis for management decision making.
7. Adequate human resource capacity for coordinating HMIS activities for all programmers at the district and state level.
8. Adequate change management procedures and monitoring & evaluation frameworks to be formulated in order to enhance ownership towards data quality at

Box 3-2: EPOS Health India Pvt. Ltd recommendation towards H MIS reforms/strengthening**3.2.2 Other Efforts Rewards HMIS Reform: Some Examples**

Since 1965, the All India Institute of Medical Sciences (AIIMS), New Delhi in collaboration with the State Government of Haryana, is running a project called Comprehensive Rural Health Services Project (CRHSP) situated in Ballabgarh district of Haryana state.

The project objective is to demonstrate a model health care delivery system and train medical students accordingly. The project covered two PHCs with six SCs each, 24 health workers and four supervisors covering a population of 85,552 in the year 2008, which spread across twenty-eight villages. A computerized data management system was introduced in February 1988 to overcome the problems faced by the health workers in handling data and making efficient use of data collected. The aim of the software was to record an individual's experience related to health services such as immunization, pregnancy related care, eligible couple and geriatric age group.

Over the years, the computerized data management system has undergone three phases of evolution. The initial software which was built on FoxPro and DbaseIII with MS DOS operating system (1988-2002), was transformed to Visual Basic & MS Access (2002-2005) and then further to Java and MySQL in the year 2006. Due to logistic reasons, both the computers dedicated for each individual PHC were placed at the project head quarter where a data entry operator updated the data with the assistance of the health workers. For security reasons, both the computers were not connected to either the Internet or the LAN. Every month, the plan of work was generated from the computer system. The plan provided a list of specific health services for individuals in the villages sorted out and listed according to house numbers. This work plan was used for updating the server by the health worker and monitored by a supervisor and medical officer (Krishnan et al 2010).

Even after ten years, the project has not scaled beyond the two PHCs. Moreover the flow of information from this system was

parallel to the flow of information from the district and was never integrated. In the initial stages, a PDA was used, but this was not sustained. Like many other such demonstrations and pilot projects, the Comprehensive Rural Health Services Project (CRHSP) also demonstrates use of an ICT solution in a limited and controlled setting. But it does not have the technological or institutional capacity to grow. There are various other similar pilot projects such as one supported by the Boruka Charitable Trust (BCT) in a dispensary located in Borugram village in Rajasthan. Though this project was established in 1990 and used software called Maternal and Child Health System (MCHS) to collect data, it did not scale to become useful even to a district (Moidu et al 1992).

3.2.3 Techno-centric Approach Towards HMIS Reform

Majority of the HIS reforms in different states involve the introduction of ICT solutions to enhance the efficiency of the administration and improve delivery of healthcare services. These projects take a technology deterministic perspective to HIS development. Raghavendra and Sahay (2005) argue that lack of sensitivity to the socio-political-institutional context contributes significantly to the potential of computerization of HIS in developing countries. They analyze empirically some of these challenges by drawing upon two specific HIS projects - India Health Care (IHC) project and Family Health Information Management System (FHIMS). These were an offshoot of the IHC project initiative introduced in primary healthcare services in Andhra Pradesh state in India.

The State of Andhra Pradesh undertook number of IT initiatives to help provide electronic support tools to the health staff at different levels of the organization. These HIS efforts were initiated in the

backdrop of larger e-governance reform policies towards achieving the objective of “SMART governance” (Simple, Moral, Accountable, Reliable and Trustworthy). Under this larger e-governance reform an ambitious project termed Multipurpose Household Survey (MPHS) was initiated. It aimed at building massive ‘name-based’ database of 75.7 million citizens, twenty-five million pieces of land and to help provide a social security identification number for every citizen of the state. While this database was created by the state revenue department for its own purposes, the government passed a directive that MPHS should be used as a standard database by all government departments and other agencies in an attempt to prevent multiplicity of databases. This database, which was compiled in 1995 and subsequently updated between 1998 and 2003, did not match with the health fundamental unit (PHC and sub-center), because for the revenue department the fundamental unit is the village. As a result, many of the health parameters necessary for the service delivery were missed in the MPHS database. Despite this difference, inaccurate and poor quality of data, it was decided that MPHS would form the basis of name-based health registry and health staff would update this database by conducting a house to house survey. The MPHS data was crucial for both the IHC and FHMIS projects, as it was to be the foundation of the name-based IS.

IHC project aimed at providing ample opportunities by using mobile computing devices, such as the PDA (Personal Digital Assistant), for assisting health staff in their routine work. The IHC project piloted in three health centers in Nalgonda district and 200 health staff were given PDAs. By using these mobile computing devices, the project intended to reduce manual paper work of health staff in collecting, collating and reporting health data to different officials

and also in eliminating redundant data entry. The application was also expected to facilitate the generation of schedules with information pertaining to immunization and antenatal services for health staff which would then allow them to geographically identify antenatal cases to be visited and children to be immunized. The schedule also highlighted pending or missed cases. This was supposed to help the health assistant to prioritize their work. The system was also supposed to help track the history of the patient and enable health staff to take preventive measures such as treating high-risk pregnant women or giving timely vaccinations to children. Thus, the uses of mobile computing devices were expected to eventually replace health staff manual registers.

However, in practice, the use of these mobile computing devices was largely unsuccessful. The reasons were:

- i) *Technology related:* PDAs used in the project were supplied with insufficient memory and the devices were slow, thus using the device while on job was time consuming. Small letters on the monochrome black & white screen made it very hard for the health staff to see the screen due to the glare of the sun. There were technical problems also in uploading data into the database.
- ii) *Public Health Domain:* The base line name based data used in PDA originated from MPHS which was basically from the revenue department. It didn't meet the needs of the health domain, such as eligible couple details (15-49 year married women) were missed in the MPHS. The survey database was of poor quality as many beneficiary names were missed and as a result a

health worker could not register the service provided for those beneficiaries through the PDAs.

- iii) *Implementation context:* Due to limited power supply in rural areas, there were problems in charging the batteries of PDAs, and complete discharge of power in PDA, erased all the data in PDAs. There was absence of timely and regular technical support and maintenance. The health staff was scared of accidentally losing PDAs which were costly as they would have to pay from their pocket. Large investments were made in these poor quality PDAs before adequately testing them.

Due to these reasons and high expenses of PDA, the project was not scaled to the whole state and over time, the health staff stopped using the PDAs.

Family Health Information Management System (FHIMS) software was developed by an IT company located in the state capital, at a cost of about 68,500 USD. The software requirement included seventeen modules involving different activities of PHC including family welfare services, various health services (such as disease control program) and administrative aspects (such as budget and logistics support). The software was developed on an Oracle backend using Visual Basic as front end. Towards the deployment of the software, the health department mobilized about 7.3 million USD through a consortium of funding agencies including the World Bank, to buy about 1500 computers and its installation in PHC, district and state offices and towards Oracle Software and Microsoft software license fee.

FHMIS system had its objective to provide name-based follow up of family welfare services such as antenatal services and immunization, to assist the health staff in scheduling of services to be rendered during the month, reduce manual record keeping, tracking incidence of diseases, facilitating PHCs effective service delivery, streamlining inventory, infrastructure and human resource management. FHMIS project was piloted in sixty-seven PHC in one district of Andhra Pradesh, later it was scaled to the entire state including twenty-two districts and 1,319 PHCs. This scaling involved updation of MPHS data by household survey, installation of computer and FHMIS, entering survey data, training the health staff and other related activities: such as printing of the MPHS book, and appointing of data entry operators at every PHC. The empirical analysis of this ambitious project revealed various challenges and complexities that were socio-technical in nature. Some of those are listed below:

- i) *Technology related:* Multiple and unattended software bugs, software incompatibility between the household survey problems were reported with FHIMS database. All the PHC had reported bugs of varying levels of complexity. Online transfer of the data took place initially but stopped later as reports generated from FHMIS were incomplete and many were missing in FHMIS which were needed by the district authorities.
- ii) *Public Health Domain:* Dependency on MPHS was developed by other departments for building a database. Medical doctors from the beginning of the project did not take ownership of the data nor were they given the broad agenda of the training program.

Health staff did not use the FHMIS regularly to update health data and as a result the system could not generate schedules or reports. Demand for the schedules did not originate from the health staff, and rather data entry operators generated and handed them over to the health staff.

- iii) *Implementation context:* Inadequate training program and approach. There was a lack of incentives given to the health staff to take an additional role of system administrator. The implementation process was largely top down with limited involvement of the PHC level doctors. Transition of knowledge between data entry operator and health staff was non-existent which limited the capacity of health staff towards technology.

Through the presentation of these empirical cases, Ragavendra and Sahay (2005) argue that the implementation of HIS is not just a matter of introducing technology, but is very much dependent on the social, organizational and process issues that need to be addressed thoroughly and simultaneously. Most often technology alone is perceived as a necessary input to improve existing conditions. In contrast, they argue to consider the importance of understanding the socio-political-organizational context during the introduction of IS. Projects such as MPHS and FHMIS may look technologically attractive, but translating their grand vision of 'one-for-all' unified system in practice, brings numerous problems and is difficult to implement.

Given the background of efforts towards HMIS strengthening in various states, of varying scales and magnitude, the empirical setting of this thesis is distributed around two large HMIS initiatives

from the national level. One focuses towards the creation of a “single window of truth” with the incorporation of a technological intervention. This will facilitate the flow of physical and financial performance data from the peripheral health institutions to the central level by using a proprietary based web portal. The other initiative focuses on addressing underlying system problems in the HMIS. This can be done by focusing on capacity building, strengthening feedback mechanisms and utility of data for local action by using a free and open source software called District Health Information Software - Version 2 (DHIS2).

By focusing on these two initiatives, the thesis attempts to develop an integrated perspective towards relevant knowledge and the use of participatory approaches in the design, development and implementation of technological solutions in the context of HIS in developing countries.

3.3 THE HISP INITIATIVE IN INDIA: THE EMPIRICAL FRAMEWORK FOR THIS THESIS

The empirical component of this thesis is carried out within the framework of the HISP initiative in India. HISP India is an NGO, working in India since the year 2000 towards strengthening HIS in various states. Since 2008, HISP India has moved to the national stage, a period which coincided with my Ph.D studies. Since then I signed a MOU with NHSRC to help provide technical support on DHIS2 to various states.

HISP India is a team of about thirty professionals in New Delhi and field level teams in Kerala and Himachal Pradesh. The team of system developers is based in New Delhi and is responsible to provide support on DHIS2 on a national level. Support includes

troubleshooting, managing servers, carrying out customization requests on the application, and also supporting states to carry out data analysis. Another key task for them is to coordinate with the global DHIS 2 team to request help on technical problems they cannot solve locally, obtain new releases of DHIS2 from the global team, update and deploy state applications with new versions, and also contribute their local developments when required to the global core.

In addition to the technical team, there is an implementation team which carries out capacity building programmes in states, as per the directions from NHSRC. States also approach HISP India to carry out specific requirement analysis studies, or help in rationalization of data and information flow. Data analysis is another area of support provided by the implementation team. As described earlier, my roles transcended these two domains of system development and implementation.

3.4 SUMMARIZING CONTEXT WITH CONTEXT WITH RESPECT TO RESEARCH OBJECTIVES:

The research objectives of my thesis concerns understanding issues related to the interaction between the knowledge domains of public health and technology within a particular implementation context, and how these shape system development processed. Further, the focus is on understanding how participatory processes could be organized and scaled to have larger health system related impacts. Along with this is the development of capacities of users to support the effective use of technological solutions towards the generation and use of relevant information aimed at strengthening local action.

This thesis takes the perspective that HIS are a product of the socio-technical context in which they are situated. In describing the different levels, vertical and horizontal, of the Indian public health system, the reader can be sensitized to the complexity of the context. Firstly, the HIS that is implemented needs to span the different level from the community and the sub centre to the state and national, raising the deep challenge of scale. For the HIS to be useful also to the multiple horizontal levels, raises the need for architectural corrections that shift focus from the existing narrow program specific schemes to a fully integrated system. The depiction of the health system also helps to highlight the structural changes that have been introduced by the NRHM. These changes bring in both opportunities and challenges. Opportunities come in the form of more resources and the creation of a more professional structure through the state and district level programme management units. The challenges come in the fact that NRHM may come to represent a parallel structure that runs at odds to the existing health system. This of course has pertinent implications for HIS, as the health services are provided by the Directorate of Health services who are then the primary producers and collectors of data. However, the processors of data are the NRHM units, and without their smooth collaboration, the HIS runs the danger of being undermined. The chapter also helps to portray the structure of the health system as being hierarchical and top down which then helps to promote a HIS geared towards upward reporting rather than local action. Aspects of poor and overburdened infrastructure, inadequate staffing, over worked peripheral health workers, and large geographical distances are described to characterize the system, which has deep influences on the quality and use of data. The general sense of apathy towards reporting

system prevailing in the existing institutional structure, creates motivational and behavioural challenges in introducing reform in the HIS.

The second part of the chapter describes prior experiences of the introduction of ICT solutions toward the reform of HMIS. The challenges in realizing these efforts have been identified as arising from their predominantly technical perspective, which ignores largely the need to address the institutional and socio-cultural challenges. Other challenges identified include the weak efforts towards fostering end user ownership, and drawing upon more participatory approaches, rather than top down ones, towards system design, and the need for more continuous long term support and capacity building rather than short term training programmes. The last part of the chapter highlights the need to develop competent technical support mechanisms, such as through the role of HISP, to support an implementation of the scale of the Indian health system. The role of NHSRC as a dedicated technical support group for the Ministry of Health, is another crucial facet of support for the HIS implementation efforts in India.

Chapter 4 : Research Methods

The research design can be described along the following dimensions: *interpretive case study approach* involving multi-level engagement, *action-based approach* involving collaborative networks, and *longitudinal research*. These facets of the research are discussed in this chapter. I would like to start this chapter with a brief discussion on my personal research stance, which helps to contextualize the rest of the chapter.

4.1 MY PERSONAL RESEARCH ORIENTATION

A key learning from my association with HISP India over the last decade and also with other countries (such as Mozambique, Tanzania, Bangladesh and Vietnam) has been that the initiation, progress and success of HIS are not just matters of mere sophistication of technology. Rather they also involve social, political and cultural particularities. This is especially of relevance when we consider issues of long-term scaling and the institutionalization of interventions.

I have a technical educational background in computers with a solid grounding in public health issues through empirical engagement (such as in defining indicators and seeing how they are useful for health functionaries). And a key puzzle I have been trying to understand is how knowledge relating to various domains of public health and technology, within particular implementation and use contexts, can be blended so that more effective systems can be designed and developed. This will allow users to draw upon and apply the generated information for making more effective public health interventions on the ground. In this context, an

important aspect of my work in various states has been to critically review what data is being captured at the field levels, in which formats, how it flows (or not) up and down in the hierarchy, and whether it translates into useful information for action for health staff at different levels or not. This information also needs to vary with time and maturity level. For example, initially the primary use of HIS was the generation of routine reports at a higher level of maturity, but now the focus shifts to strengthening data quality and analyzing data (as indicators).

My experience from most states and districts is that the existing levels of maturity remain rather basic. A practical quest in my research has been on how states can take greater ownership of their information with respect to data quality and its use.

To make the above transition, I acknowledge the crucial role of technology, making it important for me to develop knowledge in this domain. In the initial period (2000 to 2005), I was involved with the DHIS (District Health Information Software) Version 1.3 (based on Microsoft technologies), and its subsequent transition to the Java-based DHIS Version 2. I have been engaged extensively in the implementation of DHIS2 in various states in India, including its continuous upgrading, support and stabilization. Through this engagement, I believe I have a fair idea of what goes behind the technology and also to be able to adapt and customize it for required purposes. However, I am not what will be called a “core developer,” and am increasingly playing a role of a “business analyst” who mediates between the domains of the users and developers. Moreover, the developers are at two levels - the core team at Oslo, and the developers in India. My mediation role has been on the communication of new requirements (and problems which cannot be handled locally) from India to Oslo, the adaptation

and testing of new releases of DHIS2 from Oslo, in India, and their subsequent deployment to the states in India. In this way, I have had the unique opportunity to mediate between different types and domains of knowledge – ranging from users, implementation contexts, and development spanning the local and global teams.

At the user level, a major component of my field work has been to firstly understand the existing structures of the flow of information, the procedures and practices around data generation, reporting and use, and the impediments in getting the data in a reliable and usable format. This has required conducting situational analysis through discussions with the health functionaries, to understand the existing data capturing formats, the required reports, the level of infrastructure, the different artifacts (registers, paper forms etc.) in use, and the surrounding institutional practices around how data is collected, reported and transmitted. For example, I have participated and observed various monthly sector meetings in the district where the district medical officer discusses the monthly reports with the field health staff. A primary objective of this analysis has been to identify duplications and redundancies, and how flows can be redesigned to support the aim of “using information for local action.”

In this way, my research engagement has traversed three distinct but inter-related knowledge domains:

- a) The first relates to public health management, specifically the meaning and use of data as seen from a health perspective.
- b) The second concerns the technology domain, both related to core development and also customization, application testing and deployment.

- c) The third concerns the context of implementation, which involves the procedures and practices of the state and district governments with respect to the implementation of HIS projects.

My research efforts have been focussed on trying to understand how these three domains of knowledge can be blended together. Practically, this has been a complex task, and represents the journey of this thesis.

After this introduction to my personal research orientation, I will discuss the details of my empirical approach in the following sections.

4.2 INTERPRETIVE CASE STUDY APPROACH: MULTILEVEL AND LONGITUDINAL DESIGN

In social sciences, there are basically two methodological traditions of research - *positivism and post-positivism* (Noor 2008). Finch (1986) describes positivism as an approach to the creation of knowledge, where the scientist adopts the position of the objective researcher, who collects facts about social life and tries to arrange them in a chain of causality. This approach focuses on formal propositions, quantified measures of variables, hypotheses testing and making statistical generalizations from a sample where the phenomenon is studied to a larger population. Such an approach assumes that the relation between human and social reality is independent (Orlikowski and Baroudi 1991). Positivist approach seeks to test theory in an attempt to increase the predictive rather than descriptive understanding of the phenomenon under investigation (Walsham 1995).

In contrast to positivism, post-positivism is about developing

insights of a reality which is seen as being socially constructed rather than objectively determined. In line with Morgan and Smircich's (1980) argument the actual suitability of a research method derives from the nature of social phenomena to be explored. In this case, the phenomena under study are how technological solutions can support the use of information for local action in the context of public health in India. The research design, thus, involves an interpretive case study where the focus is on developing subjective understanding of the phenomena. For example, why information and the processes through which inter-subjectivity around such an understanding is constructed, are not being used. The aim here is to understand a particular phenomenon, and develop "rich insights" and coherent stories of how it unfolds in different ways and over time (Walsham 1995, Sahay 2010).

In contemporary research in IS and HIS, interpretive approaches are being widely and increasingly used (Walsham 1993). In this approach, the task of the social scientist is not towards gathering facts and measuring how often certain patterns occur, but to appreciate the different constructions and meanings that people place upon their experiences (Easterby-Smith *et. al.* 1991). An interpretive perspective helps to narrate **a** truth rather than **the** truth, as issues will always be interpreted differently by different groups of people (Walsham 1993) based on their cultural and educational backgrounds and experiences. This approach rests on the founding assumption, that access to reality is only through a social construction such as language, consciousness and shared meaning (Walsham 1993; Myers and Avison 2002).

While interpretive research aims at developing subjective

understanding of a phenomenon, the question asked then, is how this understanding can be generalized and used in other settings? Walsham (1995) describes three mechanisms to carry out such generalizations - rich *insights, concepts, and theories*. For example, an insight developed during the research has been that the high values reported of Bacillus Calmette-Guerin (BCG) coverage indicators need not necessarily involve data quality problems. The reasons for this could be a smaller denominator or a high numerator (due to double counting of children vaccinated). This then provides an insight which can be taken to other settings. While the specific reasons may be different, we could investigate into the numerator and denominator values to understand the issue in another setting.

Within the interpretive research approach in IS, case studies are an established method of carrying out research. A case study can be constructed around an in-depth situation (Cornford and Smithson 1996) or a phenomenon in its natural setting (Benbasat et al. 1987) while providing the opportunity to directly observe the unfolding events over time (Walsham 1993). The present research focus is on understanding the issue of knowledge in context, and how that shapes and is shaped by the trajectory of technology design, development and use. The knowledge issue has been conceptualized within the domains and interactions of public health and technology, and particular implementation and use contexts. The interactions between these domains, for example how a new technology is adopted or not in the health facility, is not a one-shot event that can be understood through a survey, but needs to be followed over time as a process.

Specifically, the case study I have focused on is at two levels:

- i. Firstly, with my engagement with the National Health Systems Resource Centre (NHSRC), I have had the opportunity to study the processes related to the reform of the HMIS at a national level, especially concerning the redesign of the national system. From the vantage position of NHSRC, I was engaged in various discussions with the Monitoring and Evaluation (M&E) division of the National Ministry of Health, as processes of negotiations took place in defining what data elements should be collected, what reports should be generated, and issues of software to be used in supporting the implementation of the redesigned systems.
- ii. At the next level, I selected two states for the focus of my case studies where I have had extensive engagement. These two states are Kerala and Tamil Nadu. Kerala was selected since it was the first site of the DHIS2, and I could see how the use of technology evolved from its early stages to a stage where Kerala was nominated as the leading state in the country with respect to “readiness to use information for action.” Further, because HISP India had a team of district level coordinators in each of the fourteen districts of Kerala. I was able to understand the micro-level dynamics of training and efforts being made with field functionaries to take ownership of their data and use it for action. The second state Tamil Nadu, had a very proactive and visionary head of health department who was very focused on using information for making improvements in health service delivery. The interesting aspect in this state was that there were multiple legacy systems in place, and the users were not willing to easily let them go. Through a gradual and

incremental process, we became involved in slowly rationalizing the data elements and indicators, and with this process some of the systems were discontinued.

To summarize, my case study involved a two-level design comprising of the national level, specifically the M&E division, and two states – Kerala and Tamil Nadu. However, in developing my overall research inferences, I have also drawn from my experiences of work in other states conducting training or providing troubleshooting support. The unit of analysis could be described to include the Ministry of Health (M&E division and some health programme offices), and two state offices with a primary focus on the activities carried out at the state level. This selection of cases especially at the state level can be seen as being partly post-hoc rather than being pre-determined.

Since I had been working in various states I had the luxury of being able to choose the states which were most relevant and provided analytical leverage in exploring my research questions, therefore I chose Kerala and Tamil Nadu. Over four years of my research, I have been following and also engaged in the unfolding of events over time, making my research to be part of a longitudinal design. Some examples of this are given below:

1. From January 2008 to October 2008, as a part of the NHSRC team, I was part of multiple meetings and negotiations with the national ministry, as the datasets were being redefined. For example, in India prior to 2008, all data elements were broken up into categories of schedule castes, schedule tribes and others. We were arguing for its removal from the monthly dataset and taking it to an annual one. This process involved multiple meetings, discussion, before the decision was taken for the removal of the break ups to the

annual dataset. In this way, I was involved longitudinally in the unfolding of events around this issue before a final decision was taken.

2. While the redesign of the HIS was the first part of the process, its implementation in the states was the next. Here, I was involved in this process by going to different states, explaining them the logic and meaning of the redesign of the systems, the framework for implementation, and also supporting the implementation process in various ways – training, troubleshooting, customization and policy level support.
3. Within the state, especially in Kerala and Tamil Nadu which were my focus states, I followed the process of how the systems were decentralized from the state, to district, sub-district and facility levels. In Kerala, for example, first data entry took place with district level consolidated reports, and as this process stabilized, systems were further decentralized successively to the facility levels. Not only was I observing the unfolding of this process over time (2-3 years), I was also involved with supporting this process in different ways.

Longitudinally, I was therefore involved in the unfolding of various processes, summarized below:

- a) Redesign processes of the national HIS.
- b) Implementation and stabilization process of the state level systems.
- c) Process of capacity building in states.
- d) Process of software customization in the states.

These processes were studied at two broad levels. Firstly, at the national level by being part of the redesign process of the HIS, I

could understand who defined the agenda; what were the interests, and the users' assumptions about knowledge. For example how public health knowledge was not considered important by the national statisticians.

Secondly, in the two states which were my empirical sites – Tamil Nadu and Kerala – I was involved in orienting them to the revised HIS, providing training and capacity building process. In the states, while my primary focus was on training staff from both district and state, at the state level, in some instances, especially in Kerala, I was called in to provide support to the field level staff also. The requirement was especially in designing software support for their local action. In both the states, I was involved in a longitudinal design over a period of three years, which helped me to understand the various practices around these different processes, and was in line with my view of knowledge not being static and intertwined with everyday practices of the health department staff.

4.3 ACTION RESEARCH IN COLLABORATIVE NETWORKS

A basic assumption of my work has been that HISs are implemented in diverse and complex social systems, and not merely based on technical considerations. It has been argued in IS literature that the underlying social situations can be understood while attempts are simultaneously made to change these situations and their underlying practices (Baskerville and Wood-Harper 1998). Therefore, researchers need to be reflective as well as iterative in bringing about intended and identified changes. This mode of research has been described as Action Research (Baskerville and Wood-Harper 1998), involving engagement with both fields of practice and knowledge (Whyte, 1991; Braa and Vigden, 1999).

Action research involves mutual collaboration between the researchers and the organization, based on research, action and participation (Greenwood and Levin 1998). The principle is that the researcher must necessarily participate with the stakeholders, in the specific context to obtain insights into a phenomenon that cannot be understood when studying it from a distance. Action researchers bring their knowledge of action research and general IS theories, and the local stakeholder brings situated, practical knowledge into the action research process. In this way, participatory action research is based on real assumptions and social systems are self-referencing (Baskerville, 1999).

There is Action Design research (ADR) which has been formulated as an action research (Sein et al 2011) formulated to study the development of an artefact. The network of action approach adopted in this research while possessing element of the ADR, I believe is broader as it also focuses on the implementation and scaling of the systems. The focus in a sense is broader than the artefact also including aspects of training, capacity building and institutionalization

This research is situated within the framework of global HISP initiative ongoing since 1994 and in India since 1999. Being a second generation HISP member since 2000, I have been actively involved in the design, development and implementation of HIS in India and also in some other countries such as Bangladesh and Sri Lanka. My research is inspired by the HISP philosophy of “Networks of Action” (Braa et al 2004) which seeks to create mechanisms by which collaborative activities can be developed and circulated through the network. Working in networks, helps to attack the key

challenges of scale and sustainability. As Braa et al (2004) writes:

“...scalability is a prerequisite – not a luxury – for sustainability of local action...”

(pp.15)

The network based approach argues that change is best facilitated in a collective framework rather than in single and isolated instances of change. For example, donor initiated pilot projects in single settings and over limited time frames typically die as the findings cannot be reproduced in other settings (Sahay and Walsham 1997, Heek and Baark 1998, Simwanza and Church 2001). The HISP network of action approach seeks to overcome these issues of scale and sustainability, by seeking to enable collaborative learning and sharing in a collective networked framework. I will summarize in the table below, certain examples of how the networked perspective guided my research.

<i>Nature of action</i>	<i>Point of origin in the network</i>	<i>Circulation of benefits</i>	<i>Collaboration in network</i>
Technical – design and development of a Dashboard for DHIS2	HISP India	Health departments in the State	Dashboard became part of global core, and also led to the development of another feature called “Global Dashboard”
Redesign of national HMIS in India	Use of South African design principles in India. E.g. each data element collected should contribute to	From South Africa to India	South African experts participated in Indian redesign process

1.5 indicators			
Sharing of training manuals and materials	HISP India and NHSRC	State Health department, Global HISP, HISP Vietnam	Training material which was built in collaboration with NHSRC, was circulated across HISP Network and across state
Local sustainability of DHIS2 system	Technical support group of HISP India supporting state technical group to solve local issues	State health department and district health staff	State technical group, supporting state and districts queries and sometimes across states also. E.g. Orissa state technical person helping in conversion of Karnataka state GIS map to include in DHIS2.

Table 4-3: Network perspective of my research

To summarize, the networks I was situated in and also tried to be enable were multi-level. From the global HISP network, I could learn from public health experts who had engaged in a similar redesign process in South Africa, and those learnings could be used in India. From Oslo, we gained the valuable tool of DHIS2, which was then continually enhanced and upgraded for India, based on the feedback from the HISP India team. Training materials developed in NHSRC firstly drew upon existing materials from South Africa, but then were circulated across the various state offices and even districts. In this way, various forms of collaborative action – software development and customization, training material development and dissemination, implementation experiences etc. – were developed and circulated in various global, national and state level networks. Not only did HISP India benefit from the network, but also made significant contributions to the network,

thus supporting the broader HISP philosophy of networks of collaborative action.

4.4 RESEARCH SITES

My research sites were primarily linked to HISP India operations in India. Prior to my initiation into the Ph.D programme, I was involved with the design, development and implementation of HIS in the states of Andhra Pradesh, Kerala, Gujarat, Jharkhand, Madhya Pradesh and Chhattisgarh. Around the time of starting my Ph.D in 2008, HISP India started to work more actively at the national level. The mechanism for this was the linkage of HISP India with the National Health Systems Resource Centre (NHSRC), an institution created to provide technical support in various domains to the ministry, including HMIS. While my research insights have been greatly supported by my engagement with the health systems over the last ten years, yet my empirical focus in Ph.D draws upon the post 2008 engagement at the national level, and in selected states of Kerala and Tamil Nadu. I deliberately focus on these two states as they provide remarkable examples of attempts to merge knowledge from the three domains of technology, public health and implementation. In the two tables below, I would provide a small summary of this effort of amalgamation:

It was necessary and required to build a bridge between Tata Consultancy Services (TCS) system that was used in state health department of Tamil Nadu and DHIS2 as the TCS system (a propriety system developed by the TCS vendor for the state) could not transfer data (both in right format and completeness) to the national health portal. By building an import module in DHIS2, we could create a bridge between the TCS system and the national health portal. Plus, using DHIS2 allowed health staff to perform

overall data analysis and provide feedback to the sub district levels. The different domains of knowledge which were addressed are summarized below.

Technical issues	Building the bridge between existing TCS system and DHIS2 so that the data could be transferred to national web portal.
Public health	Identifying missing data elements in TCS system which the state required to report to the national level routinely. Incorporating additional data elements needed by the state for enabling local analysis.
Implementation	Training district and facilities' health staff in importing data from TCS system to DHIS2, training them on data entry of additional data elements in DHIS2, and conducting data analysis on overall coverage. Thus this involved changing the work practices of the health staff.

Table 4-4: Example from Tamil Nadu State expressing the multiple domains of knowledge

DHIS2 was installed in all the primary health centers in Kerala, where health staff entered their monthly service delivery data. This data was exported and transferred to the district either manually or via email. District health staff, in turn, would import these data in their locally installed DHIS2 and export the aggregated or consolidated data up to the block (sub-district) level into the online DHIS2. Thus online DHIS2 contained data up to three levels of the health system hierarchy (State, District and Block). In the year 2009, State health department of Kerala adopted the redefined national HMIS and shifted to online data collection from the health facilities, and over time the online DHIS2 would contain data from all levels of the health hierarchy. This shift to complete online mode of data collection was due to improvements in internet

<i>availability in most of the PHCs in the state. The different knowledge domains that were addressed are summarized below.</i>	
Technical issues	This shift required populating of all the organization units and the associated hierarchy into the online DHIS2 and also replicating all the user names, user roles and authorizations across the organizational units statewide.
Public health	When the state adopted redesigned national HMIS data set, the concerned team at the state level incorporated some local data elements, such as Iron Folic Acid (200) tablets given, ANC registration under nineteen years, twin births, etc. into the existing data set. Prior to its incorporation, we engaged in discussions with the programme managers on why they wanted to include these elements, and what indicators would be generated. Once agreed, these additional elements were circulated throughout the state in the data collection forms.
Implementation	State wide training program on orientation of the revised HMIS and the guidelines for implementation. The Block coordinators were trained to serve as master trainers to provide technical support at the field level.

Table 4-5: Example from Kerala State expressing the multiple domains of knowledge

I have sketched below the timeline of my activities in my three primary sites:

	<i>Kerala</i>		<i>National Level</i>		<i>Tamil Nadu</i>
2005	Situation Analysis		Situation Analysis		Importing legacy data
2006	Initial Piloting and development & Testing (2006),	2008	Redesign of National HMIS,	2008	Situation Analysis,
2007	Deployment of offline DHIS2 system,	2009	Building public health tool kit- Implementation guidelines	2009	Orientation training program & use of ICT solution,
2008	large scale training of Master trainer, Feedback on data quality,		Design & implementation of training programme,		Data Quality Analysis & dissemination,
2009	Switch over to online system, System strengthening & local capacity,	2010	Data Quality Analysis & dissemination,	2010	Integration with existing ICT solution.
2010	building Sustainability and transfer of ownership.		Strengthening capacity building & state ownership.		Creating of Master trainees & building state & district level support group.
2011		2011		2011	

Table 4-6: Outline of my activities

4.5 DATA COLLECTION METHODS

Data collection methods have involved the use of both qualitative and quantitative data. Both these sets of data collection methods are now described.

4.5.1 *Qualitative data*

Qualitative data, as Silverman (2000) has argued, helps to map inner experiences, language, culture, and forms of social interactions to develop deep contextual understanding of a phenomenon. As a part of my in-depth and continuous involvement in the field, I have been engaged in collecting different forms of qualitative data through various mechanisms which include, conducting situation analysis, interviews, training programs meeting and presentations, analysis of documents and forms, system prototyping, and electronic communication at both the national and global levels. Some of these mechanisms are

described.

4.5.1.1 Situational analysis

Before attempting to introduce computerization in any organization, it is essential to understand the existing data flow, work processes, as well as the capacity of the organization's personnel to use technology. It is not only important to understand the formal hierarchy, or the prevailing organizational structure, but also the informal working relationships within the organizational set-up. Thus, the situational analysis should go beyond the processes and guidelines usually prescribed for a formal systems analysis phase. My approach has involved:

- a) Understanding the existing data flow, including all the data input-output formats.
- b) Identifying redundancies in data elements and duplications in data entry procedures and,
- c) Presenting these findings to the concerned stakeholders so that they can understand the need to rationalize and integrate these flows.

This process would often lead to the development of a "minimum data set," and then subsequently to the "essential data set" wherein the data elements collected would be linked with its use in the generation of indicators. This in essence could provide the basis for building a blueprint for how data can be converted into information required for action. This process typically involved a series of stakeholder workshops and the adoption of an iterative process where these issues were openly discussed and alternative solutions to problems identified.

During the above consultations and discussions with the stakeholders, their capacity to use ICT-based systems was assessed, and, correspondingly, the needs for training identified. An example from the situation analysis carried out in Tamil Nadu is presented in the Box below.

Sl.No	Data Element	District	Value in ISMR	Value in PHC Online System
1	Doctor Sanction	MADURAI	98	102
2	Doctor InPosition	MADURAI	95	94
3	Doctor Sanction	SALEM	150	151
4	Doctor InPosition	SALEM	147	145
5	Doctor Sanction	Ramanathapuram	49	50
6	Doctor InPosition	Ramanathapuram	42	41
7	ANM Sanction	MADURAI	49	48
8	ANM InPosition	MADURAI	49	48
9	ANM Sanction	SALEM	93	92
10	ANM InPosition	SALEM	91	88
11	ANM Sanction	Ramanathapuram	30	31
12	ANM InPosition	Ramanathapuram	30	31

Table 4-7: Comparing output from two systems for the same period of time.

After identifying these redundancies, we were able to make recommendations on how to rationalize the data flow.

4.5.1.2 System prototyping:

System design and development is a core element of my research. However, as mentioned earlier, my role has been primarily as a business analyst mediating between the different levels of developers (global and national), and also between the users and developers. Being a developer myself and also having had extensive field experience in implementation, I can say that I am able to speak the language of both the developers and users. Further, on the Geographical Information Systems (GIS) side, which was my specialization for the Master's thesis, I have been directly involved in the primary development of the application.

System prototyping typically follows a process where the forms, data elements, and reports identified during the situation analysis are used in the design of the database, the data entry screens, and also of the reporting formats. These prototypes are then shown to the users either through the training programs or in the pilot sites, to get their feedback which serves as input for the development of the next version of the system. For example, during the first training program in Kerala when the first prototype of DHIS2 was released, the medical doctors gave various comments, including their concerns for security. These comments were then fed back to the global developers, who included these requirements in the next version. This process of exposing the users to the prototypes and getting feedback, served as an important source of data for my research, as it gave me an understanding of their respective requirements for local action.

4.5.1.3 Meetings and discussions:

I have participated in numerous meetings, discussions, and presentations with health functionaries at various levels. Meetings

at times have been formal, where we have been expected to present an overview of the project, or been evaluated with respect to other projects. Mostly the meetings were informal where we briefly discussed project status, or informed the administrators of the problems being experienced (for example, the hardware problems in the field which were not being rectified in time by the vendors). In addition, there were formal presentations to be made to the state administrators or also to the national level program managers on approaches to HMIS design and use.

These meetings and discussions served various purposes, such as informing the officials about issues we faced, scheduling meetings and training programs and various others matters. Given the structure in India, where often many issues are solved in an informal manner, the role of these meetings was significant for data collection. However, given the numbers and spontaneity of these meetings, it was often not possible to document all these meetings. So, gradually there was the cumulative building up of tacit knowledge and experience, which would only become explicit when communicated to the other HISP members or my supervisors and research colleagues in meetings or via email.



Figure 4-11: Meeting between HISP Team members, University of Oslo and a local public health institution in Kerala

4.5.1.4 Participatory observation:

This form of data collection took place in various ways. Sometimes it took place through a visit to the clinic where the software was running, to examine its performance, to do some trouble shooting, and sometimes while conducting training programs on site. There were sometimes observations of meetings, especially conducted at the national level, where I attended various presentations made by government officials and other public health experts. Participating in meetings helped gain different kinds of insights, sometimes related to knowledge of new projects or public health problems, and at other times about general processes such as related to the nature of decision making in the government.

During the year 2008-2009, after the process of redesign of the

National HMIS, orientation and training programmes on HMIS were conducted at various state headquarters. During this period, I actively participated in conducting orientation training programmes on HMIS, and how it could be adopted at state and district levels. These training programmes provided me with rich insights on the internal functioning of the state information flows, their infrastructure, state and district capacity, importance of local language, existing culture, work practices and local priorities. For example: during one orientation training programme on HMIS in Leh, which is situated at 3650m above sea level, in Ladakh region of Jammu & Kashmir state of India, I understood the physical challenges to data flow. During the winter season, four blocks of the Leh region are not able to send any routine report to the district headquarters due to breakdown of transportation and communication. During this period, only one satellite phone was kept operational for emergency cases. Such exposures helped to deepen my understanding of the ground realities of the implementation context. In the map below, I have indicated with a star, the different states I have visited for training since 2008.

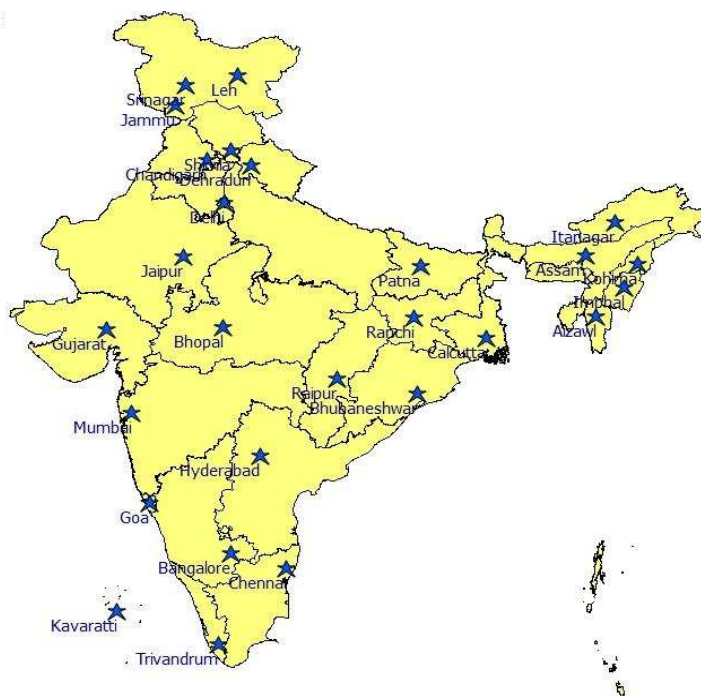


Figure 4-12: States where I have been involved in training programme

Sl.No	State	Vists	Average Length of visit in days	Total Days	Sl.No	State	Vists	Average Length of visit in days	Total Days
1	Andhra Pradesh	2	2	4	13	Madhya Pradesh	6	3	18
2	Arunachal Pradesh	2	2	4	14	Maharashtra	3	1 to 2	6
3	Assam	8	2	16	15	Manipur	2	2	4
4	Bihar	8	1 to 2	16	16	Mizoram	1	2	2
5	Chhattisgarh	2	2	4	17	Nagaland	3	2	6
6	Goa	2	2	4	18	Orissa	10	2	20
7	Gujarat	10	2	20	19	Rajasthan	1	2	2
8	Haryana	2	2	4	20	Tamil Nadu	15	3	45
9	Himachal Pradesh	6	2	12	21	Uttarakhand	3	3	9
10	Jammu and	3	2	6	22	West	1	2	2

	Kashmir					Bengal			
11	Karnataka	10	4	40	23	Lakshadweep	1	3	3
12	Kerala	15	4	60	Total Days of Training/Workshop				307
Delhi (Base) Training program, Workshop & meetings 48									

Table 4-8: Showing my visit to state towards strengthening of HMIS



Figure 4-13: Orientation workshop on HMIS in Kerala

My extensive involvement in the states of Kerala and Tamil Nadu were the reasons I selected them for my case studies.

4.5.2 Quantitative data

Further to this qualitative data, I have also been deeply engaged in carrying out analysis of the routine services data that is being collected by the health care system. For example, I studied the legacy data for various states to conduct both, the analysis of the quality of data and of the health status. Through this analysis, for

example, I could see the percentage of data elements being reported as zero or blanks, which helped me to make interpretations around the non-use of data elements, and it, provided important inputs in the redesign of the data sets.

Data Elements Reporting Units captured	Kerala		Jharkhand		Gujarat
	1116		165+45		
	551	1667	8	623	1128
	482+84	566	2232+102	2334	25
Expected record per month	5257764		414996		28200
Expected record for 9 months	10758240		3734964		253800
Total record reported for 9 months	654131		1494502		169392
Record with non zero value	310100		735914		86381
% record with zero value	53.61		50.86		49.11

Table 4-9: Percentage of zero values reported between three states in routine HMIS data

Similarly, during the analysis of legacy data, it was observed that there was no considerable change for many months, in the data for the disaggregated dimensions of caste, gender and age for certain services (such as immunization). The table below represents percentage of total delivery and measles vaccine disaggregated by caste for three districts at various times of the year (April, August, and Dec). The percentage of disaggregated dimensions (such as schedule caste SC, schedule tribes ST, and others) of data elements remained nearly constant throughout the years. For example in ChhinDwraca district, percentage of total delivery with respect to scheduled caste was constant throughout the year (12.01, 11.99, and 11.99 for April, August and December respectively). And monitoring and making local action plans based on such small variations, over short intervals was difficult to

execute in practice and also not required. Such analysis provided the basis to argue at the national level for removing these disaggregated categories of data elements from the data set for routine data and move them to survey data where it would be collected bi-annually or annually.

District	Data Element	April			Aug			Dec		
		SC	ST	Other	SC	ST	Other	SC	ST	Other
Chhindwara	Total Delivery	12.01	35.01	52.98	11.99	35.01	53	11.99	35	53.02
	Measles	12.01	34.99	53	12	35	52.99	12.02	34.99	52.99
Jabalpur	Total Delivery	25.11	5.89	69	25.11	5.89	69	25.11	5.89	69
	Measles	25.11	5.89	69	---	---	---	25.11	5.89	69
Gwalior	Total Delivery	19	3.48	77.52	19	3.48	77.52	19	3.48	77.52
	Measles	---	---	---	19	3.48	77.52	19	3.48	77.52

Table 4-10: Showing three district routine data disaggregated by Caste (SC,ST, Others)

4.5.3 Other Data Collection Methods:

In addition to the above described methods, other data collection methods used by me included:

1. *Electronic medium:* Extensive communication over email took place between me and the other HISP members in different states, and also with the developers in Oslo. While the exchanges nationally were related to understanding project progress, troubleshooting of issues, dealing with administrative issues (such as salary payment of team members), the interaction with the Oslo developers was primarily concerned with conveying requirements, informing

them of field level problems, and seeking clarifications on new developments. The website managed by Oslo also served as an important source of data for making communications around technology, accessing training manuals and also researching papers and masters/doctoral thesis.

2. *Face to face meetings with HISP team members:* In Kerala especially, the HISP team had institutionalized a practice of weekly meetings on Saturdays to review progress, discuss problems, and chalk out future plans. Whenever I have been in Kerala on a Saturday, I have gained valuable data from these meetings, especially getting micro-level insights to the user perspective. Every day in office there were constant interactions with other team members which provided different sets of information on projects and new developments.
3. *Conversations over mobile phone:* Mobile phone conversations have played a very important role in gathering data, especially for me and other HISP team members, and also for my supervisor. On an average, at least 20-25 phone conversations in a day took place as various types of information were exchanged, problems discussed, solutions proposed, and important decisions were taken.
4. *Secondary data:* Various kinds of secondary data were collected which were useful in different ways. For example, national health statistics reports helped me to firstly understand about the different indicators favored by the government, but also gave important inputs on how the

national DHIS2 database should be designed to incorporate and facilitate the generation of these indicators.

Due to the multiplicity of data collection methods, the intensity and continuous nature of engagement, data recording too took place through multiple means. Some of them are listed below:

1. *My diary*: I have tried to record key points from meetings, discussions, and system prototyping sessions in my diary. I wrote these in short hand form, which at a later point I tried to expand while typing them out.
2. *E-mails*: Writing emails to other members, Oslo developers, my supervisor, and also to the users, became an important source of documentation of information. I created folders on each of the states I was working in, and all the emails sent and received were put in respective folders. This has served as an important process of documentation of various issues which I could easily trace with the subject headings for different states.
3. *Formal evaluation reports*: For example, for the situation analysis, formal reports were developed, discussed and presented. This provided a detailed and systematic documentation of the situation till then. Similarly, evaluation reports, presentations and other formal documents, served as important sources of data recording.

Photographs: I have taken multiple photographs of different events such as training sessions, recording forms, users with the system etc. I used my mobile phone to carry out these photographs. These too have helped to make the context more clear, in which the research has been carried out. Often, I used

the phone camera to take pictures of formats and reports, to help conduct the situation analysis.



Figure 4-14: Health worker in Jharkhand doing routine data entry in DHIS2

The theoretical foundation of my thesis is based on the key concept of local knowledge: concerning the domains of technology and public health and the manner in which it is shaped within a particular implementation and use context. Implementation refers to the broader condition reflecting work practices, organization resources, hierarchical relationships and infrastructure situation and the use context refers to the conditions around the user towards enabling use of information. The other basic concept used was that of participatory networks reflecting the inter-linking of multiple processes of participatory design across various contexts towards enable sharing and learning in the network. The third

concept concerned systems development which focused on the inter-linkages between processes of participatory networks and local knowledge. Through the processes of data collection and subsequently its analysis, I have tried to map out the relation of data to these guiding theoretical concepts. In the table below, I have tried to summarize some of these inter-linkages.

<i>Theoretical Concepts</i>	<i>What data to collect</i>	<i>How data was collected</i>
Local Knowledge	<ul style="list-style-type: none"> ✓ Organization structure ✓ Information flow ✓ Work practices ✓ Infrastructure situation ✓ Skill set of user towards use of information ✓ Problem in data collection, its translation. 	<ul style="list-style-type: none"> ✓ Situational Analysis ✓ Formal evaluation reports ✓ Training Programmes ✓ Informal meetings and discussions. ✓ Interviews
Participatory Networks	<ul style="list-style-type: none"> ✓ Relevant stakeholders, their interest and vested interest. ✓ Challenges towards data sharing ✓ Mechanism towards organizing participatory processes 	<ul style="list-style-type: none"> ✓ Meeting and discussion, ✓ Participatory observation ✓ Orientation and hand-on training
System Development	<ul style="list-style-type: none"> ✓ Feedback from the user on system design ✓ Problem experienced. ✓ System /Project status ✓ Requirements ✓ System enhancement 	<ul style="list-style-type: none"> ✓ System prototyping ✓ Quantitative data ✓ Electronic Medium ✓ hand-on training ✓ Email exchange with global and local developers ✓ Face to Face meeting with HISP project staff

Figure 4-15: Relationship between concept and data collection

4.6 DATA ANALYSIS

My thesis was broadly concerned about the issue of linkage between knowledge and participatory processes, and specifically the details of different types of knowledge and how they inter-relate.

Specifically, my focus was on local knowledge, and also how they could be scaled to broader participatory networks. So, in the different papers, I explored different aspects of local knowledge. For example the paper relating to Metis (paper No 4), my focus was on understanding the different facets of local knowledge relating to data quality, information analysis and use. In the paper on outliers (paper No 5), my focus was on understanding specifically how the analysis of data quality is done using statistical techniques, and how that corresponds to data quality as studied through a public health lens, specifically using ideas of validation rules. The paper on social capital (paper No 2), focuses more on the role of social relations in accessing and generating knowledge, and thus becomes an important mechanism for scaling, while simultaneously serving to address the issue of local knowledge. The paper on participatory networks (paper no 1) from Kerala focussed on understanding how local knowledge could be understood and linked more effectively with systems development processes. These different papers helped me to move towards addressing the overall research aims of my thesis.

At the level of individual papers, I used a mix of quantitative and qualitative data which provided me with the possibility of making a rich analysis that would not have been possible if only one or the other method had been used. For example, in understanding the statistical methods of outlier analysis being carried out at the na-

tional level, I first needed to understand the Box and Whisker Plot (BoxPlot) method, and whether it was used appropriately. The outliers generated through this statistical method were then compared with data validations checks carried out using the DHIS2, which was based on looking at the relation between different data elements drawn from a public health perspective. For example, under the BoxPlot method, while looking at outliers in the data element "number of new-borns weighed at birth," the data values were taken for the last twelve months, and abnormal values were identified outside the "normal range" away from the central point determined by the statistical method. However, a public health analysis based on validation rules would compare new-borns weighed at birth with the number of births in the first place. And comparing the "abnormal values" generated from the two sets of methods showed very different results.

In this way, a combination of quantitative and qualitative methods helped to first identify the "what" of the issue, and the interpretive analysis the "why" of the problem. Similarly, the quantitative analysis of "zeros" and "blanks" in the datasets helped me to identify elements which were possibly redundant in the HMIS. Then from discussions with different stakeholders, for example the health programme managers using qualitative data (interviews and discussions), I could identify what may be their rationale for justifying these zero and blank values, and combine the quantitative and qualitative analysis to make overall interpretations. For example, in the disease surveillance reports, while we could see a lot of zero values, I was told by the Integrated Disease Surveillance Programme (IDSP) managers, that the reporting in a surveillance system has a different logic to HMIS, and looking at patterns of zeros is important to understand disease surveillance issues.

Thus, the quantitative data helped to identify the symptoms of a problem while the qualitative data allowed me to drill down and understand the perspectives of those involved. This approach was formalized in the paper on data, information, knowledge (paper No 3) where we articulated the "Symptom, Diagnosis, and Analysis" method, wherein DHIS2 was used to first identify a problem, such as an abnormal value of an indicator. This was seen as a "symptom," which was then "diagnosed" by drilling down to the particular facility or period which contributed to this abnormality. Further, by talking to the stakeholders involved, I tried to further "analyze" the problem and identify the interpretive reasons for the abnormality.

While I did not follow formal methods such as grounded theory to develop codes and themes, broadly my approach to data quality analysis can be described as being inductive in nature. Starting from my basic quest around the topics of knowledge, participation and systems development, I tried through different empirical methods to understand issues around knowledge. In the table below, I provide a summary of some of the research activities I was involved with and the inferences it helped me to develop:-

<i>Level</i>	<i>Nature of my involvement</i>	<i>Inductive inferences</i>
Outreach or community level	Designing of primary registers	→ The mismatch between the primary data recording and reporting
Primary health care facility level	Design of data set and its associated data element & indicators	→ lack of uniformity & standards in naming conventions of data element & indicators
District level	Design of feedback / downward reports	→ Challenges in supporting supervision and establishing feedback mechanism

State	Importing of legacy data Orientation training program Data quality workshop	→ High percentage of zero and blanks, pointing out to system design problem → Less proportion of data element contributed to actionable indicators. → Mismatch between HMIS routine data and survey indicator. HMIS data is comparatively high than survey indicator. → Data mismatch between HMIS data and health program data → Need for incorporation of state level data element in national HMIS dataset to support state specific health program
National	Redesign of National HMIS. Data Analysis & dissemination	→ Fragmentation and verticality of systems → Disproportionate attention to hardware/software → Challenges in integration vertical health programmes → Centralized monitoring mechanism
Global	Design and development of DHIS2 & name based system	→ Challenges in coordination between Indian development & Core design. → Challenges in translation of local requirement and problem to design changes in core

Table 4-11: Summary of research activities and inductive inferences

My understanding of different theoretical themes I was developing was discussed with other colleagues at both NHSRC and HISP India, and also with my supervisor to get different perspectives, opinions, and their underlying rationale for them. At various points in my analysis process, I developed reports and made presentations both

for practice (e.g. national and state level HMIS staff) and research at Department of Informatics (IFI) in Oslo. Feedback received from them helped me to further revise and improvise the analysis. This helped in the development of the first versions of my papers, which were further developed on receipt of comments from reviewers or the audience in seminars.

The table below aims to portray how empirical observations were interpreted and their correspondence to various types of action I was engaged in.

<i>Empirical Observations</i>	<i>Puzzling interpretation</i>	<i>Corresponding Action</i>
Paper 3: In Gujarat State: Out of 97 critical dashboard health indicators only 47 indicators could be calculated in routine HMIS and only 5% of data elements collected contributed to above Indicators	<ul style="list-style-type: none"> ✓ Only 5% of data elements collected contributed to indicator imply that data elements were collected with many dimensions such as Age, Caste, and Gender break up. ✓ It also indicates that many of data elements collected need not be reported upto to the state level as it could not be measured. These data elements could be record at relevant peripheral institutions but not reported. 	<ul style="list-style-type: none"> ✓ Recommendation presented to review the existing list of critical indicator to include many other useful and measurable Indicators from the list of data element collected. ✓ Use of the principle of hierarchy of standards (Braa and Hedberg, 2002)
Paper5: Use of solely statistical methods in identifying outlier in public health data were carried out	<ul style="list-style-type: none"> ✓ Applying purely statistical method on data value when not accompanied by a public health interpretation or contextual 	<ul style="list-style-type: none"> ✓ Demonstrating the incorrect inference caused by apply solely statistical method on public health data value.

toward improving data quality by normalizing identified outliers.	understanding may lead to inadequate or even incorrect inference of data quality.	<ul style="list-style-type: none"> ✓ Promote use of validation rule which compared relative data elements for quality checks. ✓ Promoting use of min-max range on data entry to prompt user on skewed values
<p>Paper4: In routine HMIS data on different health programs relating to reproductive and child health, immunization, family planning, neonatal care, etc are been collected from all the peripheral health institutions were same data been transmitted right up to national level. These data elements most often disaggregated across various dimensions. The data is expected to flow upward, with little or no feedback system</p>	<ul style="list-style-type: none"> ✓ Same data elements were reported in multiple data form from a facility and more often with different figures ✓ High % of zero and blanks were collected which can be interpreted as systemic design problem ✓ A general sense of apathy towards reporting system 	<ul style="list-style-type: none"> ✓ Shifting the focus from data forms to data set ✓ Moving disaggregating data elements to annual surveys ✓ Reciprocity between the provider and recipient
Paper1: During the cultivation of participatory	✓ Hierarchical structure of work practice	✓ Various mechanisms used to enable

network in state of Kerala it was noticed that, it was not very conducive to have both the medical doctors and health workers represented on the same forum.		active enrollment of multi-sectoral and multi-level user in participatory networks
Paper2: Implementation of eHIS application (DHIS2) in the state of Gujarat	✓ Technology could be seen as enabling and strengthening social relation between HISP team members and state health staff	✓ Improvisation and customization of HIS application.

Table 4-12: Interpretation of empirical observation and its corresponding action

In this way, I have tried to combine an interpretive analysis with action.

While my empirical basis has been India, I believe the findings from my thesis have more general implications to other contexts. Knowledge, participation and systems development are general issues which have implications not only to other geographical contexts, but also domains other than public health. The components of technology and public health domains within particular implementation contexts represent a generic model, which has implications beyond public health. What will vary across contexts would be the kind of local knowledge that may be relevant, although the normative aims of supporting the use of local language is a generic quest.

Chapter 5 : Research Findings

5.1 RESEARCH PAPERS INCLUDED IN THE THESIS

This chapter summarizes the research findings from different publications which I have included in this thesis. After summarizing the findings from different papers individually, a synthesis is provided to examine how the overall research questions posed in this thesis are being addressed. This synthesis then provides the foundation for the discussions presented in Chapter 6. The list of my papers (placed as Annexures 1-5) is provided below:

- (i) Building Participatory HIS networks: A Case Study from Kerala, India. Puri, Satish Kumar; Sahay, Sundeep; Lewis John. *Information and organization* 2009; Volume 19. (2) p. 63-83, UiO.
- (ii) The Role of Social Capital in the Integration of Health Information Systems. Mekonnen, Selamawit Molla; Sahay, Sundeep; Lewis, John. *Journal of Health Informatics in Developing Countries*. 2011
- (iii) Challenges and Approaches in Translating Data to Information and Information to Knowledge: Case Study from the Gujarat State Health System India. Sahay, Sundeep; Lewis, John; *International Federation for Information Processing 9.4*; 2009-05-26 - 2009-05-28. UiO
- (iv) Strengthening Metis Around Routine Health Information Systems in Developing Countries. Sahay, Sundeep; Lewis, John. *Information Technologies and International Development*

2010; Volume 6. (3) p. 67-87. UiO

- (v) "Outliers": A Public Health Inspired Perspective.
Sahay, Sundeep; Lewis, John. *South African Journal of Information System*. Under review-
Revise and resubmit.

A brief summary of each of these papers is provided in the next few pages.

5.2 BUILDING PARTICIPATORY HIS NETWORKS: A CASE STUDY FROM KERALA, INDIA

Over time, researchers have argued to view ISs as socio-technological heterogeneous networks, rather than as primarily technical artefacts. This perspective has contributed to the adoption of various socio-technical design approaches. It has also increased sensitivity to the social context of IS design and placed a greater emphasis on enabling user participation. This paper specifically examines issues of participation in the context of public healthcare settings in India. It is an attempt towards reformulation of the notion of participation by articulating the concept of "*participatory networks*", and its cultivation within the context of an action oriented HIS implementation project, in the public sector of the state of Kerala.

Participation in traditional Participatory Design (PD) theory implied primarily the involvement of end users within particular organizational settings. Such a perspective is limited, and needs to shift from user centred participation to broader stakeholder participation within a network framework. The aim should be to create both multi-sectoral and multi-level participatory networks, with due consid-

eration to the multiplicity of interests and the role of the infrastructure itself. The particularities of the context need to be included into the participatory design paradigm which stretches far beyond design methodologies and techniques.

The participatory network approach, articulated in the paper, draws attention especially to the processes of participation and how it can be cultivated and circulated within a networked approach. The notion of participatory networks has been elaborated in both its constitutive and instrumental facets. Conceptually, the notion of participatory network emphasizes, firstly, the diversity of the types of participation which need to be cultivated in the context of HIS development project in a developing country setting. And secondly, the multiplicity of the mechanisms through which these are enabled. Arguably, without these various kinds of participation in both their constitutive and instrumental aspects, a complex HIS project in a unique setting cannot be effectively realized.

Based on the empirical experiences gained in Kerala, four main areas of re-conceptualization of PD are identified:

- (i) building of participatory networks,
- (ii) context sensitivity,
- (iii) focusing on outputs and not on the PD methodologies alone, and
- (iv) inculcating a judicious mix of both behavioural and structural aspects of participation.

5.3 THE ROLE OF SOCIAL CAPITAL IN THE INTEGRATION OF HEALTH INFORMATION SYSTEMS

While the dominant approach to the research and practice of HIS integration remains largely technology focused, it is increasingly being recognized that integration of IS and HIS in particular is as much a technical exercise as it is about addressing the institutional, social and political conditions. In continuing with this line of research, this paper analyzes the role of social capital in a HIS project towards implementing an integrated computerized system, to manage the routine health information in Gujarat state of India.

Social capital is the value of social networks, bonding similar people and bridging between diverse people with norms of reciprocity (Dekker and Uslaner 2001; Uslaner 2001). Even though, the notion of social capital has its roots in social sciences, in recent times various researchers have applied this framework in technological studies and IS research. These research efforts have largely focused on how technology mediated interactions contribute to the development or not of social capital and its various constituting aspects, while paying inadequate attention towards the constituting relations between technology and social capital. This paper has explored the analytical relation of how social capital shapes the realization of ICT based HIS efforts and the role of ICT in building social capital.

The empirical material was collected through qualitative semi-structured interviews and email conversations. However an interpretive framework of data analysis was adopted to understand different aspects of the nature and implications of social capital, and its interaction with the HIS integration initiative under study. By analyzing the empirical case through the three dimensions of social capital - *structural, relational and cognitive* - the paper

draws two key theoretical inferences:

- (i) Social capital is not something given and static, but it grows with time, both shaping and being shaped by the processes of implementation.
- (ii) ICTs and e-HIS play a key role in further building social capital that is helpful to integrate the fragmented HIS.

5.4 CHALLENGES & APPROACHES IN TRANSLATING DATA TO INFORMATION AND INFORMATION TO KNOWLEDGE: CASE STUDY FROM THE GUJARAT STATE HEALTH SYSTEM INDIA

The paper describes the empirical difficulties experienced in the translation of data, collected by an Indian state, through its HIS into information and further to knowledge. Researchers in HIS in developing countries have repeatedly lamented that while huge amounts of data is collected by the public health system, a very limited amount of that actually gets translated into 'Information for Action'. The material for the paper is drawn upon from experiences of the design, development and implementation of HIS within the public setting of Gujarat Health Department in India. The paper empirically analyzes the various social, technical and institutional challenges inherent in this translation process and how they may be addressed. The reflects upon a practice based view to understand the relation between users, different forms of knowledge in play and the context within which knowledge is negotiated, appropriated and shared. An attempt has been made to bring about a shift in the mindset of data administrators who normally believe that, "HMIS data can't be used for planning as quality is poor. Until data quality is good we can't use the data". This belief constrains improvement of data quality which requires constant and continuous use and interaction.

To enable this shift, appropriate technological tools like a Dashboard Monitoring System (DMS) and Geographic Information System (GIS) were seen to play a crucial role. The paper provides examples on design issues such as data indicator mismatch, need for standardization, data dictionary use, and data triangulation across surveys and targets. The paper demonstrates through practical examples a simple and useful approach called Symptom Diagnosis and Action (SDA) to help in facilitating the translation from data to information and then to knowledge. The paper also argues that translation from information to knowledge is complex as it is intertwined intimately with various organizational practices difficult to change.

5.5 STRENGTHENING METIS AROUND ROUTINE HEALTH INFORMATION SYSTEMS IN DEVELOPING COUNTRIES

While there is an increasing acknowledgement of the important role that information plays in strengthening management, there is also the stark realization that computer based information systems have failed to deliver their promised benefits. In developing countries huge investments of money and resources, which they can barely afford, have literally gone to naught over the past two to three decades, with more than 90 per cent of such efforts being termed as incomplete or partial failures. Addressing these issues both in research and practice of public health is of urgent importance.

By applying James Scott's notion of 'metis' to public HISs, this paper aims to provide an alternative approach which could help increase the relevance and utility of HISs in developing countries. Metis, as defined by Scott, represents a form of practical skills and acquired intelligence helpful in responding to a constantly changing natural and human environment. Through various examples, Scott demonstrates that the use of state power in initiatives aimed at social transformation, including the making of society legible for central recording and monitoring, have led to large scale tragedies. The alternative for dealing with complex social phenomena, Scott argues, is the development of the notion of metis, which we have expanded to the domain of HIS in this paper.

The empirical material for the paper is drawn from the longitudinal experiences gained during the design, development and

implementation of the ongoing action research project of HISP. It is presented in the form of examples, grouped into five thematic areas –

- (i) Information flow
- (ii) Managing data quality
- (iii) Software characteristics
- (iv) Design for monitoring and
- (v) Knowledge spread

Here two contrasting approaches towards design, developing and supporting HIS are depicted. The first approach represents a more traditional view which contributes to promoting a form of state surveillance and control system using simplistic design assumptions (such as “building a single window of truth”). This in turn tends to suppress or kill metis. The other approach illustrates how the onus is placed on the user (not the state), and how the information system then tries to provide information support in such a way so that the existing metis can be strengthened, not replaced or killed.

Through these examples, two sets of implications are developed around metis:

- The first concerns the underlying design characteristics of systems that help to either cultivate or suppress metis and why. With respect to HIS; the following specific implications are presented: focus on information use; promoting decentralized information for decentralized action; integration of information flow in the data warehouse approach; collaborative participatory design; promoting networks of action.
- The second set of implications is towards the role of an

institution in contributing to the nurturing of metis. This is discussed in terms of the roles and responsibilities of institutions towards breaking the vicious cycle of the lack of trust and non-use of data, in order to build a culture of the use of local information. To enable this shift, an approach based on the principle of “satisfying”, rather than optimizing is suggested. This could help break the cycle of lack of trust and instead help to create another trajectory or cycle of data use leading to improved quality. Further this cycle will help to usher an environment where metis can flourish and prosper.

The argument of development and encouragement of metis to strengthen information support in public health is based on one underlying principle. It is that field practitioners have a good general understanding of public health problems which their local area faces, as well as knowing how to deal with them. This practical knowledge, if combined with an information support that is relevant and designed sensitively, can contribute to the development of a more effective metis. It will in turn, help to address pressing public health problems faced by states. The paper identifies three important factors towards establishing effective information support:

- i) appropriately designed systems,
- ii) an institutional agency that seeks to break out of the historical mistrust of HIS, and,
- iii) an approach to data based on a principle of satisfying, rather than optimizing.

5.6 “OUTLIERS”: A PUBLIC HEALTH INSPIRED PERSPECTIVE

Drawing upon various empirical examples, the paper discusses two approaches to diagnose data quality problems. The first uses methods which have their origin within a paradigm of statistics, while the other presents a public health inspired approach which sees data to be representing a public health event that needs to be interrogated and understood.

The statistical perspective on data quality described in this paper is based on techniques of outlier analysis using the Boxplot method for identifying and normalizing data quality. The empirical data for the paper is drawn from examples of data quality analysis reports presented from the national level to the states in the country. These reports are developed and disseminated by the statistics division as a part of their intensive and on-going efforts to improve the quality of data, being reported by the states to the national levels.

Through empirical examples, the paper presents an argument that applying purely statistical methods to improve data quality of routinely collected data, without subjecting it to a public health inspired contextualized interpretation may lead to inadequate or even incorrect inferences of an outlier. The paper also argues that it is best to conduct and investigate the analysis of outliers at the local level where data has been collected, lest interpretation becomes decontextualized and loses its local meaning as it travels from the periphery to the centre. A key finding of this paper is to emphasize the importance of public health domain related

knowledge, and how that must shape our understanding of issues around data, including data quality.

5.7 Summarizing Individual Papers

After having discussed the findings and focus of the individual papers, in the table below, I would summarize these discussions and findings with reference to the research questions posed in this thesis.

<i>Research Question</i>	<i>Findings</i>
<i>Paper1: Building Participatory HIS Networks: A Case Study from Kerala, India:</i> Conceptualize the notion of Participatory Networks Cultivation of participatory networks with in an action research framework	The notion of participatory networks is to shift the focus of participation from a stand-alone user focused actively to one that involves heterogeneous networks with an inherently socio-political nature. Multiplicity of mechanisms to be used towards participation of stakeholders from multiple sectors and levels, as the purpose and interest of each differ. Participation should focus more on instrumental objectives by emphasizing efficiencies and material benefits. Context Sensitivity: the contextual issues such as political, social, cultural, geographical or infrastructural in nature need to be fully comprehended to enable successful inculcation of PD processes Focus on Output, not just techniques of participation.

	Inculcating a judicious mix of both behavioral and structural aspects of participation.
<p><i>Paper2: The role of Social Capital in the Integration of Health Information Systems</i></p> <p>How does social capital shape the realization of ICT based HIS efforts in the context of developing countries?</p> <p>Role of ICT in building social capital</p>	<p>The role of social capital in the design, development and implementation of HIS enables the introduction of new system or technology, and the new system itself enables the creation of social capital. Social capital is not something given and static, but is a process that grows over time, both shaping and being shaped by the process of implementation.</p>
<p><i>Paper3: Challenges and Approaches in Translating Data to Information and Information to Knowledge: Case Study from the Gujarat State Health System, India</i></p> <p>Challenges in translation from data to information and information to knowledge</p> <p>How these may be addressed?</p>	<p>Inappropriate ratio of data elements collected with respect to actionable indicators. Lack of standardization across data elements and indicators defined. High percentage of zero/null values been collected routinely emphasizing problems towards system design for data collection. Appropriate use of tools such as DMS to enable comparison across facilities and periods, target and achievement, routine and survey figures. Use of SDA approach towards the translation of data to information, and towards improving data quality. Use of practice based view of knowledge towards translation from information to knowledge.</p>
<p><i>Paper 4: Strengthening Metis Around Routine Health Information Systems in Developing Countries</i></p> <p>What is the relevance of the concept of Metis to the context of HIS in order to support public</p>	<p>Metis represents a form of practical skills and acquired intelligence in responding to a constantly changing natural and human environment. Metis is contextual, fragmented, and based on empirical observation. It tends to be extremely</p>

health management?	permeable and open to new ideas. Similarly, in the context of HIS, the field practitioners—nurses, supervisors, medical doctors—have, as a result of their experience and practical knowledge, a good general understanding of the public health problems their local area faces, as well as know how to deal with them.
How can HIS be appropriately designed and used, to support effective use of metis for public health management?	HIS design should be focused towards the use of information rather than emphasizing the means or tools; it should promote decentralized information for decentralized action; it should enable integration of information flow through a data warehouse approach rather than creation of a single window of truth; it should enable collaborative participatory design between user of the system and its technical developers; it should promote a network of action approach through which experiences, advocacy, ideas, products, software & training resources can be shared; an approach to data used based on the principle of satisfying, rather than optimizing.
<i>Paper 5: “Outliers”: A Public Health Inspired Perspective</i>	Use of statistical techniques need to be necessarily integrated with this domain of understanding of public health and local context.
To examine the effect of two approaches towards data quality improvement, one based on the paradigm of statistics and the other representing a public health inspired approach.	While use of statistical analysis may be appropriate at the central level where large volumes of data are processed, at the local level use of simpler tools such as comparison across

	facilities by period using graphs & charts are more effective in reducing data quality. Use of Statistics can only lead to erroneous results and is therefore dangerous in information action.
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Table 5-13: Summary of five papers

The schematic figure below highlights the relationship between the papers and the research questions listed in chapter 1.

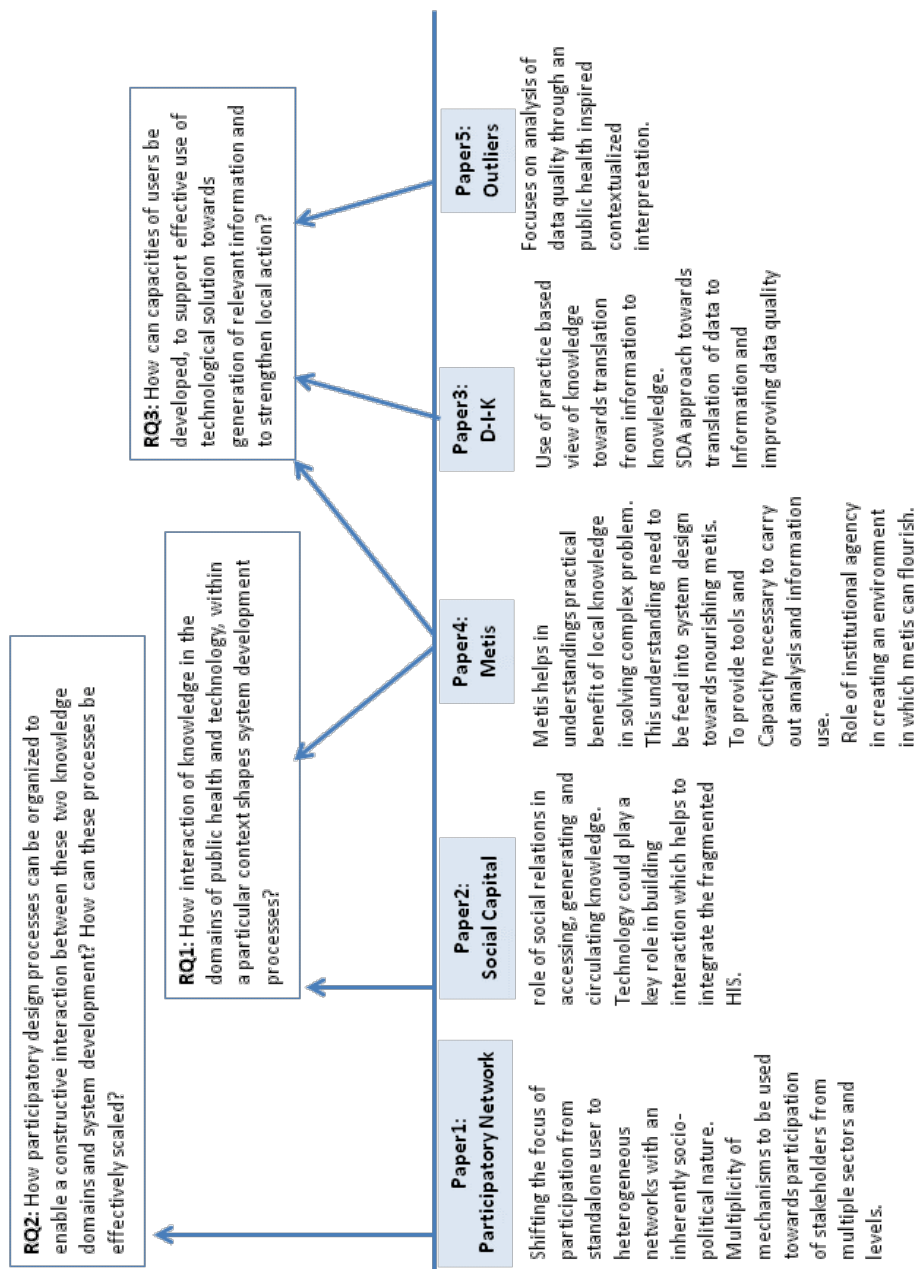


Figure 5-16: Schematic figure representing the relation between individual papers and research questions

The different papers summarized above, help to highlight different aspects of knowledge and the challenges in bringing them together. This helps contribute to the normative aims of supporting use of information for local action. Participatory networks are is a key mechanism which can make this happen. These together help define substantive answers to the research questions posed in the thesis relating to the nature of local knowledge, how this may be integrated, and their implications towards supporting local use. From the individual discussions of the papers, in the next two chapters I zoom out to firstly discuss the findings and then outline my contributions respectively.

Chapter 6 : Discussions - Participatory networks and systems development

In the previous chapter, I presented individual papers, specific questions addressed in each of them, and how they attempt to answer the overall research questions posed in this thesis. In this chapter, the focus is to discuss two central issues in my thesis - *participatory networks and system development*, along with their inter-linkages. In chapter two, in the theoretical discussion I had analyzed some key concepts around issues of local knowledge, participatory design and systems development. In this chapter, I will elaborate on that through an integrated theoretical perspective, based on the different insights gained during the empirical work.

This chapter on discussion is organized as follows:

- The first section focuses on the constitutive component of participatory networks. It describes local knowledge in the form of metis, with respect to technology and public health, and also how this plays out within an implementation and use context.
- In the second section, using the two case study examples from the states of Kerala and Tamil Nadu, I will discuss the establishing and evolving aspects of the respective participatory networks.
- The third section zooms out and seeks to present a more integrated understanding of participatory networks.

6.1 THE CONSTITUTIVE ASPECT OF PARTICIPATORY NETWORKS: LOCAL KNOWLEDGE - METIS

Over a period of time, researchers have argued to view ISs as socio-technological heterogeneous networks, rather than technical artefacts. This perspective has contributed to the adoption of various socio-technical design approaches, thereby increasing sensitivity to the social context of IS design, and placing a greater emphasis on enabling user participation. Traditionally, participation implied primarily the involvement of end users within particular organization settings. Such a perspective is limited, requiring a shift from a user centred participation to broader stakeholder participation within a networked framework that is both multi-sectoral and multi-level. This shift emphasizes the involvement of a multiplicity of interests, and with it different forms of local knowledge – Metis.

Such participatory networks have both constitutive and instrumental facets. We conceptualize the constitutive aspects of these networks with respect to local knowledge, relating both to the domains of technology and application area of public health which play out in a context of implementation in use. In the following section, based on the empirical analysis, this constitutive aspect of the participatory network is elaborated. Prior to that, a broader discussion on local knowledge is presented.

6.1.1 Local knowledge: Understood Through Metis

A key concern in metis, relating to local, contextualized and in-use knowledge, is the practical benefit it provides, which in this thesis is towards strengthening the aim of enabling local action. Metis is important to understand, as it feeds into the process of systems development towards strengthening appropriate design. With respect to HIS, there are two key knowledge domains, namely tech-

nology and public health, whose interactions are situated in an implementation context, playing out in everyday practices (Suchman 2002, Gheradi 2000) of the health staff.

The focus of this thesis has been primarily on the peripheral health workers and medical officers. In keeping this focus on the local level, I have deliberately not taken into account the knowledge domain of epidemiology. Even though being a key aspect of public health, in this case it has relevance primarily at the state and national levels. In the local settings of district and below, epidemiologists are not available in India, and no such analysis takes place. The aspect of metis in focus has thus been related to data collection and its processing, using the HMIS software. It deals with the analysis and interpretation of information and its application to address everyday health issues, such as how to improve immunization coverage or to ensure that pregnant women receive their required antenatal services.

Local knowledge in the empirical context studied, is defined as *'understanding and supporting work practices of the health functionaries (such as field nurses, medical doctors, district administrators) for the design, implementation and monitoring of interventions geared towards practically improving health outcomes'*. While such understanding is largely based on experiences of day to day work, it is argued in this thesis that it can be strengthened through appropriately designed HIS, which enables processing, analysis and display of routine or other data (such as surveys) for utilization by the users to guide practical action. Such knowledge, as the concept of metis emphasizes, finds value in the practical benefits it provides, and not as abstract and theoretical knowledge (Scott 1998). For example, by using

computer based HIS, if the field nurse's burden of manual compilation, time of travel to deliver reports, or identification of those pregnant mothers who have skipped a check-up more accurately, can be reduced then there are practical benefits associated. Learning how to use the computer system in turn helps to enhance her practical knowledge. Given this operational definition of local knowledge, I unpack through practical examples the nature of technology related and public health knowledge.

6.1.2 Constitutive aspect of participatory networks: metis related to technology

This relates to the capacity of health staff to be able to use technology, primarily the HIS application, towards achieving practical value in taking local action. Technology related knowledge relates to *practical understanding of how to use HIS, and also the capacity to solve some technical issues on how to keep the application operational*. Based on this definition, inferring from the empirical work, I identify the following facets of technology related knowledge:

- I. *Capacity to carry out local customization*: This capacity concerns the ability of the user to carry out local changes and customizations in the application to address the local needs he/she experiences. Some examples of this include:
 - ✓ Addition or deletion of local data elements into the database.
 - ✓ Adding, updating or modifying the existing organizational unit structure to reflect changes in the hierarchy.
 - ✓ Creating new validation rules for carrying out data quality analysis.

- ✓ Creating new indicators for conducting health status analysis.

Building capacity for the users to carry out these concrete operations, not only helps them in their everyday work, but also empowers them to become less dependent on external agencies for support. The greater this self-reliance, the stronger will be the technical knowledge of the users, and will also provide them with more confidence to learn other things. Below, I provide an example of how the organization units and data elements can be modified by a user working with HMIS application – DHIS2 - which was in use in the empirical sites. These modifications are done directly through the user interface and do not require any programming intervention, and work without vendor support. Figure 6.1 represents the user interface for creation, editing and deleting of organization units. Figure 6.2 represents the user interface for addition, modification and deletion of data elements. The point emphasized through these examples is that the skills required to carry out basic but crucial operations could be developed relatively easily through training. The health staff could also acquire these skills to create potential in them to be able to orient the application towards supporting their local needs. As the users see the system being useful to them, they would be more welcoming towards it, as compared to their view of it as just a tool for upward reporting.

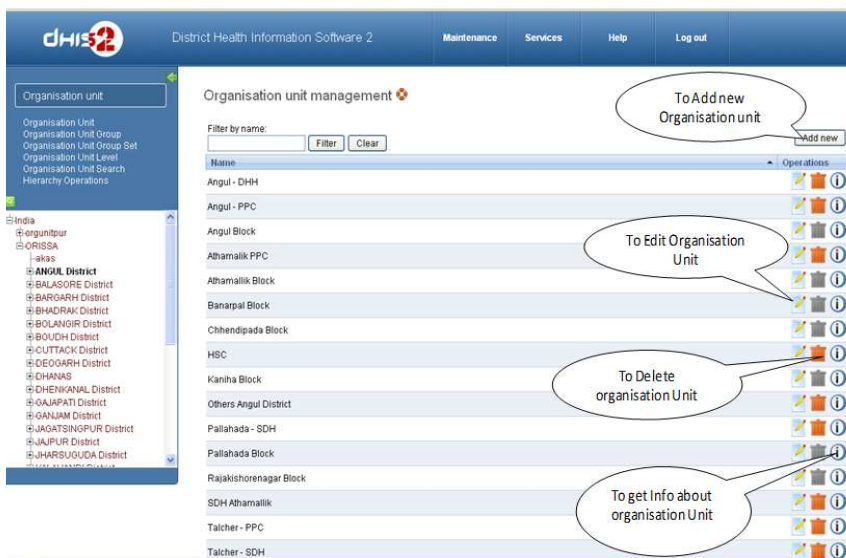


Figure 6-17: flexibility for local customization of organization unit



Figure 6-18: Flexibility to add, edit and delete data elements

- II. *Capacity to use data analysis tool in the case of DHIS2:* This capacity concerns the ability of the user to use the data analysis tools, such as pivot tables or Dashboard Monitoring Tool which are typically a part of HMIS applications like DHIS2. A dashboard facilitates the user for viewing their

local data as graphs and charts displaying performance indicators. Such visualization of data pictorially allows a better understanding of how the “data behaves” and can positively enable implementation of relevant local action. Some examples of practical tasks the user can carry out through the use of tools like the dashboard include:

- ✓ Creation of “achievement against target” charts.
- ✓ Creating routine performance charts.
- ✓ Comparison of related indicators.
- ✓ Comparison of indicators across health facilities.

As an example, a chart is shown below.

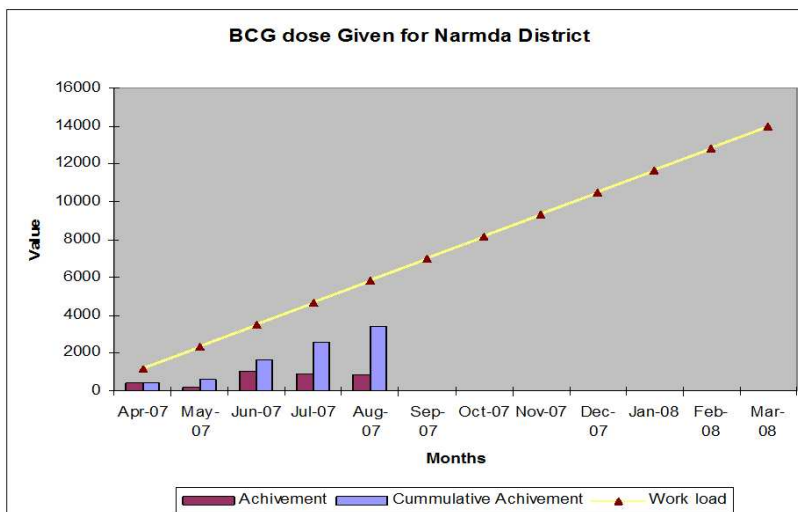


Figure 6-19: Comparing monthly and cumulative achievement with annual target

In the above figure, the yellow line represents the cumulative monthly target given to a health worker for a particular service she is expected to provide (in this example administering BCG doses), while the brown and blue bars represent the monthly and

cumulative achievement figures. Health workers by viewing the above chart can assess their progress on a monthly basis in relation to assigned targets and take required corrective action. This supports self-monitoring of tasks, which would be more empowering than being externally controlled.

Another example is given below on skilled birth assisted deliveries.

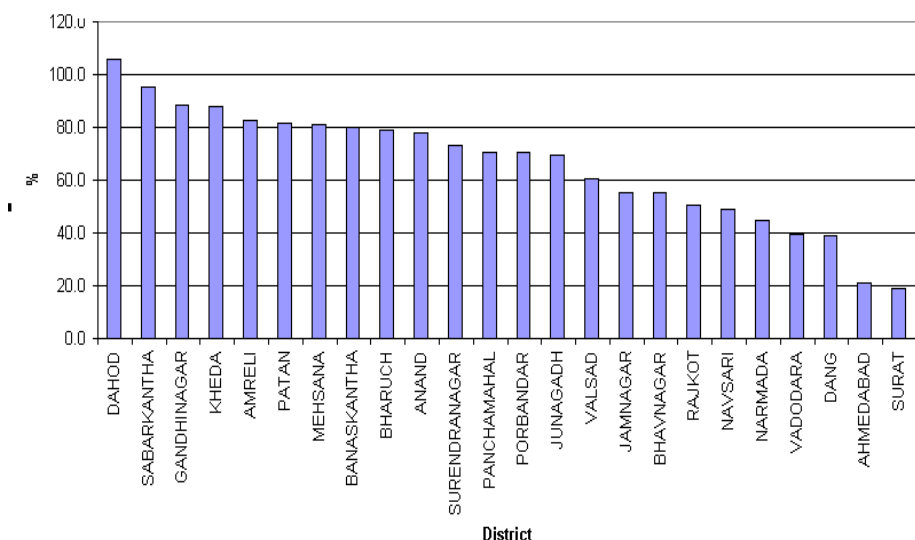


Figure 6-20: Percentage of skilled birth attendants assisted deliveries across districts

The above graph which shows the district wise performance of skill birth assisted deliveries, can be useful for the state level planner to assess performance of the districts on an important parameter relevant for the Millennium Development Goal (MDG) achievement. By identifying poor performing districts (example Surat), the planner can help by firstly talking to the authorities in that district to pin point the issues causing low performance. This can lead to the design of relevant interventions such as increasing skill birth assistance training, providing more facilities for basic emergency obstetric care services, and improving referral transport services

for pregnant mothers where skilled birth attended deliveries is low.

The figure below provides the snapshot of a user interface of the dashboard monitoring tool in DHIS2. Here the users can select their required indicators and compare them across all facilities under a parent organization (districts in a state, or blocks in a district). For example, the figure below illustrates the different steps towards the generation of indicators compared across all the districts of the parent organization unit, Gujarat state. Through the use of this tool, the health staff and administrators can compare any indicator across organizational units for different periods. This thus provides the staff with flexibility in carrying out local data analysis and monitoring performance across **their own** health facilities. Relevant analysis can then lead to a proper diagnosis and based on this, the required focused action can be implemented.

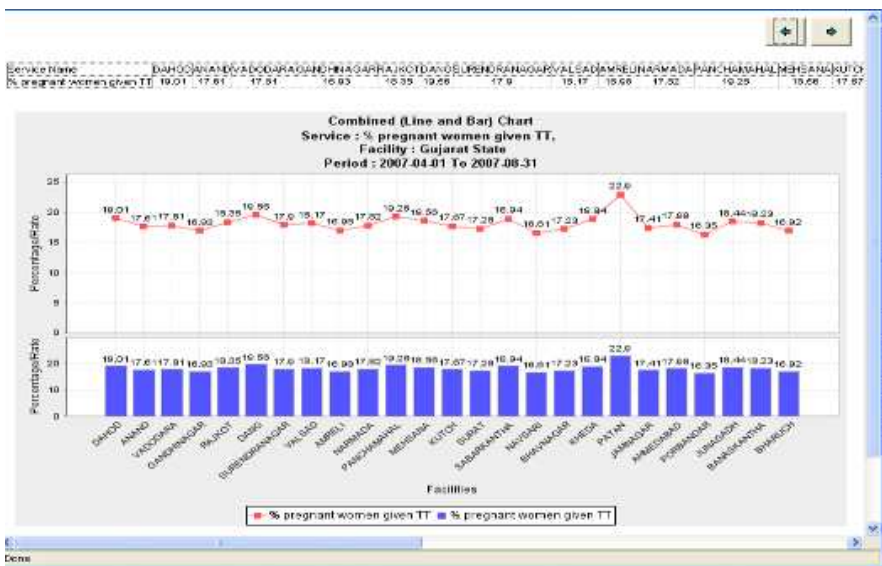
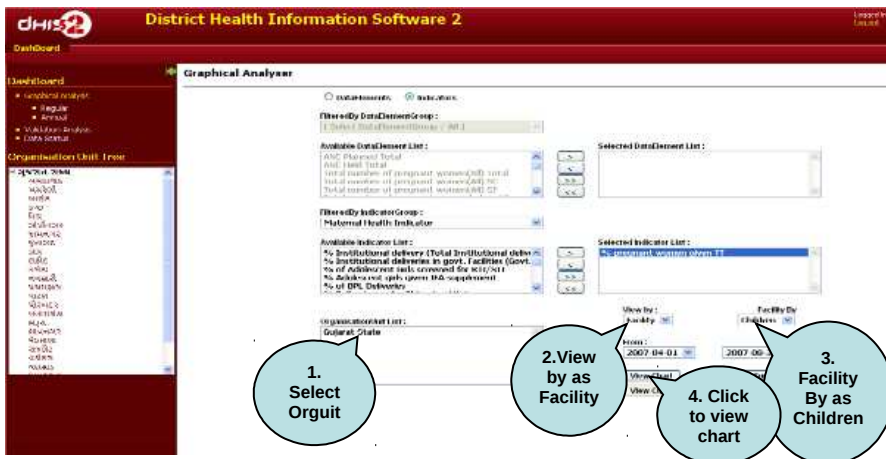


Figure 6-21: Use of dashboard monitoring tools of DHIS2

- III. *Capacity to do basic level of troubleshooting of technical problems:* This capacity establishes the ability of users to address basic technical problems in HMIS application at their level, before seeking external technical help. These technical skills are relevant for firstly providing the user with a sense of local control and understanding of the

application, and secondly to reduce dependency on external support which is very often hard to obtain in rural settings in a reliable fashion. Some examples of the skills required to carry out such local level troubleshooting are:

- ✓ Ability to reset forgotten passwords for users in the application.
- ✓ Skills to create new users and define their access roles.
- ✓ Ability to address data mismatches between data entry and reports: A common problem seen in data aggregation is the mismatch between data entered and the report generated. Often, this mismatch is attributed as a software bug, but most of the time it is not that, but is caused due to a data entry mistake, where data for same data elements are entered both at the child and parent organizational unit levels (say block and district). This creates duplication in aggregation, leading to data mismatch.

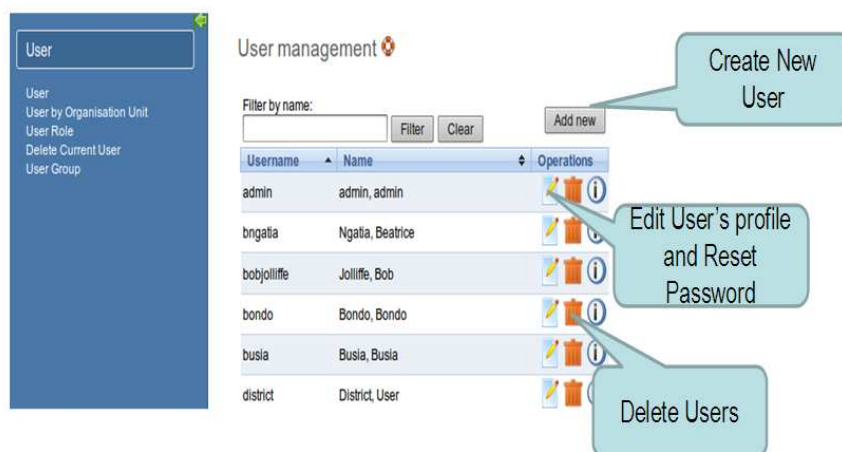


Figure 6-22: Functionality to create new user and reset of password

Figure 6.6 represents the user interface for creating new users and the resetting of forgotten passwords. Users with due access to carry out this operation can then easily create new users and also help users with lost passwords, a very common occurrence in the field.

- IV. *Capacity to use visualization tools such as GIS:* This capacity concerns the skills required towards the use of GIS and other such tools for improved visualization of data. This capacity enables the user to generate health indicators and view them on a map, and does not involve core technical skills on GIS, such as the creation or editing of a map, which arguably is a function more appropriate for the state level. Map based visualization of health indicators provide a powerful avenue for users to spatially understand issues. For example, the prevalence of a disease across a district, and also the surrounding facilities it can affect. Seeing these spatial inter-connections can then help establish necessary

actions to improve effectiveness of health delivery, such as through optimizing of resources in co-located areas. Some specific skills that can be developed for the user in this regard include:

- ✓ Ability to differentiate between a GIS (e.g. shape file) and non GIS map (e.g. jpeg file).
- ✓ Ability to use the GPS to record the longitude and latitude for health facilities.
- ✓ Capacity to use the GIS software to generate health maps in order to display health indicators and data elements.

Skills to export the generated maps into jpg format so that they can be included in presentations and documentations.

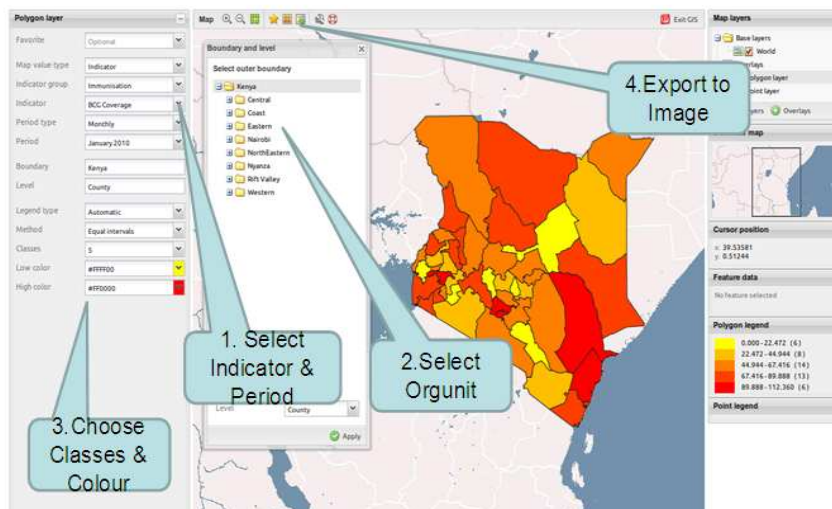


Figure 6-23: Screen shot of user interface of GIS module in DHIS2

The above figure represents a snapshot of a user interface screen of the GIS module in DHIS2. Through this interface, the user can link health data, both indicators and data elements, to a spatial

map. The above figure also demonstrates the steps towards the generation of maps and its export to a jpg file, for incorporating in presentations and documentations.

6.1.3 Constitutive Aspect of Participatory Network: Metis Related to Public Health Knowledge

In the context of this thesis, public health knowledge is operationalized as relating to the *ability of health professionals (with my focus being on peripheral level health staff) to interpret and use information for supporting their everyday work*. Such knowledge relates to the understanding of diseases, their determinants, and also about the different services (eg. immunization) that the health staff is expected to provide. The relation between these domain issues and the HIS is primarily through the ability to define the appropriate data elements that need to be collected (which should reflect the problem to be addressed). It also includes knowledge of how these data elements can be converted into actionable indicators, and then how these are interpreted in the context of the problem in hand and acted upon. Practical skills in this regard are towards understanding the definition and behavior of data elements and indicators, and how these may be interpreted and used to guide action. Some specific skills in this regard include:

- I. *Capacity to understand data elements and indicators, including their definition, correlation, and significance in use:* This capacity concerns the ability of health staff to have a common understanding of data definitions and their linkages towards actionable indicators. For example:
 - ✓ How to use the data dictionary which provides data definitions, guidelines and processes of aggregation.

- ✓ How to use the indicator dictionary which provides indicator definitions, its rationale, suggested actions and levels of use.

Data Element : Total number of pregnant women Registered for ANC

Definition: Total number of NEW pregnant women registered for antenatal care during the reporting month.

Guideline: The visit should include relevant checkups required for antenatal care. Registration should include ANC check-up. ANC first check-up is same as ANC registration. A pregnant woman is generally registered during the very first contact with the health facility/worker, irrespective of her stage of pregnancy.

Data Source – Antenatal Register / Pregnancy Register

Box 6-3: An example of the data element dictionary for total number of pregnant women registered by ANC.

The above box represents an excerpt from a data dictionary defining the data element of *total number of pregnant women registered by ANC*.

Starting with the data element definition, the data dictionary provides guidelines for its collection and details of the primary source of data, which in this case is the antenatal or pregnancy register. So, using this, the user can clearly understand the meaning of the data element, how to carry out a diagnosis on data correctness (by examining the primary data source), and also how to use that data for developing interpretations on service performance.

Indicator MH 1: Antenatal care first visit coverage rate**A: ANC under 19 years****B: ANC in first trimester**

Definition	Percentage of pregnant women who used Antenatal Care (ANC) provided by skilled health personnel, for reasons related to pregnancy, registered and examined for the first time and received some form of care, such as TTI Women under 19 years of age First visit in first trimester of pregnancy
Numerator:	ANC first (initial or registration) visit ANC first visit under 19 years ANC first visit in first trimester of pregnancy
Denominator	Total expected pregnancies A and B ANC first visit
Rationale	This first visit should be a "registration" visit where all initial procedures relating to assessing/preparing a woman for pregnancy and delivery occur. This should include full history, examination, initial blood tests and immunisation. Antenatal care coverage is an indicator of access and use of health care during pregnancy. All women should have at least three antenatal visits during a pregnancy. These should start as early in pregnancy as possible. ANC under 19 years shows proportion of teenage pregnancies % ANC booking in first trimester shows early care and level of awareness.
Data Source	Antenatal / maternal health registers, Maternal health card, Household surveys Population data - an estimate of the number of pregnant women is close to the number of children born (2.2-3.2% of population)
Suggested level of use	National and below
Other Useful Indicators	Risk and continuity indicators are important in ANC. VDRL (syphilis) and HIV testing coverage shows quality of care. This should be taken at first ANC visit. Haemoglobin testing and anaemia management rates ANC referrals shows risk detection (and transport availability). % women getting third ANC shows continuity of care, which is often related to perceived quality. Unbooked deliveries at facilities is an accurate indicator of failure of ANC services.
Common Problems	Attendance for pregnancy test or simple registration without history and examination do NOT constitute antenatal care.

Box 6-4: Indicator dictionary for Antenatal care first visit coverage rate

The above box represents the screen shot from an indicator dictionary for antenatal care first visit coverage rate. The indicator dictionary starts by formulating the indicator definition, followed by detailing the data elements to be included in the numerator and denominator. Further, the dictionary provides a rationale towards the use of the indicator, its source of collection and level of its use. It also identifies other related useful indicators and common problems toward its articulation. This information assists the health planner towards the use of this indicator in local analysis, planning, and primarily for taking action. Since indicators are comprised of data elements, the user should be aware of the fact that we should avoid collecting data elements which do not contribute to the generation of an indicator.

II. *Capacity around understanding data element behavior:* This

capacity concerns the ability of health staff to understand the behavior of data elements, with respect to other related data elements in the context of a local situation. Such an understanding can help diagnosis action points for improving data quality. Some of the specific skills in this regard include:

- ✓ Identifying related data elements and their behavior.
- ✓ Identifying acceptable data ranges of data elements, including “min” and “max” ranges that help to monitor data quality.

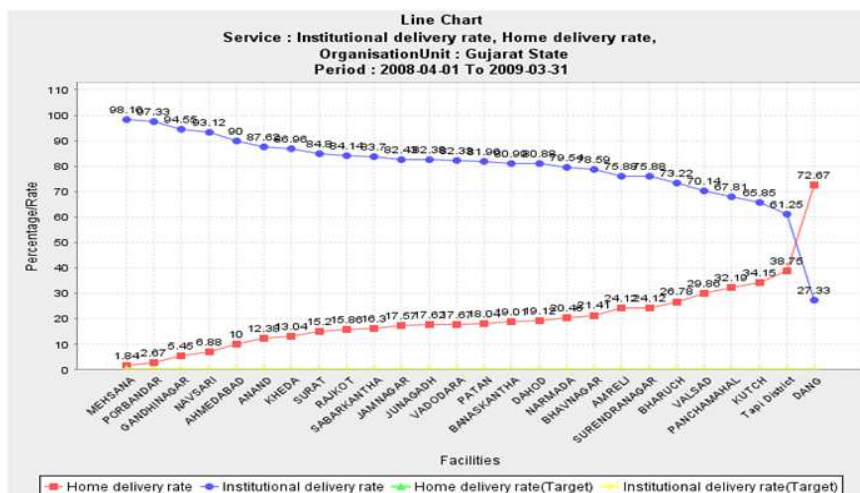


Figure 6-24: Comparison of institutional and home delivery rate across district of Gujarat State.

The Line chart in the above figure represents a comparison between two related indicators, institutional (shown by blue line) and home delivery rates (depicted by red line), across all the districts of Gujarat State for the financial year of 2008. Using this chart, the health planner could identify districts with low institutional delivery rates. This information could help design

corrective measures such as strengthening facilities for enabling delivery services. Further, since home delivery is not being encouraged according to some policies in India, the health planner could use the chart to identify districts where this rate is high, and further see the break ups of that indicator as deliveries assisted by skilled and non-skilled birth attendants. This helps to identify concrete corrective measures which need to be taken.

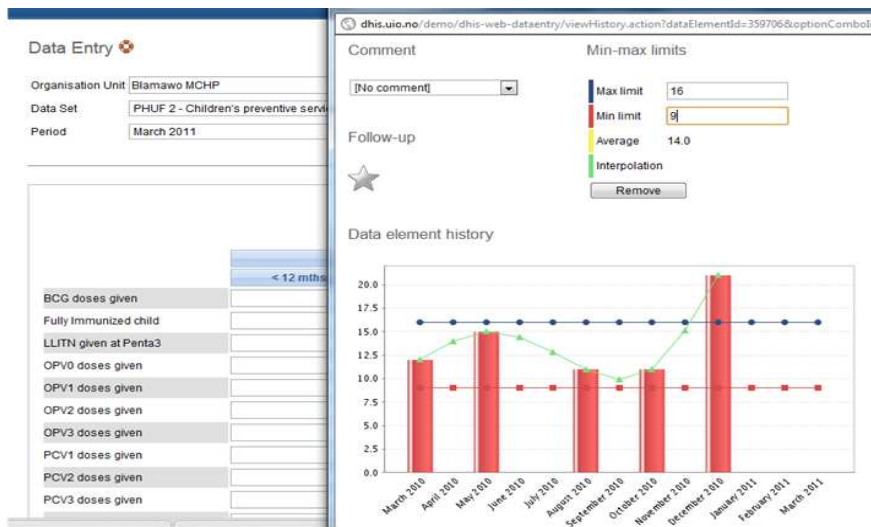


Figure 6-25: Screen shot of data entry screen with min and max range for data elements

The above figure represents the snapshot of a data entry screen in DHIS2, where the health worker can view data values for the past thirteen months, for particular elements with respect to min and max ranges corresponding to particular health services (such as BCG doses given in the above chart). This option in the data entry screen provides the health worker or data entry operator to view at the point of data entry, whether the value lies in an acceptable range (which shows as red if out of range). Additionally, the user has the possibility to fill in an additional comment as a reason for

out of range data, such as stating that the vaccine was out of stock or a staff was on leave which contributed to the data being out of range. This helps to distinguish between an abnormal value as a “data artifact” (such as a typing error) or representing a “health programme artifact.” Such a distinction is especially necessary considering that the normal tendency is to attribute all data related issues as data quality problems (due to manipulation or wrong entry). Such an attribution then also draws attention away from the health programme related problems, which may require different kinds of interventions such as improving the cold chain supply of vaccines. This additional comment not only validates the data but also provides information at the time of data analysis by putting useful local context to the raw data.

III. *Capacity to develop interpretations of data and formulate them in the design of local action:* This capacity concerns the ability of health staff to develop a public health based interpretation of data for taking corrective local action and intervention. For example:

The chart below represents a life cycle chart for immunization which compares raw data (actual numbers) of total delivery, live birth, the individual antigens of child immunization, and also complete children routine immunization. The chart highlights two issues: high BCG coverage and high dropout rates of immunization.

- ✓ Over 100 per cent live births recorded with respect to BCG coverage; the chart indicates that there are more births recorded than deliveries reported. This suggests that maybe not all deliveries were recorded in the system, despite the possibility of twin births and also wasted deliveries. But in the case of over

100 per cent of BCG doses given, two possibilities can be inferred. One indicating that not all live births were recorded, and secondly that there was an over reporting of BCG doses, including duplicate entries.

- ✓ Identifying dropout rates to address the problem of immunization coverage: Through the graph below, it can be seen that there is a drop moving from BCG to full immunization, including steep falls from DPT1 to DPT3 and DPT3 to Measles doses. This graph then helps the outreach worker to identify specific points where she needs to strengthen action to improve immunization coverage.

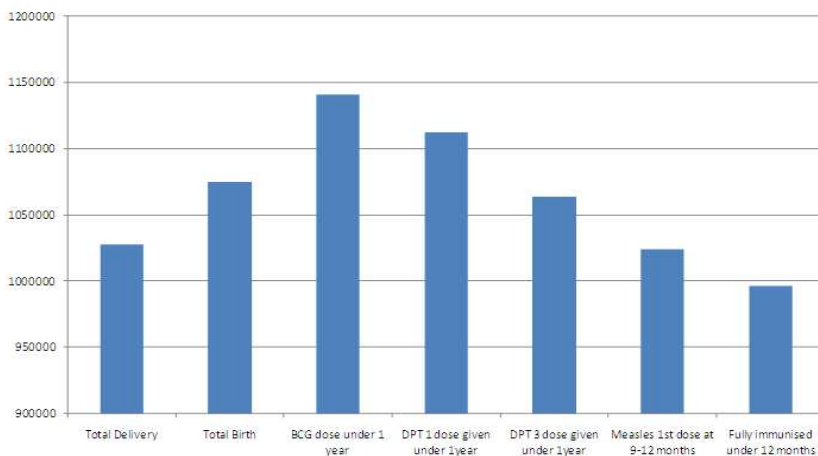


Figure 6-26: Life cycle chart of immunization comparing delivery, live birth to full immunization

- IV. *Understanding target population:* This capacity concerns how well the health staff understands the target population she is dealing with, a concept fundamental for the analysis of indicators. Only when the health staff knows precisely the target population they are dealing with, can they analyze

the achievement (service given) against a target (what they were supposed to achieve). Some examples of target populations that are relevant for indicator analysis include:

- ✓ Eligible couples, defined as married women in the age group of 15 to 49 years. This represents about 15 per cent of the total population and is of specific focus for family planning activities.
- ✓ Children under one year representing the infant population which is around 2-3 per cent of the total population, and is required for computing immunization coverage.
- ✓ Estimated pregnancies, which are typically much higher than reported deliveries. This helps to understand important indicators such as percentage of institutional deliveries. Comparing institutional deliveries against reported and estimated pregnancies also helps to understand what percentage of the target population has been provided service against that expected.

V. *Capacity to define locally relevant indicators:* While the DHIS2 allows a user to define indicators relevant for them, it is the public health knowledge that guides the practitioner to understand what indicators are required. This understanding comes with an intimate sense of the local situation, including the ongoing problems that need to be addressed. For example: antenatal care, skill birth attendance and institutional deliveries are key indicators argued to shape maternal mortality. This requires improving the coverage and quality of care in the identified areas. For

this, the following indicators are relevant:

- ✓ ANC coverage rate which is defined as the percentage of pregnant women that were provided antenatal care service by the health worker at least once during pregnancy. And, ANC TT2 or TT booster coverage rate indicators are defined as percentage of pregnant women who received TT2 or TT booster vaccine. While the ANC coverage rate indicators provide an indication of coverage of care, the others indicate the quality of care.
- ✓ Similarly, institutional delivery rate, which is defined as percentage of institutional deliveries with respect to total delivery, provides an indication of coverage, while that of discharge rate within forty-eight hours after institutional delivery indicates the quality of institutional delivery services.

Capacity to define local validation rules: This capacity relates to the conduct of data quality analysis based on locally articulated validation rules. For example: monthly reports of health data contain various interrelated data elements which could be cross checked against each other to help analyze quality. Another example is of, pregnant women registered for ANC under first trimester represents a subset of the total pregnant women registered for ANC, implying the sub set cannot be greater than the total. Similarly, total deliveries reported should be equal to the number of live births plus still births (notwithstanding the possibility of twin births). The ability of the health staff to identify local validation rules that are relevant and how these can be used

to make improvements in data quality is an important aspect of local public health knowledge.

6.1.4 Implementation: The Context of Applying Metis

Local knowledge, both technical and public health related, are inter-linked in a situated implementation context. For example, using information to identify children dropped out from the immunization programme, plays out within a particular implementation setting, and demands both technology related (how to use and support the HMIS) and public health knowledge (how to interpret a data element and immunization coverage indicator) to be combined. The implementation setting is defined by various conditions such as how work practices are organized, what are the institutional arrangements for verification of data, providing feedback and supervision, the available infrastructure of registers, computers, and internet. The introduction of new technology undoubtedly has the potential to reconfigure this work context, and also the context itself helps shapes the nature of what HIS solutions design. For example, the use of mobile phone to send data directly by SMS to the central server will necessarily affect the existing practices of manual recording and transmitting of data. And, whether the mobile solution developed is based on SMS or GPRS technology it is shaped by the ability of the context to support particular kinds of technical solutions. System design and development processes need to be informed of the characteristics of the context, the opportunities and constraints that they present. Some specific understandings related to the implementation context include:

- I. *Understanding how the HMIS relates to work practices around information flows:* This capacity concerns the ability

of health staff to understand how different types of health data are collected by institutions based on the services they provide. For example:

- ✓ The Community Health Centre (CHC), representing the secondary level of healthcare in the system, reports on Comprehensive Emergency Obstetric Care Services (CEmOC) such as C-sections and blood transfusions which are not available at lower level facilities like the Primary Health Centre (PHC). So, such data should only reflect in the CHC and not PHC datasets.
- ✓ Similarly, home deliveries would be reported by the sub-centres and not by other health institutions, as it is only a sub-centre specific outreach service.
- ✓ Further, data elements for programmes like IDSP (Integrated Disease Surveillance Programme) are collected at a different frequency (daily or weekly) as compared to the HMIS data which is reported monthly. The flow to support this data needs to be thus different from HMIS reports.

II. *Procedures around data flows, data verification:* This capacity concerns the ability of health staff to establish, follow and understand procedures around data flows, data verification and providing feedback to field staff on data issues. For example:

- ✓ District monthly reports comprise of data from different health programmes, such as mother and child care, immunization, blindness control, district stocks and so on. The concerned health program managers need to verify their respective data and

endorse it with their signature. The overall in-charge of the district health system (the district medical officer) then needs to verify the integrated report before transmitting it to the state level, where a similar process of authentication is done before it is sent to the national level. The HIS must therefore be able to reflect these work practices, and if the system demands changes in the practices, then these must be well understood by the health staff.

- ✓ The process of feedback is important to learn and understand for the health staff. Through the thesis, three types of routine feedback reports were identified to be relevant, including comparison of selected indicators across all children units (all districts in a state for example), across its parent unit, and across time periods (months in a year). Feedback reports not only help improve quality of data, but build in accountability as the reports are compared to specific performance indicators. In the absence of feedback, health workers doubt the utility of engaging in the collection and transmission of data upwards, which they see of no local value. The picture below shows an example of a feedback meeting from Kerala.



Figure 6-27: Health supervisor scrutinizing routine data during monthly sector meeting at PHC in Kerala

In the table below, I have summarized the nature and facets of local knowledge, identified as being relevant and important in shaping system design and development processes. The practical or functional value obtained with respect to these knowledge elements are also discussed through examples.

<i>Knowledge domain : Technology</i>	
Characterized by	<input checked="" type="checkbox"/> Various features in the HMIS application tool to allow the end users to use technology for their local benefits.
Running example	<input checked="" type="checkbox"/> Using the user interface to make correction in data elements, organization units, its hierarchy, validation rules and indicator definitions.
Functional value of knowledge	<input checked="" type="checkbox"/> User can work with a locally relevant system which he/she can guide towards supporting local health interventions.
	<input checked="" type="checkbox"/> User builds capacity for carrying out local customizations towards dealing with the

	ongoing and changing needs of the health system.
<i>Knowledge domain: Public Health</i>	
Characterized by	☑ Data elements and indicator dictionaries which describe the nature and behavior of data elements, indicators and their relationship.
Running example	☑ Identification of areas of concern requiring action, such as high dropout rates from immunization, and low performance on service delivery.
Functional value of knowledge	☑ User built capacity towards interpretation of trends from graphs and charts, and being able to articulate this understanding towards designing local planning and action.
<i>Local knowledge domain situated in an implementation context</i>	
Characterized by	☑ Work practices, culture towards data collection and understanding information flows.
Running example	☑ Understanding services deliveries by different health facility types and how these relate to the HIS. ☑ Understanding the data collection and reporting frequencies of different health programmes. ☑ Defining the role of health supervisors at different levels of the health administrative hierarchy to provide relevant feedback ☑ Institutional procedures in place for data collection, verification and transmission.
Functional value of knowledge	☑ Capacity of health managers and planners in designing relevant data collection forms and their flows.

	<input checked="" type="checkbox"/> User built capacity towards scrutinizing data quality and establishing constructive feedback processes.
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Table 6-14: Knowledge domain and its functional value

After having discussed the nature of local knowledge and the functional value it offers, a key question explored is how this knowledge feeds into system development processes? This is discussed through the concept of participatory networks, argued as being vital to this linkage between local knowledge and participatory networks.

6.2 ESTABLISHING AND EVOLVING PARTICIPATORY NETWORKS

In the above section, I have described the nature of metis based on my empirical work, specifically related to technology and public health knowledge. This local knowledge is conceptually understood as “metis.” In this section, I will discuss the concept of *participatory networks* in relation to its role in facilitating the linkage between metis and systems development processes in the context of two case study examples. This notion is inspired by the concept of “networks of action” (Braa et al 2004), described as actors consciously creating and circulating action in the network related to software, material (like manuals), and implementation experiences. In this same vein, participatory network in this thesis is described as members engaged in *developing, using or circulating local knowledge in the network which is useful for supporting local action*. For the two case studies reported in this thesis, their participatory networks are elaborated, including how they were established, the process through which they evolved and the implications towards systems development.

6.2.1 Participatory Networks in Kerala

While HISP India was working in Kerala since 2006, the state formally entered into a formal MOU in 2008 to carry out a state wide implementation of the DHIS2. As per the agreement, in addition to a state team of five persons, HISP was now supposed to place a two member team in every district (fourteen in total) also for the first year. This number was to be increased to four persons in each district in the second year. According to the design, the project was structured to be broad based, covering the entire state, being *multilevel and decentralized*, and focusing on the field health worker, specifically the JPHN (Junior Public Health Nurse). The state level involvement was through its support for open source software, and HISP coordinator teams were established in the district network, making the support structure multi-level.

The context plays an important role in the setting and scaling up of the network. In Kerala, the political history of the Left rules the state policy of support to free software for the public sector. A strong culture of decentralized governance shaped the initial design of the network, and created the potential to scale towards certain trajectories that were locally owned.

In Kerala, through the engagement of the district teams, there was a direct role of the HISP India with the field staff in building their capacities, supporting them in need, and also building relations of trust and confidence. This had positive implications mutually, for the health staff to gain knowledge of the system, while the HISP team could better understand the *implementation context*. Various mechanisms were used for understanding local knowledge, and to scale this to other parts of the network – such as HISP India and Oslo development teams.

During the initial development of DHIS2 system, workshops were held at the local public health institution with medical doctors from the health facilities of Trivandrum district in Kerala, where the first prototype of DHIS2 was presented. Such workshops helped in two ways. Firstly for the HISP team, it helped to understand the nature of local knowledge that was seen as relevant from the perspective of the community of non-developers (the medical doctors and the academics). For example, the doctors expressed concerns of security – a nurse should only be able to see data from her facility and not of others. Such inputs gave insights into understanding metis, and locally relevant knowledge. Secondly, the aim was to make such local knowledge more global. Therefore at the same time participatory network helped to provide the mechanism to do so. DHIS2 played a key role in scaling the network. One, by its “free” nature, it could be taken to all the facilities in the state, without any license restrictions, a process which took about three years to move from one deployment in one clinic to cover the complete state. Local requirements understood through various participatory means could be inscribed in the systems, being continuously developed and upgraded, and taken back to the field with new updates.

The deployment model for DHIS2 also changed over time. Initially, the configuration was of a district based system where the application was deployed on the state server and data entry was done at the district level because of internet restrictions for the sub-district levels. Later the state moved to a hybrid model where offline DHIS2 was established in all the PHCs in the state, data entry could be done offline there, and then the monthly data could be exported to the district into the online database. As the internet

became more available, the data entry started to be done online from the PHC level, making Kerala the first state in the country to have such a decentralized structure for data entry and reporting. The three different models of networks are given below, which also had key implications in structuring the participatory network – moving from centralized to broad based and decentralized models.

Model-I: District based deployment model: enabling rapid scale deployment

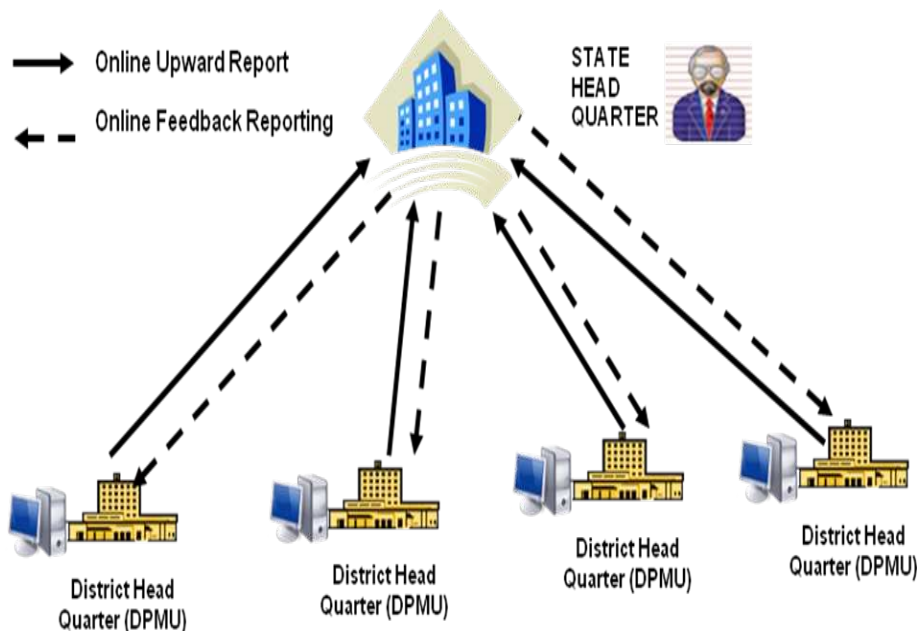


Figure 6-28: District based system model

During the initial phase of the project, a district based deployment model was adopted. It enabled rapid scale deployment to cover the whole state by leveraging on the existing infrastructure and resources to produce quick overall results. For example in this case, most of the district health quarters in Kerala were well connected to internet. By deploying a state HMIS application with district access, staff at the district level could enter data that

already existed at their level. This deployment model enabled the access to an overall state coverage with consolidated data from all the districts.

Model 2: Hybrid deployment model: combination of offline and online systems

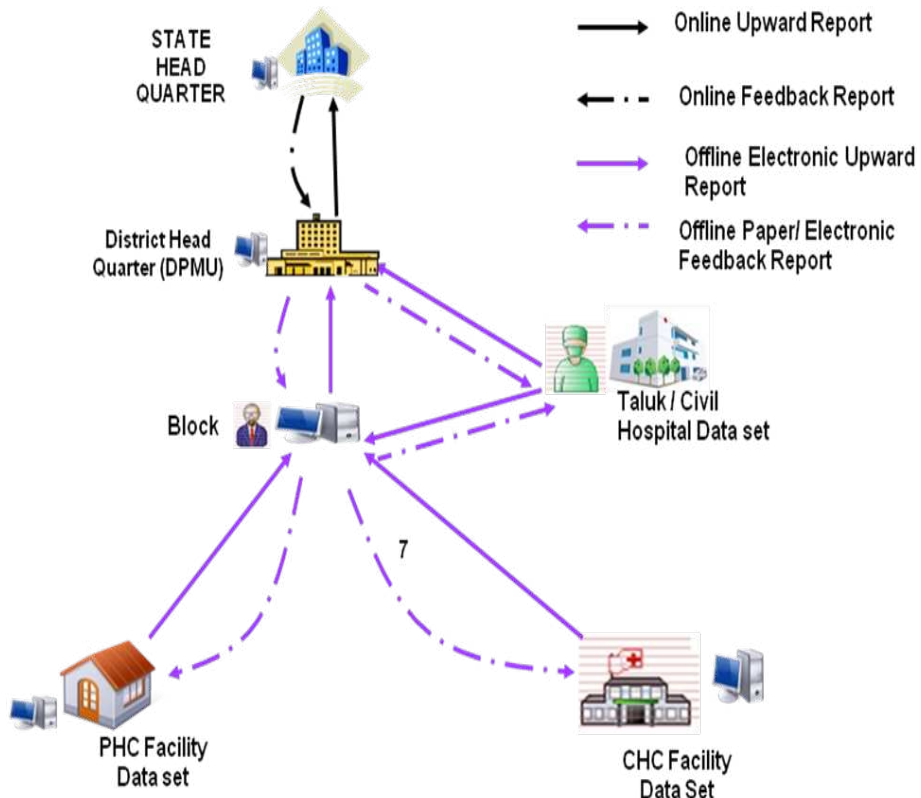


Figure 6-29: Hybrid deployment model

Most of the health facilities, such as CHCs, PHCs and district hospitals, had computers at their stations with limited or no internet access. The HISP facilitators installed the offline version of the DHIS2 in these computers, and the health staff were trained

and facilitated to enter their routine data in these systems on a monthly basis. This data was then transferred electronically to the district level through the sub-district level of the block, either through a USB stick or via email. The staff at the district level then imported this data into the district database through the import/export module of the DHIS2 and was made available to the state level through the online system. Further, the districts would generate feedback reports and send it to the block office from where it was transmitted to the peripheral institutions. The district health staff also entered data on stocks at their level which became part of the consolidated district data that was exported to the online state application. Thus, the online state application consisted of three levels of data: Block, District and State. This model was adopted to overcome the effect of lack of internet connectivity at the peripheral institutions.

Model 3: Complete online deployment model: complete and decentralized coverage

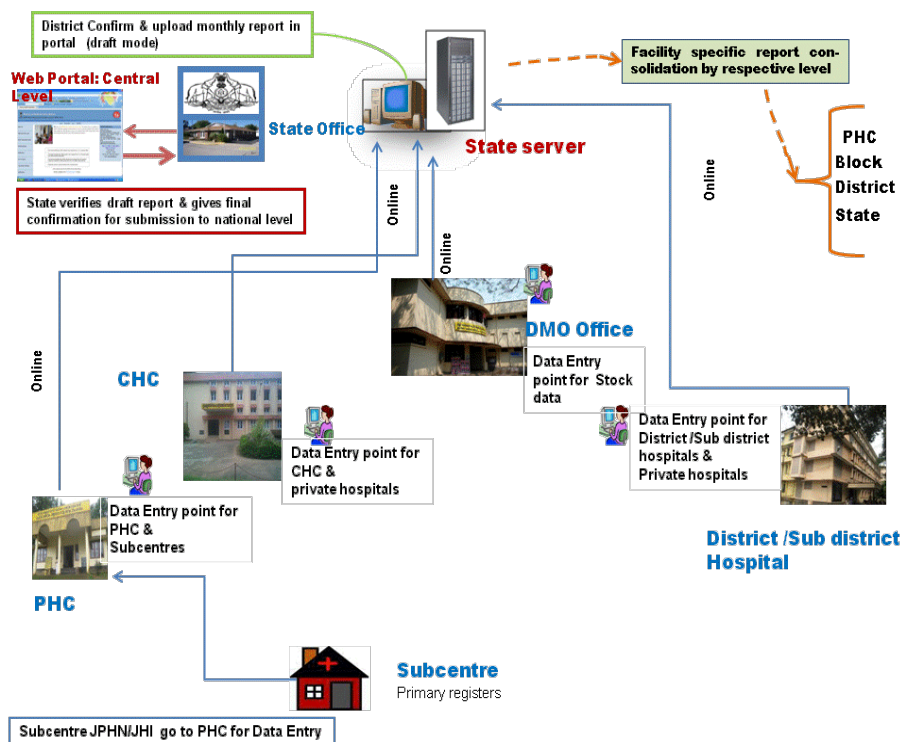


Figure 6-30: Complete online deployment model

As internet became more available to the peripheral institutions, the deployment model was also changed. The state HMIS application was configured with all the health facilities and their hierarchy with respective username and access for each user from each facility. Through this, the health staff at the peripheral institutions could access the online application via internet, enter their routine data, and generate their reports. Gradually, through the support of the HISP coordinators, the health staff would be able to carry out local level data quality analysis and the analysis of graphs of their local performance.

Social capital was developed through the strong inter-personal relationships enabled through participatory mechanisms such as

workshops, which helped support processes also relevant for the future. For example, a faculty member of the public health institution where the DHIS2 workshop was first hosted helped to anchor HISP India to the local context, and build understanding of local knowledge. His public health expertise was called upon several times by HISP to understand local or public health issues. Further, as HISP team members often went to this institution for giving lectures, the ideas around metis and local knowledge were also circulated to the students, who would hopefully use them to expand the participatory networks in future. Participation of health workers and field users were elicited in different kinds of settings. It was done with the aim to make the mode of user participation extend beyond its instrumental role of creating efficiencies and making system improvements to a more constitutive role. By doing so the health workers would start taking ownership of the system, and use their capacity towards ends that would be valuable to them as individuals.

While there were various ongoing and physical means of developing participatory mechanisms such as workshops, training programmes, meetings and demonstrations, and informal relations with users, technology was also used as a key means to foster these networks. The use of web sites, online resources, email and chats helped to develop the crucial role of social capital, as a means to both draw upon local support and to provide a way to spread local understandings. The DHIS2, which had by then developed a large community of users, served as a boundary object by which social capital development and its transmission could take place.

The network was made robust by strong political support received

by both the state level administrators, who had a very keen understanding of public issues, and also the Minister of Health who held a strong sense of pride for Kerala to maintain their primary status in the country with respect to Public Health indicators. A combination therefore of various processes and structural conditions contributed to the growth of a vibrant participatory network, which strongly contributed to Kerala being ranked number one in the country on “readiness to use information for action” in a national workshop in 2009.

In the table below, the nature of the participatory network is summarized for Kerala including the key actors and their role in the network.

Structure	Key actors	Role in participatory network
State: Kerala		
Participatory Network “Multi-level and decentralized”	Female health workers called JPHN	Creators and users of local knowledge
	Public health educational institution	Strengthening of public health knowledge
	HISP India	Implementation and systems development intermediaries
	National Health Systems Resource Centre	Providers of national legitimacy to HISP India
	State policy makers	Support for open source software
	Oslo DHIS2 group	Translating local knowledge into systems solutions
	DHIS2	

	Software solution inscribing local knowledge
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Table 6-15: Participatory networks, its key actor and their role in the network

6.2.2 Participatory Networks in Tamil Nadu

In contrast to Kerala, HISP India had an indirect involvement in the state of Tamil Nadu, as an operational level support partner of NHSRC towards providing technical support to the states. This was through the framework of a national level MOU of HISP India with NHSRC. Since NHSRC was mandated by the MOH to provide technical support to the states, HISP as their technical partner was called upon by the state to operationalize this support. According to this, the HISP team would go to different states, including Tamil Nadu, for 2-3 day visits, to carry out focused training programs at the state level, which district members would attend. As far as the design is concerned, this network was *single level and centralized*. Further, not being continuous and without physical presence at all times, the relationships of the HISP team with the state teams were different, and there were next to no linkages of the HISP team with the local level field staff in Tamil Nadu, which in contrast, in Kerala was the foundation for the entire network. While in Tamil Nadu, interventions towards local knowledge could only be carried out at the state level; in Kerala these took place in context, in the site of use also.

Tamil Nadu, a progressive state with respect to IT, perceived itself as rather self-reliant with respect to technology capacity, and therefore felt a state level focus was sufficient. Their long history of IT projects in the health sector also made the creation of a broad based focus difficult. This was because various initiatives had

already taken root in the state and created their own local and competing networks. They were not so open to allow the introduction of what they saw as competing systems and networks. Further, there existed a strong cadre of statisticians in the state, who showed a deep sense of ownership of their respective systems and data geared towards central reporting rather than on feedback and local action. A state level official told me jokingly: “in this state, we have too many statisticians and computers, so change is complicated.” Strong institutional and technical legacies were experienced empirically, making it difficult to collaborate with or even dislodge.

As a part of this technical support to the states, an important mandate was first towards orientation of the national HMIS reform and its operational requirements for implementation to the state level teams. During the initial visit to the state, it was noticed that the Tamil Nadu state had multiple ICT solutions from different vendors. These included:

- **PHC Online System:** This was a web based system built by Tata Consultancy Services (TCS), a leading software vendor in the country, using Microsoft ASP.net and MySQL (Structured Query Language) as the backend platform. This system was designed to collect aggregated area service data from all the PHCs in the state. While the PHC online system provided simple user screens for data entry, replicating all the paper forms, it did not offer the end user with the flexibility of adding, deleting or modifying data elements. The system was primarily designed towards automating the existing reporting system and did not provide functionalities towards the creation and generation of indicators for data analysis. Further, the system was

limited on interoperability, and was not capable of generating and uploading the reports on a national level into the national web portal.

- ***Institutional Service Monitoring Report:*** This system was developed in association with DANIDA using an Optical Marker Reader (OMR) Sheet for data collection in 1999, but was still running in 2008 even though the PHC Online system was in development. Monthly PHC performance data like outpatient, inpatient, deliveries, staff strength, lab services, drug budgets, vehicle usage, family planning performance, minor surgeries details, were collected from all the PHCs using the OMR (Optical Marker Reader) sheet, which was then transmitted to the state level through the district. At the state level, these sheets were scanned by an OMR reader machine and the output tables were generated, to be analyzed and stored at the state level. Because the design was hardcoded to the sheets, this system was also capable of providing the national level reports, or carrying out indicator wise analysis.

- ***Pregnancy and Infant Cohort Monitoring System:*** This system was designed to track individual beneficiaries (pregnant women and infants enrolled for the antenatal and immunization programmes respectively) through their health program life cycle. This was a web-based system designed to help the field nurses (called ANMs) in providing their outreach activities. Like other programs, this system was also rigid, centrally controlled and relied on the developer or programmer's intervention to make any

changes. This name-based system was not integrated with the facility system, and thus functioned as a standalone to the other systems; even through nearly 60 per cent of the name based data was required for the national facility reports. Further, it was also limited in providing analysis and feedback reports to the ANMs, whose functions the system was primarily expected to support.

The table below summarizes some of the web based software being used at the PHC level.

WEB-BASED SOFTWARES – PHC LEVEL ENTRY					
SN	WEB-ID	ENTRY LEVEL	PERIODICITY	CONTENTS	SOURCES
1	intra.tn.nic.in/dph/phc	PHC	MONTHLY	OP MORBIDITY, PHC DELIVERY, INFANT DEATH, BLOOD DONATION CAMPS, PHC PERFORMANCES WITH SPECIFIC REFERENCE TO RCH SERVICES Etc.	INSTITUTIONAL & AREA INFORMATION
2	intra.tn.nic.in/dph/pcm	PHC	EVERY TUESDAYS & WEDNESDAYS	MCH - MCR & CCR DETAILS	
3	intra.tn.nic.in/rch	PHC	AFTER COMPLETION OF EVERY MMU CAMP	MMU CAMP DETAILS	
4	nvbdcp-mis.gov.in	PHC	MONTHLY	MALARIA INFORMATION	
5	intra.tn.nic.in/dph/edis	PHC	DAILY	FEVER SURVEILLANCE	
6	intra.tn.nic.in/dph	DDHS	MONTHLY	IMMUNIZATION, DELIVERY & PPI & AFP DETAILS	
7	intra.tn.nic.in/dph/vkt	DDHS OFFICE/PHC	AFTER COMPLETION OF EVERY CAMP	VKT CAMP DETAILS	CAMP ATTENDANCE & MORBIDITY
8	intra.tn.nic.in/dph/rmbs	DDHS OFFICE		MLR & JSY DETAILS - CASEWISE DETAILS TO BE ENTERED	

Table 6-16: Web based software at PHC level in Tamil Nadu
(Source: www.indiahealthtast.org)

Despite the existence of these multiple systems in the state, obtaining an overall view of the health delivery status was difficult, since these systems were each standalone, controlled by different groups and ran on different platforms. While the national HMIS reforms announced in 2008 required all the states to upload their monthly district wise performance onto a national online web-portal, the various systems were unable to provide this required report. Towards national compliance, then at the district level the staff had to enter the district level data manually into the portal. The existing systems, based on their institutional and technical legacies, continued to live and support their limited constituencies primarily towards statistical reporting. A study made by the HISP India team, found that even by combining all the data from the different systems, there was nearly 10 per cent of the data missing that was required to generate reports for the national level.

The head of the health department of the state was a visionary and extremely committed to strengthening public health related analysis in the state. Her actions were constrained by the institutional and technical legacies that she inherited as the head, .but slowly tried to negotiate with her different state level constituencies for an incremental strategy for integration. She had seen the demonstrations and presentations of the DHIS2 software, and saw its potential as an integration tool through the software features of flexibility, end user control, open source, data analysis and representation including GIS. After multiple meetings, workshops with the state and district staff, she aimed towards the rationalization of the various systems and data collection forms, a process going on for nearly two years. She took the decision to use DHIS2 as an “integration and analysis” tool.

The integration model was that the PHC online system would be used to collect the facility level data, and this would be exported into the DHIS2 using XML data standards, and the DHIS2 would perform three key functions:

1. Serve as the district repository of data;
2. Generate the national level reports, and upload those into the national web portal;
3. Serve as the tool for carrying out district level analysis, and to provide feedback reports to the peripheral level institutions.

Simultaneously, it was agreed that the ISMR (Institutional Service Monitoring Report) system would be discontinued, and the Pregnancy Cohort Monitoring System would continue, potentially to be integrated in the future. Following this decision, the HISP India team, along with state representatives worked with the TCS technical team to create a software bridge which enabled data transfer from the TCS system to DHIS2. With the help of this software bridge, all the routine data for the year 2010 was transferred from the PHC online system to DHIS2. In addition, data entry screens covering the remaining 10 per cent of data elements required for the national reports, but not currently included in the PHC system, were created in the DHIS2 to enable direct data entry. This integration strategy has now enabled fulfilling of the national reports.

To support her decision, the state head also took a decision of creating a team of five master trainers at the state level to enable the DHIS2 implementation. This team was first sent for a -ten days workshop in Delhi on DHIS2 customization, so that they could learn the required skills to be state administrators of the system, to also support capacity building processes in the state and to build up the

cadre of district level master trainers. Following this training, the HISP team came to the state and carried out a series of training workshops along with the team of five, in which the new integration bridge was demonstrated and made operational. Further plans have been made on how the scaling process of creating master trainers is pending approval.

The participatory network as it stands today, is centralized to the state, but has the potential to be extended to the rest of the state. The strength of this model is that the state has a strong and competent team to drive the process, but potentially it will be a long time till the peripheral level staff is reached. The process of analysis is currently restricted to the district level, which is another disadvantage, and the PHC online system has only a primary focus on sending data up, with very limited local analysis facilities. But some of these limitations would be partially met as the district level analysis process takes firm root and the process of feedback to the peripheral institutions gets institutionalized. A further step towards strengthening local action would be the integration of the Pregnancy Cohort Monitoring System with the facility based system, and also incorporating it with greater functionalities for analysis oriented towards the ANMs. This would further require institutional negotiations and the creation of technological solutions like the software bridge.

In the table below, the participatory networks in the state of Tamil Nadu is summarized.

Structure	Key actors	Role in participatory network
State: Tamil Nadu		
Participatory	State Department of	Policy making body, for

Network “Single-level and centralized”	Health & Family Welfare	decisions relating to training.
	HISP India	Technical support on DHIS2, building bridge to integrate different systems.
	National Health Systems Resource Centre	MOU with HISP enabled provision of technical support to the state
	DHIS2	Tool for integration and data analysis

Table 6-4: Participatory networks, its key actor and their role in the network

With respect to structure, in the two states studied – Kerala and Tamil Nadu – the aim was to create a structure of “master trainers” internally in the state. However the processes followed were quite different along with the structures of the participatory networks in the state. The aim of the master trainers was to take responsibility for the HMIS function, and to gradually take charge of the support role that HISP was playing to a certain extent. After having discussed in detail the initial design and scaling processes and structure of the participatory networks in the two states, a summary table is provided to enable a comparative analysis.

<i>Mechanisms of scaling</i>	<i>Implications on Systems development</i>	<i>Status of the network</i>
<i>State: Kerala</i>		
HISP India facilitators at district level serving as “intermediaries” to facilitate the participatory networks	Data sets designed reflecting state needs as well as national compliance reports Strong focus on	A robust participatory network exists, but requires continued nurturing to achieve

<p>The focus on JPHNs at facility level, provides internal and local dynamism to the scaling process</p> <p>Important role of public health institution in providing a public health based anchoring in the state</p>	<p>creating local level functionalities for data quality analysis reporting, and data locking</p> <p>Heavy server load because of state wide online use, necessitates making optimizations and improvements in the system for server performance</p>	<p>irreversible level of maturity</p>
State: Tamil Nadu		
<p>Designed with focus on state level master trainers</p> <p>Key role of state head in defining the overall vision of the state architecture of the system</p> <p>DHIS2, a key factor in scaling, through features of being able to integrate, and strong analysis features</p>	<p>Intensive workshops conducted to understand system requirements – an extremely complex undertaking given deep rooted and multiple systems</p> <p>System development focused on creation of integration bridge, and filling gaps of existing system with national requirements</p>	<p>A potential has been created in the participatory network to scale to district and sub-district levels. However, not as broad based as Kerala, since its limited to master trainers, and not all state users</p>

Table 6-17: A comparative analysis of scaling of the participatory network

6.3 UNDERSTANDING PARTICIPATORY NETWORKS

The case examples from Kerala and Tamil Nadu help to emphasize the following aspects of participatory networks.

1. **Building of participatory networks:** The process of building participatory networks is partly a function of

design, but often shaped by situational exigencies. The initial set up matters, as it helps to shape future trajectories. While Kerala had a broader based set up than Tamil Nadu, the trajectories of network growth were also more pervasive. Mediators, like HISP India, play a crucial role in the building of the network, but their agency is shaped by what opportunities the context provides.

2. **Context sensitivity:** The context is extremely important in shaping both the initial set up of the participatory network, and also its growth. For example, in Kerala the history of the Left rule and stronger culture of decentralization and participation helped to set up a network that was broad based, decentralized and pervasive. While in Tamil Nadu, with the strong legacy of technical systems which needed rationalization at the state level, the focus of the networks too remained central and largely on technology. In contrast, public health knowledge gained emphasis in Kerala.
3. **Focusing on outputs and not only on participatory methodologies:** While the prototyping methodology was used extensively, it was not isolated from what was trying to be achieved – which was to create a robust state wide HIS. The techniques were thus tied up with the outputs, and the nature of outputs shaped how the techniques were used. If integration was a goal to achieve (as in Tamil Nadu) the prototype bridge created would help the users to understand how it can be done and seek improvements. The end, and how it can be integrated into the context of use, was the important aspect of the participatory process followed.

4. **Inculcating a judicious mix of both behavioural and structural aspects of participation:** Enrolling various actors in the participatory network required work both on the structural and behavioural dimensions. Without the structure of a network in place, actors cannot link with each other, share experiences and ideas. The structure of the network in Kerala allowed us to reach out to the peripheral workers, but in Tamil Nadu the network limit to the state level meant, field staff could not be enrolled. The primary behavioural focus was on building awareness on the notion of “information for local action” and through the action based engagement to try and show how this works in practice. Building such an orientation and acceptance of it, is necessarily a long term task, as there are legacies of “upward reporting systems” inscribed in the institutional culture. But with the structural aspects of the networks in place, this process of behavioural change can be cultivated gradually.

The discussions help to illustrate that the different efforts towards design, development and implementation of HIS were directed towards facilitating the eventual translation of data into information. This translation is neither a simple linear “requirement input-application design – application adoption / use” activity as envisioned by most technocratic approaches, nor a tool providing “data on click of a button” as it usually relates to supporting the expectations at the user end. This makes it a complex, often chaotic process involving the interplay of stakeholder perceptions, understanding, agendas, contextual conditions, initiatives and pro-activeness that shapes what requirements are a priority, how they are ‘designed’

into the application and how the outcome of these development efforts will be eventually utilised. This interplay is further compounded by the fact that stakeholders' understanding and response to the HIS initiative is embedded in their respective knowledge domains, i.e. representing the know-how of how to do things the 'right way' or understanding gained through experience and further enhanced and distributed in the process of appropriation and use. These expectations are hopefully effectively supported by the computer based systems.

I illustrate these issues of expectations and context with an example in which HISP India was involved with. In Kerala there was an on-going initiative through a central government agency in 2005, responsible for the development of the first supercomputer in the country, manned by computer scientists. Their approach to HMIS design was very technocratic, a function of their background and expertise. Their resulting system did not provide the possibility of generating any indicators, and allowed processing of raw numbers only in the form of lists and tables. Further, the web-based deployment that they envisaged was relatively non-feasible as the available infrastructure in the state (no connectivity at the facility level) at that time did not support it, and so this agency wanted data entry to be limited to the district level where internet was accessible.

Their approach contrasted sharply with the HISP India model of development in one district, which relied on a bottom-up method that sought to empower the field nurses to take ownership of the data and systems. HISP adopted a model of offline deployment of the systems which allowed data entry, processing to take place at the facility level, and the data to be synchronized with the district data-

base through a manual process of import-export. At the time when HISP systems were evaluated against the system of this computer agency, HISP could demonstrate facility wise results which at that time the agency was saying facility wise processing was not possible. The superiority of the HISP systems, coupled with the political environment in the state that favoured decentralized governance and free software, encouraged the state to ask HISP to implement the systems state wide in different phases. The above example shows how different forms of knowledge paradigms get inscribed into the system, and also shapes the practices towards participation and implementation. These local level participatory processes are shaped by broader cultural-political environments, which provide the enabling (or constraining) conditions for scaling. Therefore central to design, development, implementation activities is the challenge of bringing together the stakeholders, and doing so strategically to the advantage of the eventual translation of data into information. This fundamentally involves the development of participatory networks.

Broad based stakeholder involvement in 'participatory networks' serves two broad purposes:

- i. **Instrumental** in promoting the initiative in form, is sharing and building the purpose and vision of the HIS initiative and in the process influencing stakeholders in the network. For example in Kerala, the bottom up vision of HISP was reinforced when they could show, during the evaluation, the facility wise reports, while in Tamil Nadu the integration vision was promoted through bridge software.
- ii. **Constitutive** by way of endorsing certain knowledge, practices, structures and use, which in the long run contributes

to shaping the knowledge domain of the concerned stakeholders. It also ensures the translation of data into knowledge for purposes of making public health improvements. For example, in Kerala the bottom up approach of creating and supporting local knowledge was inscribed in the strategy of field nurses, who were not only taught about how to use the software but also about the meaning of the data elements, how they are converted to indicators, and how data quality could be strengthened locally.

Further, I empirically emphasized that focusing on the building of participatory networks demands attention to the context (for example, the political will in Kerala and the Head of department vision in Tamil Nadu), the outputs (DHIS2, integrated formats, indicators use etc.), requiring both structural and behavioural changes. While the concept of participatory networks touches upon the issue of how local knowledge can be understood, shared, and inscribed into systems design, the concept of metis focuses specifically on the nature of local knowledge.

The nature of metis is elaborated through contrasting two alternative models of information flow. One represents a "cylinder" where all the data collected at the local level flows to the top, and the other represents a "hierarchy" where detailed data is retained below, and increasingly more aggregated data is sent to the levels above. These two different models represent varying knowledge paradigms, one based on statistics and the other on public health. These different paradigms have specific implications on the design of what data gets collected, how it flows up, the processes around data quality, and the emphasis on converting this data to actionable information in the form of indicators. A practical example of

how metis is applied is through outlier analysis conducted by the M&E division, and how the statistical and public health domains approach the same issue in a different manner. This helps to understand how knowledge is bound up in practices, and gets linked also with specific technologies of knowledge production, such as statistical methods and software used.

Along with participatory networks, the concept of social capital helps to understand how local knowledge is developed and circulates. Based on the roles and responsibilities of being a business analyst in the HISP initiative that formed the empirical basis of the thesis, and the first hand experiences of the strategies that contribute positively to the advantage of the HIS initiative, the concept of social capital is highlighted. Social capital is the *“network ties of goodwill, mutual support, shared languages, shared norms, social trust, and a sense of mutual obligation that people can derive value from.....the value derived from being a member of a society or community. By being a member, people have access to resources that are not available for non-members”*. This capital, though often coloured by informal vested interests, can be built by presenting the value a stakeholder can get, in relation to their respective (formal) agendas and goals. By drawing upon social capital to address local problems, local knowledge is both generated and transmitted. There is an intricate relation between technology and social capital, which also provides a means of transmitting knowledge through mediums such as emails and websites.

6.4 RELATING THE CONCEPT OF METIS AND PARTICIPATORY NETWORK TO EXISTING IS LITERATURE

The concept of metis has been introduced by Scott (1988) in the

domain of political science and is not been used in IS or HIS research. In Scott's "Seeing like a State" he describes how large scale state initiatives seek to render complex social phenomena legible and simplify them through simplistic standardization techniques such as the creation of an identification number or a cadastral map. In HIS, we see parallels to these situations where the State is trying to standardize complex social dynamic practices around for example pregnancy and child immunization through tracking systems. Thus a contribution of this thesis is identified as applying this concept of metis once developed in political science to the domain of HIS. Arguably, such a concept will have application and use in the study of ISs in general and HIS in other contexts, particularly in the public sector, where state schemes endorsing centralization, control and standardization are challenged by local knowledge.

In the IS literature there have been other concepts that have been articulated which focus on understanding micro level social dynamics such as improvisation and bricolage (Ciborra 1994, 2002). The word Bricolage is derived from the Latin word *bricola* which means tinkering through the combination of resources at hand (ibid) and these resources become the tools and they define *situ* the heuristic to solve the problem. Ciborra writes:

"bricolage is about leveraging the world as defined by the situation. With bricolage, the practices and the situations disclose new uses and applications of the technology..." (Ciborra 2002, p. 49).

The concept of metis is similar to that of bricolage but with a distinct difference with respect to its focus on the practical benefit

it provides, “...*what matters is local use and value.*” (ibid, p.323). While the concept of bricolage, people apply known tools and routines at hand to solve problems, the concept of metis highlights the practical value /benefit of applying local knowledge. There is further a greater emphasis on existing knowledge and skills, and not just on opportunistic behaviour. My thesis has helped to elaborate in more concrete terms what constitutes local knowledge with respect to public health and technology situated within a particular implementation context and use, and how this can be supported through effectively designed systems. Further, metis has helped to focus attention on the constitutive aspects of participatory networks, and how these need to be scaled to contribute to system development.

The notion of participatory network as articulated in this thesis is derived from two concepts that are pre-existing in IS research. The first concerns participatory design, and my work is specifically inspired by the strand of research within the Scandinavian tradition that emphasizes user empowerment and workplace democracy. The other concept the participatory network is derived from concerns Networks of Action articulated by Braa et al (2004) within the research domain of HIS in developing countries. Participatory Design primarily focuses on the process of understanding user needs and knowledge that feed into system development processes. In the same vein, I have used the concept towards understanding the linkage between knowledge domains of public health and technology situated with in an implementation and use context with processes of system design and development. The Network of Action approach specifically deals with the issue of how HIS can be scaled more effectively and made more sustainable. In my thesis, by combining these two concepts in the notion of

Participatory Network, I have tried to develop both sound participatory design methods which while being locally relevant can also be scaled over entire health systems. This concept was first articulated by Puri et al (2009) in the context of our empirical experience in Kerala. During the course of this thesis, arguably this concept was further enriched, by bringing in other concepts such as social capital as important mechanisms of scaling participatory design processes.

Chapter 7 : Contributions

In this chapter, the theoretical and practical contributions arising from this thesis are summarized. Four key contributions are formulated:

7.1 SYSTEMS DEVELOPMENT: FOCUSING ON NURTURING OF METIS

The theoretical discussions presented in the previous chapter focused on understanding the relationship between local knowledge, or metis, with systems development as being enabled through processes of participatory design and participatory networks. This perspective helps to focus on how system design and development needs to focus on the nurturing of metis, rather than its suppression, which is often the case with monolithic and centralized systems focused on upward reporting.

The basic assumption around metis is that the public health practitioners are experts in their own field. They have an in-depth understanding of both the health situation and the kind of interventions that may work in practical field situations, because of their experience and local contextual knowledge. Further, the assumption made is that this in-depth knowledge needs to be provided with an appropriate and well-designed information support system which complements their metis. Through this thesis, an approach is developed towards systems design and development, which is focused on enabling the use of information for local action rather than the means itself, that is, technology being seen as an end itself. This is an approach focused on supporting information conversion into local action and motivating

the user. One way towards motivating the user is through consciously incorporating routine feedback which focuses on encouraging user's engagement in data collection and transmission. This approach towards focusing on local action is in contrast to traditional systems development approaches such as systems development lifecycle method (Sommerville, 2001), where requirements are frozen based on existing work routines of users. The proposed approach therefore tries to shift systems development from a primary automation focus to one which focuses on information needs for action.

Another approach, towards the nurturing of metis, is reflected in the adoption of the pyramid structure representing the "hierarchy of information needs" (Braa and Hedberg, 2002) flow in the design of the HIS. This structure is based on the principle that not all information is needed or relevant at all levels of the health administrative hierarchy, and only data required for decision making for a particular concern should be reported. This approach also provides health users at different levels to add locally relevant data elements, while simultaneously adhering to the mandatory requirements of the level above. In order to support such a hierarchical information flow, the thesis contributes to a clearer articulation of the following system design principles:

- Shifting the focus from data forms to data sets (representing a logical grouping of data).
- Moving disaggregated data elements such as age, sex, caste break ups, etc. to surveys where there were not significant variations in data across months. This helps to reduce the load on the data provider of providing similar data every month and also improve the quality of data.

- Designing for reciprocity between the provider and recipient of a report. Operationally, it would mean all reports going up should have a corresponding feedback report. This contributes to strengthening accountability of both the provider and recipient of data, and also to support processes of learning through feedback. Obtaining feedback can serve as a source of empowerment for the data provider, who sees her report having more substantive purposes other than just surveillance and control.
- Shifting the focus from data element to indicators, thus moving from raw data to information, which provides a basis for action. This therefore contributes to make HIS action led and not data led. The adoption in the Indian HMIS reform process of the principle of “each data element should contribute to the generation of at least one indicator,” first articulated in South Africa, also provides a vivid example of how scaling is about principles of design, rather than of boxes and technical artifacts (Braa and Sahay 2011).

A complimentary approach of supporting the pyramid structure flow was the adoption of flexible, free and open source software, DHIS2. DHIS2 by design has implemented the hierarchical structure in its data model, thus allowing the user to practically see the hierarchical principle work in practice. Another guiding principle of DHIS2 is enabling integration of information flows through a data warehouse approach, rather than re-inventing the wheel of creating multiple systems with inbuilt redundancies. Integration of

information from different sources allows for reducing work load of the health staff in collecting the same data in multiple forms, in addition to supporting effective decision making. Through the action component of the thesis, the practical value of adopting DHIS2 and supporting the integration needs of a rapidly changing health department has been demonstrated in the field.

Further, the principle of “satisfying” rather than “optimizing” was articulated with respect to existing data. The basic principle is to “learn to live” with the limits of historical inefficiencies of the existing data. The idea is to see what data is available, how it can be used, and adopt the principle that quality of data will improve only with its use. If we try to design a perfect system from the start, where we get all data in a perfect state before it is used, this cycle of using existing data will never start leading to the status quo. This is “because data quality is poor, it is not used, which continues the vicious cycle of it not being used.” For example, if the HMIS is collecting 1,000 to 1,500 data elements monthly, and out of which only 15 to 20 per cent are “essentially” required for program management, then the focus could be limited to improve the quality and use of this essential data, rather than the entire data set. Waiting for that, maybe optimal, but it will not suffice to improving concrete and possible action.

Several key system design and development principles can be summarized from this thesis:

- i) Emphasizing the focus of HIS design and development towards use of information for local action rather than on the technology itself.

- ii) Seeking to motivate the end user towards data, by incorporating constructive routine feedback mechanisms in the application.
- iii) Redesigning the information flow towards the adoption of pyramid structural flow.
- iv) Enabling the use of flexible, free and open source system where technology is not seen as single one time event, but as a means to adapt to ongoing and continuous changes.
- v) Articulating the principle of satisfying rather than optimizing to help break the cycle of non-use of data, leading to continued poor quality.

7.2 PARTICIPATORY NETWORKS: PROCESS AND STRUCTURE

The two states discussed in the previous chapter describe different starting points and strategies for evolving them. While in Kerala, there was a focus on a decentralized approach right from the start, in Tamil Nadu the approach was primarily on the state capital. Again while in Kerala, the network was primarily constituted around principles strengthening public health practices, in Tamil Nadu the constituent knowledge was primarily technical, focusing on integration. The structure and the process were important elements in how the network was formed and the manner in which it evolved.

In the case of both the participatory networks, a key mechanism adopted for its building and strengthening was in the creation of “master trainers.” Considering the geographical extent of India, and the need for reaching the peripheral level which is the foundation of the HMIS, it is next to impossible for a single agency

to reach out to the full scale. An approach typically followed in the Indian public health system for such training efforts is through the creation of “master trainers.” These master trainers are actually from the system, based at the state, district or block levels who are then imparted specialized and continuous skill building interventions from the external agency, so that they can train others. By being part of the system and based in site, the possibility of scaling efforts is much more feasible, and helps towards building stronger internal capacities in the state.

The approaches to creating the master trainers in the two states, as a strategy for growing the participatory networks were different. In Kerala, the HISP India coordinators by virtue of being based in the district, even though not being internal to the state, served the role of master trainers. The idea being that gradually they would build capacities of a core group of district and sub district users, and so that they could take on the role of master trainers when the HISP India trainers would be withdrawn two years after the initiation of the project. The risk with this approach is that the state staff because they feel comfortable with the external trainers do not take on the responsibility upon themselves to play the role. Thus there is a challenge of ownership and sustainability which needs to be addressed. In Tamil Nadu, the strategy was of creating a strong core group of internal state master trainers, who initially supported by HISP, could impart training to their state teams, but would gradually assume independent responsibility. The risk here is of very slow speed of scaling, especially, given the fact that they also have other responsibilities in the system, not just being master trainers.

Even in the other states where HISP India worked, the approach

was to first identify the state level master trainers, and specific training was imparted to them so that they could be the backbone of the state level team. For example, their training content included skills to carry out DHIS2 customization and how they could create users, manage servers and various other tasks. The HISP team together with the state master trainers helped to identify and build capacity of the district level master trainer teams. Further, they were also taught skills on how to create similar teams at the sub-district levels. In this way, a cascading approach to capacity building was operationalized and master trainer teams were created at different levels. The development and implementing of this cascading approach is a key contribution of this thesis, with respect to capacity building, and the strengthening of participatory networks. The success of this approach varied across states, and was largely influenced by the institutional approach of whether the states could designate dedicated master trainers, and include this responsibility as a part of the formal job description. This was often not possible due to reasons of bureaucracy. A more general inference that can be made from this discussion is that creating master trainers as resource people, who can grow the participatory network by circulating in their local spaces, is an effective approach. However, for making it work, there must be an institutional will in place, and associated formalization of roles and responsibilities.

With respect to the constitutive component of the participatory networks – metis – the thesis has helped to identify concretely the nature of local knowledge – technology and public health related – that is relevant to supporting the use of information for local action. This is summarized in the table below.

<i>Knowledge Domain</i>	<i>Content of training program</i>
Technical domain	<ul style="list-style-type: none"> ✓ Capacity on local customization ✓ Capacity on using data analysis tools such as DMS and pivot tables. ✓ Capacity to do basic troubleshooting of technical problems such as allocating access roles to respective users ✓ Capacity to use visualization tools such as GIS
Public health domain	<ul style="list-style-type: none"> ✓ Capacity to understand data elements and indicators, including their definition, correlation and significance in use. ✓ Capacity around understanding data element behavior with respect to other related data elements. ✓ Building capacity around interpretation of data and its use in local planning ✓ Capacity to define locally relevant indicators and validation rules
Context of Implementation	<ul style="list-style-type: none"> ✓ Establishing procedures around the data flow and verification ✓ Understanding the work practices around different types of health facilities towards data collection and information process

Table 7-18: Content of training program categorized by knowledge domain and context of implementation

With respect to design of the training content, the first version of the training approach was developed through the HISP action efforts, in collaboration with NHSRC which was encapsulated in five manuals that were packaged together in a HMIS Tool Kit. This included:

1. **Data Dictionary** – describing meaning, definition and use of data elements, and also including a comprehensive list of data sets in the national HMIS. Basic principles of data, such as the difference between data recording and data reporting were articulated in this dictionary.

2. **Indicator Dictionary** – describing indicator definitions and how they should be used. The dictionary described key indicators identified for different levels (from national to facility) of the health system. The indicators were mapped back to the data elements required, thus helping to operationalize the principle of each data element contributing to the generation of at least one indicator.
3. **Basics of computers** – a user manual. Since many of the health users had not worked with a computer before, this manual provided basic guidelines on computer use, including describing the different parts of the computer such as keyboard, mouse, and also basic operations such as turning on and off the computer.
4. **Using DHIS2** – training manual which provides a user guide on the software. A CD with the source code of the DHIS2 was provided to the states along with an installation manual. Obtaining the source code helped the users to feel empowered with ownership of the application, something which they had not experienced before.
5. **Using information for local action** – training manual which describes basic concepts (such as the information cycle) on how to move from data to action. This manual was based on the concept of “information cycle” and described the role of the software in supporting each step of the cycle – data collection, cleaning, analysis, visualization and action.

Through the offices of NHSRC, this tool kit comprising of the above pieces was printed and disseminated to the states. This tool kit then became an effective mechanism in growing the participatory

network by being used in training programmes, both as a template for content, and through the training, to see how it can be further enhanced in new versions to better reflect emerging training needs. The knowledge content now identified through this thesis will further contribute to its upgrading and increased relevance in supporting use. Further, NHSRC is also engaged in the translation of these manuals to some of the local languages (such as Hindi) to strengthen its relevance to the field user in different Hindi speaking states. Since the design, development and implementation of a HIS require multiple skills and knowledge domains, it is important that the various components are identified and packaged together in one place. This then becomes an important “boundary object” that can help to enroll and support diverse actors in the network, and strengthen their skills to become active participants.

Participatory Networks:

Practically, various mechanisms were adopted for enrolling different actors such as users, developers, health managers, administrators, faculty members of public health institutions into the HIS participatory networks. For example: During the initial development of DHIS2 system, workshops were held at a local public health institution with medical doctors from health facilities of Trivandrum district in Kerala, where the first prototype of the DHIS2 was presented.

Such workshops helped in two ways.

- For the HISP team, it helped to understand the nature of local knowledge that was seen as relevant from the non-developer community. For example, the doctors expressed concerns of security – a nurse should only be able to see data from her facility. Such inputs gave insights in

understanding metis.

- Second, as the aim was to make such local knowledge more global and scalable at the same time, participatory networks provided the mechanism to do so.

Social capital was developed through strong inter-personal relationships between the members of the workshops, which also helped in the future. For example, a faculty member of the public health institution where the workshop was hosted helped to anchor HISP India to the local context, and build understanding of local knowledge. His public health expertise has been called upon several times by HISP to understand local or public health issues. Further, as HISP team members go to the institutions often for lectures, the ideas around metis and local knowledge were also circulated to the students, who would hopefully use them to expand the participatory networks. Participation of health workers and field users were elicited in different kinds of setting. It was done always with the aim to make the mode of user participation extend beyond its instrumental role of creating efficiencies and making system improvements to represent a more constitutive role, where health workers started to take ownership of the system, and used their capacity towards ends that were valuable to them as individuals.

While there were various ongoing and physical means of developing participatory mechanisms such as workshops, training programmes, meetings and demonstrations, and informal relations with users, technology was also used as a key means to foster these networks. The use of web sites, online resources, email and chats helped to develop the crucial role of social capital as a means to both draw upon local support, and to provide a way to

spread local understandings. The DHIS2, which had a large community of users, served as a boundary object to which social capital development and transmission could take place. In different contexts, DHIS2 played varying roles in scaling the participatory networks. While in Kerala, because of it being free and flexible to adopt across the state, it helped in facilitating a structure of the participatory network that was state wide, multi-level and decentralized. In contrast, to help overcome the challenge of multiple technical and institutional legacies, DHIS2 was positioned as an integration tool which could help the state to take the decision of integration. This helped to initiate the participatory network as being rather centralized to the state level, nevertheless with the potential to gradually decentralize.

In the earlier section on capacity, the structure of cascading of master trainers was described, which helped to create internally an institutional structure in the state, that could potentially enable further scaling processes. Master trainers created at every level, oriented to the principles of information for local action, provide this potential of scaling of design principles related to scaling of networks. Further, the HMIS Toolkit development and its subsequent dissemination to different states, helped to disseminate various relevant design principles that had been encapsulated in different manuals. While of course, the mere spread of materials does not guarantee that they will be read, and even less so they will be understood and acted upon, but it does represent a first and necessary step in getting a larger fold of the actors with a shared understanding of what is HIS in the participatory network.

7.3 IMPLEMENTATION: IDENTIFICATION OF CONSTRAINTS

For scaling to be effective, it is also important to identify the constraints so that strategies to overcome them can be formulated. In the table below, various constraints identified empirically through this thesis are summarized.

Impediments to the use of information for local action

<i>Knowledge domain</i>	<i>Key impediments to using information for local action.</i>	<i>Approach towards addressing impediments</i>
Technical domain	Rigid, centralized, proprietary software system	Promotion and use of flexible, free and open source software.
	Centralized statistical tools being promoted to analyze data quality through outliers techniques	Decentralized user driven approach towards improving data quality by use of min and max option and locally defined validation rules.
	Restricting of interoperability, implying local systems will be subsumed	Integration of information flows by adopting principles of a data warehouse approach.
	Focus primarily on automation of the data entry process and routine report generation and transmission.	Supporting processes of data analysis and multiple visualizations through graphs, charts and maps of locally relevant indicators
	Narrow view on capacity building, which focuses primarily on basic skills of using	Shifting focus of capacity building towards strengthening the capacity of health staff, to eventually

	computers and the HMIS application.	assume independent ownership of managing their information processing needs and to use information to support their everyday activities.
Public health domain	Mismatch between data element and its contribution towards actionable indicators. Too much data being collected	Emphasizing the principle of only those data should be collected that leads to the generation of an actionable indicator.
	Lack of standardized data definitions and guide for collection and use.	Creating data dictionary and indicator dictionaries. Policy level advocacy.
Context of Implementation	<p>“Cylindrical” structure of central reporting, where all the data collected goes up</p> <p>Lack of motivation of health worker towards data collection, transmission and use</p> <p>Duplication of data elements recorded and reported in multiple forms</p> <p>Huge work load of health staff towards data collection and reporting</p>	<p>“Pyramid” information flow where detailed data, including those locally required, will be at lower levels, and increasingly aggregated data goes up the levels, adhering to the mandatory requirement of level above.</p> <p>Institutionalized process of routine constructive feedback, based on principle of reciprocity between the provider and recipient of a report</p> <p>Shifting the focus from data forms to data set, and the creation of “essential data sets”</p>

	Moving disaggregated data element such as age, sex and caste breakups from routine data to surveys
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Table 7-19: impediment to the use of information for local action categorized by knowledge domain.

The approaches to address impediments further represent concrete actions towards strengthening processes of scaling. By taking constraints around the domain of technology, public health and implementation in conjunction, more holistic approaches towards scaling can be formulated.

Chapter 8 : Conclusions

Traditionally, HISs in developing countries have been criticized to be upward focused (reporting to the central ministry) and not effective in supporting local action and decision making. A common approach to HIS reform across various developing countries has been the implementation of ICT based HIS, which in many cases have been used to reinforce this centralized focus. Despite the potential of change carried in such technological solutions through their capabilities for storing, processing and retrieving large amount of data for various levels, these technologies have been often seen to become a tool in the hands of decision makers to further reinforce the existing culture of upward reporting and centralized control. While various researchers have pointed out this lack of local use of information, they have not shed significant light on the question of “what can be done about it?”

This thesis has explored this question of strengthening local action within the empirical context of Indian public health system. Specifically, the focus was on understanding how can the role of technology be shifted from being seen as an end in itself, to one where it is seen as a useful tool that can help generate relevant information towards strengthening local action, oriented towards improving health delivery outcomes. This shift from raw data processing into generation of relevant information and its use for local action is conceptualized as translation from data to information to knowledge. Achieving such a translation in practice is a complex task, given that different kinds of knowledge and understandings come into play. In enabling such a shift in terms of HIS, the approach of participatory networks has been identified as

a key strategy through this thesis.

Participatory networks have been described to be constituted of local knowledge – representing what is it that needs to be networked. This has been conceptualized through the notion of metis, representing practical and locally beneficial knowledge. So, a starting point of this thesis then was to understand by unpacking the different facets of knowledge involved, and how these may be interlinked to develop a more holistic approach to HIS, not only one that focused on technology. Having identified this, the next relevant question addressed was on how to develop user capacity on these dimensions. Addressing this challenge, necessarily takes us to the question of what are the mechanisms for growing participatory networks in a holistic manner, which can support the use of information for local action, and to understand what could be the role of technology in facilitating this process. A normative aim of the thesis was then to focus on local knowledge, and to understand how technological solutions could contribute to creating and nourishing local knowledge instead of suppressing it. Mechanisms of master trainers, tool kits, and other means such as workshops and hand holding support, have all played a role in this regard.

Theoretically, the thesis drew upon a set of concepts from different domains and tried to use them in the exploration, rather than drawing upon a meta theory. This approach, arguably, provides more flexibility in selecting relevant concepts for different facets of the exploration.

Two sets of key concepts were drawn upon.

- The first relates to Metis from political science, which was

used to understand different facets of local knowledge. It was based on the criteria of how it can help provide practical benefits in addressing the problem at hand – of supporting information use for local action.

- The second is relating to participatory networks drawn from the notion of networks of action and participatory design from IS literature, to help understand the relation between the use and development contexts ongoing simultaneously in multiple contexts. The concept of participatory network in conjunction with metis, helps us to understand the “what” of what needs to grow, and also the mechanisms by which this can be enabled. This then helps to further both the constitutive and instrumental roles of the participatory network. These concepts taken together have helped articulate the theoretical framework from the thesis in which the contributions could be articulated.

The contributions presented in the thesis have a strong empirical focus. The first was in specifying the details of what is meant by “local knowledge” and also the functional benefits it provides. This aspect of the contribution could be useful to designers and implementers in marking the domain of focus when designing or implementing HIS which seeks to strengthen local action. The second relates to identifying what are the practical impediments in fostering local action, and is based on insights from the empirical work, sought to be addressed. The integrative framework comprised of the concepts identified earlier, presents the overall theoretical contribution.

The practical contributions that have been developed from this thesis include the articulation of an approach to capacity building,

based on the focus on local knowledge. The facets of local knowledge articulated in the theoretical model provide an understanding of the concrete content that should be the focus of capacity building programmes. An explanation of how such an approach could be packaged and implemented, through the structure of master trainers and supported by tool kits also represents a practical contribution from the thesis with respect to processes of growing participatory networks.

A further contribution in this regard has been the approach to system design and development, based on this focus on local knowledge. What should be the content of system design efforts, and how such knowledge should be understood and inscribed into the system are important insights presented. System is more than the software, but also includes data, and attention is given to understanding how the cycle of historical mistrust of data can be broken – primarily through enhancing processes of use. More the data is used, the more the users will engage with data quality issues that provide a key vehicle for making improvements. How we can support the strengthening of participatory networks, including the level of social capital is another area of practical contribution.

Though these findings have been developed based on empirical work carried out in India, the implications derived could be relevant for other empirical settings. While the specificities of local knowledge would be different, and be the subject of empirical investigation, the general framework of multiple knowledge domains and the focus on understanding it, based on the practical benefits it provides, represents a more general framework. In this way, the theoretical framework could also have a relevance to

domains other than public health, where the application domain is different but the approach to understanding it could be the same.

Like every research, this too has its limitations. For me, a key struggle and also limitation has been in getting the balance between action and research right, which is always an issue in an action research study. In this case, the problem magnified because I had been engaged in action for nearly 5-6 years prior to enrolling in the Ph.D programme. Also during the course of the research, the action continued in sites which I had not explicitly included in my research design. As a result, the boundaries between action and research have not been easy to separate, with a clear bias towards action. There has been an intensive and ongoing engagement with the practicalities of making system improvements from design, development, and implementation in its various facets including the engagement with the politics of things. As a result, often systematic data recording and its analysis at times suffered, and addressing practical problems had primacy. However, this deep engagement in action is also the strength of the thesis, as it helped provide insights to various processes which would not have been possible otherwise.

The thesis also helps to identify some interesting and relevant areas for future research. While this present research has focused on the domain of routine health information system in a public health context, it could be further extended to understanding local knowledge in other domains such as the design, development, implementation and use of HIS in hospitals, human resources, and mobile health. These systems are part of the larger public health system, and are currently under active implementation in India. A future trend in the public health domain, an agenda being pursued

by donors and also ministries, is of creating integrated e-health architectures, constituted of multiple systems that are linked through standards of inter-operability. What we mean by local knowledge in such an integrated configuration will be qualitatively different, because of the multiplicities of technologies, actors and implementation contexts involved. Extending the framework developed in this thesis to such complex domains would be a relevant and exciting future domain of research.

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Building participatory HIS networks: A case study from Kerala, India

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ABSTRACT

This paper addresses the challenge of developing participatory networks to support the design, development and implementation of Health Information Systems (HIS) in the context of public health in Kerala, India. It is argued given the nature and complexity of HIS, there is the need to bring together our understanding of participation from two streams of development theory and IS design and development. While development theory provides interesting insights on how to enable participatory processes, they tend to not consider technology. Further, traditional participatory design in Information Systems research has its origins in Western workplaces, often quite divorced from the context of public health in developing countries. In trying to combine these two streams of learning, we propose and develop the concept of participatory networks. Drawing upon an ongoing empirical analysis of an action research effort to introduce, scale and sustain Health Information Systems in Kerala, this paper elaborates on the nature of participatory networks that come into play, and the various mechanisms and purposes of participation with the different network partners. In the discussion section, four areas of re-conceptualization of participation in the context of HIS in developing countries are identified: (1) creation of participatory networks; (2) increased context sensitivity; (3) focus on outputs of participation, not just inputs and techniques; and, (4) focus on structural aspects of participation, not just behavioral issues.

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1. Introduction

Much of the Information Systems (IS) research during the last four decades or so focusing on the deployment and use of Information and Communication Technologies (ICTs) has argued for more active participation of the concerned users in various facets of systems design, development and use (Barki & Hartwick, 1994; Baroudi, Olson, & Ives, 1986; Fitzgerald, Russo, & Stolterman, 2002; Franz & Robey, 1986; Garrity, 1994; Hunton & Beeler, 1997; Ishman, Pegels, & Sanders, 2001; Mumford & Weir, 1979). While a majority of the reported research has primarily emanated from organizational settings in the West and shaped by their societal contexts (Asaro, 2000; Kanungo, 2004; Lyytinen & Klein, 1985; Mbarika, Okoli, Byrd, & Datta, 2005), this paper examines the issue of participation in the context of public healthcare settings in Less Developed Countries (LDCs). Both the national and organizational contexts of such an application makes the issue of participation quite unique, and a challenge to operationalize in settings characterized by centralized and hierarchical design approaches (Avgerou & Walsham, 2000; Boon, 1992; Hutchinson & Toledano, 1993; Madon, 1993; Sahay & Walsham, 1997). Such developmental approaches inherently lead to “design-reality” gaps (Heeks, 2002), which impede the realization of the potential of ICTs for addressing identified aims (Avgerou & Walsham, 2000; Sahay & Avgerou, 2002).

Participation in the context of ICT projects in LDCs tend to emphasize issues of social inclusion of civil society groups and rural communities (Byrne & Sahay, 2003; Kanungo, 2004; Korpela et al., 1998; Madon, 2005). Participatory efforts seek to gain access to the wealth of relevant knowledge and experience that local communities hold and which could potentially serve as critical inputs for effective information systems (Byrne, 2005; Puri, 2007; Puri & Sahay, 2003a). However, such local knowledge and experiences tends to be elusive to understand and use, especially using traditional IS design approaches. Contributing to this are challenges in both the socio-cultural development context and the complexities inherent in the ICTs and supporting infrastructure (Braa, Monteiro, & Sahay, 2004; Heeks, 1999; Madon 2000). For understanding this complex issue and how to approach it, we argue in this paper, the need to combine both development theories concerning the nature of challenges related to community participation, and IS literature on Participatory Design (PD) (Byrne, 2005; Byrne & Sahay, 2007; Korpela et al., 1998; Madon, 2005; Puri & Sahay, 2007).

Empirically, we address this issue in the context of the design, development and use of computer-based Health Information Systems (HIS) within the context of the primary health sector in the state of Kerala located in South India. The health sector raises its own particular challenges related to participation in relation to HIS given the involvement of various donor agencies, the nature of diseases, the geographical spread of outreach services, and typically weak ICT related capacity of the health staff (Braa, Monteiro et al., 2004). Heterogeneity with respect to user types and needs, administrative levels, and uneven distribution of infrastructure and resources, raises the urgent need to examine the issue of participation not as stand-alone and organizationally confined systems, but with respect to networks involving the multiplicity of actors, technologies (and paper systems) and various institutional practices in their diverse socio-political contexts. The paper seeks to conceptually and empirically understand the notion of “participatory networks” in the context of HIS in LDCs within the framework of the ongoing Health Information Systems Program (HISP) initiative to design, develop and implement HIS in Kerala. Specifically, two research questions are addressed: conceptually, how can we understand the notion of participatory networks; and, empirically, how can these participatory networks be created within an action research framework.

The rest of this paper is organized as follows: in the next section, after providing brief overviews of literature related to participation within the two streams of research (development and IS theories), we argue for their hybridization. A brief outline of the research methods adopted is presented in Section 3, followed by the case study description in Section 4. The case analysis, focusing on the challenges and approaches to building participatory networks is presented in Section 5, followed by some brief conclusions.

2. Participation: primary healthcare and design of IS/HIS

2.1. Participation in IS development

Over time, researchers have increasingly argued that IS should be viewed as socio-technological heterogeneous networks (Walsham, Symons, & Waema, 1988), rather than as primarily technical artifacts (Lyytinen & Klein, 1985). These arguments have led to the adoption of various socio-technical design approaches (Asaro, 2000), an increased sensitivity to the social context of IS design (Avgerou, 2002), and a greater emphasis on enabling user participation (Bødker, 1996; Greenbaum & Kyng, 1991; Obermeyer, 1998).

Studies around participation in IS projects framed within the domain of PDs in the West has been largely confined to organizational settings (Gregory, 2003; livari, 2007; livari & Lyytinen, 1998), and largely inspired for three main reasons: (i) to improve the quality of systems (Asaro, 2000), (ii) to introduce democratic empowerment at the workplace (e.g. better work life quality and power sharing with workers) (Bjerknes & Bratteteig, 1995; Ehn, 1993; Floyd, Wolf-Michael, Fanny-Michaela, Schmidt, & Wolf, 1989; Kyng, 1998; Mumford, 1993), and (iii) to redress the dominance of technical and managerial control over workers by enlarging the scope of emancipation (Hirschheim & Klein, 1992; Hirschheim & Klein, 1994; Lyytinen & Klein, 1985). Such participatory approaches have flourished in the particularities of given settings of Western countries, for example in Scandinavia, enabled by the homogenous and open nature of societies, high literacy and living standards, well developed and modern infrastructure and a historically vibrant social democratic polity including a strong trade union movement (Boland, 1998; livari & Lyytinen, 1998).

In contrast to the Scandinavian countries, the participatory approach adopted in United States was not supported by a strong legal framework (Gregory, 2003; livari & Lyytinen, 1998), and represented a form of “engineering co-development” (Asaro, 2000, p. 276) with a primary focus on customer-centredness. The methodology used was to place working prototype systems at customer sites for obtaining their feedback to ‘tune’ the artifact as per the customer needs and reduce the overall product development time, improve customer satisfaction and the overall skill levels of the designers. Another popular strand of participation in the US is related to initiatives of Business Process Reengineering where various organizational tasks and business processes were analyzed to eliminate redundancies to establish a tighter, functionally related process flow (ibid., p. 273). It was claimed that the employees tend to establish a closer and more direct relationship with the re-engineered processes that they engage with. PD in the United States has extended over the years to community informatics (Carroll & Rosson, 2006), reflected in the increasing popularity of biennial PD conferences (Kensing & Blomberg, 1998).

Spinuzzi (2003) has argued that knowledge-intensive work requires participants to control the ends, not just the means of work. This requires a greater understanding of the differences in why and how workers participate, and to treat participation not as a binary of yes and no, but as a continuum involving different degrees and types. Similarly, Orr and Crowfoot (1996, p. 205) have argued to understand “what counts as knowledge, who is acknowledged as knowing... and how questions of design deal with these issues of knowledge within the organization...” These questions are linked with larger issues of structures of power and networks of working relations (Suchman, 1994). Braa, Monteiro et al. (2004, p. 342) try to address these issues through the concept of “networks of action,” which aims at “aligning heterogeneous networks of routines, technology, and learning within politically contested terrains of opposing projects and ideologies in an effort to promote sustainable, replicable changes.”

Participatory design can be seen to be necessary but not sufficient in itself to ensure the success of IS (Beck, 2002; Howcroft & Wilson, 2003), and requires contextualization such as arising from the processes of globalization (Giddens, 1991), the growth of transnational corporations and distributed business processes (Scholte, 2000). livari & Lyytinen (1998, p. 167) have argued that IS design methodologies tend to be an “offspring of their time, reflecting for example dominant research trends and theories of that time.” In the same vein, Dahlbom (2003) has argued that with the service sector becoming more dominant, “A new agenda of action research will have to be developed, new large

scale projects with trade unions and public agencies are waiting to be initiated, involving both users of information technology, and, more important, consumers as well, in a consumer oriented approach to services" (ibid., p. 105). A noticeable recent trend in the IS field, therefore, has been the re-conceptualization of IS as Information Infrastructures (Georgiadou, Puri, & Sahay, 2006), and how they subsume different technologies, networks, standards and practices to support a diversity of application areas over time and space (Hanseth, 2000). At the application level, a key characteristic of an information infrastructure is that "it is shared by a large user community across large geographical areas such that it might more appropriately be seen as an infrastructure than as a system" (Hanseth & Monteiro, 2004). Therefore, traditional PD theories and approaches need to be reformulated to reflect these changing trends and simultaneously inscribing greater context sensitivity to the methods used (Markus & Mao, 2004).

After this brief overview of the origins of PD, the different trajectories through which they have evolved in varying contexts, and some existing criticisms, we discuss PD in the context of LDCs, which is the empirical setting for this paper.

2.2. Participatory design in less developed countries

Like in the Western contexts, studies in LDCs have emphasized how the lack of a social systems approach contributes to ineffective projects (Heeks, 2002; Madon, 1993), and the need to have more effective ways to engage with the particularities of local cultures (Korpela, 1996; Ojo, 1992), including processes of participation (Braa & Hedberg, 2002; Sahay & Walsham, 1997). These processes tend to be inhibited in LDCs by rigid bureaucratic structures (Avgerou & Land, 1992). Following Lamb and Kling (2003), the notion of the user too in LDCs needs to be re-conceptualized reflecting "meaningful and productive relations between those charged with technology design and those who must live with its consequences" (Kensing & Blomberg, 1998, p. 172). A main departure in LDCs is that IS projects¹ typically target rural, often poor, communities, for example, those depending on a primary health system (Braa, 1996; Byrne, 2005; Korpela, Mursu, & Soriyan, 2002; Korpela et al., 1998). An inference of this is that the IS developer needs to consider implications of participation both from the perspective of socio-economic development and IS (in the context of primary healthcare in our case), and see how they can be meaningfully integrated. This is now discussed.

2.3. Participatory design in development theory

Development theory deals with conceptualizing the strategies involved in analyzing changes in LDCs, and their implications on policy options (Preston, 1996). In this context, researchers started investigating issues and options to improve the participation of communities in development project some 40 years ago. The acknowledgement of the failure of top-down modernization and dependency models of development (Escobar, 1995; Montgomery, 1974), which entailed limited participation of local communities, led to the rise of more intensive participatory approaches during the 1980s. Several theoretical and empirical models aimed at enhancing community participation, and drawing upon indigenous knowledge to improve the design and implementation of field programs, have since been developed and used (Chambers, 1994). While this shift towards increased focus on participation was welcome, there were also various criticisms which we summarize and discuss under the following three themes: (i) promoting participation primarily for instrumental purposes, (ii) conceptualizing community as an unproblematic monolith, and (iii) insufficient attention given to the role of power and politics.

The first criticism on *instrumentality* refers to the State and development agencies "using" people only to provide crucial inputs of knowledge about field reality not possessed by outsiders (bureaucrats, donor consultants, etc.), to try and ensure the "success" of projects (Rahnema, 1992). Such an approach marginalized the constitutive role of participation in furthering empowerment and democratization (Sen, 1999). Appropriation of the participatory paradigm into government policies and institutional practices was described as a political technology (Procacci, 1991), representing a hidden agenda to further political, bureaucratic or personal power at the cost of local people, since budgetary

control, policy formulation and other manifestations of authority remained with the state or the development agency (Escobar, 1984).

Examples of this instrumental use of participation are seen in the application of Rapid Rural Appraisal and Participatory Rural Appraisal (RRA and PRA) techniques (Chambers, 1983, 1994), popular amongst international aid agencies like the World Bank. Escobar criticized these techniques for being “strictly conceived in an utilitarian fashion while denying the political character of participation... importation of models or ideological doctrines from a different cultural and historical context is often-times a counterproductive or diversionary strategy as far as development is concerned” (1984, p. 391). These techniques were also criticized for their “tool-kit” approach more suited for a “market research role” (McGee 2002, p. 99) than a development intervention.

The second strand of criticism concerning treating the *community as a homogenous*, unproblematic entity, related to the marginalization of the poorer or weaker sections including women (Guijt & Shah, 1998; Mosse, 1994) by not giving emphasis on the existence of discrete interest groups that constitute a community. There are implicit power structures such as those of class, caste, gender that define, determine as well as circumscribe actions of various underlying divisions within communities. Participation is thus “socially determined... so public expression of community interests may disproportionately reflect the private interests of dominant group or individuals” (Mosse, 1995, p. 28). The indigenous knowledge that comes to fore in such participatory practices is deeply modulated by those invisible though vibrant power relations (Mosse, 2001). Kothari opined that “the more the ‘participatory’ the enquiry the more its outcome will mask the power structure of the community” (2001, p. 146, quoting Woodhouse, 1998), unless the existing power structures are explicitly acknowledged and addressed. For example, Escobar (1988) has argued that international development agencies, based on specific ways of knowing the world and articulating problems, manipulated intervention “design.” Similarly, Nelson and Wright (1995) demonstrated how ‘objects’ of development may be constructed:

In the course of being run through the theoretical machine of ‘development’, an impoverished labor reserve becomes a ‘traditional, subsistence, peasant society’; wage laborers become farmers; ... and a government of entrenched elites becomes an instrument for empowering the poor (Ferguson 1990, quoted in Nelson & Wright, 1995, p. 10)

These researchers have emphasized the distortions embedded in development programs through asymmetrical power relations among the ruler and the ruled, raising where who are “embedded in the development apparatus” (ibid., p. 11). Such approaches can then “perpetuate and disguise continued top-down attitudes and approaches” (ibid.). It is in this context that alternative perspectives of development posited by Sen (1999) are greatly relevant, which seek to further the constitutive component of participation, and to advance the empowerment of people themselves to define the agenda of development programs, eliminating, or at least greatly diluting, the role of outsiders.

2.4. PD in IS for primary healthcare

The Alma Ata declaration of 1978, where the principles of primary healthcare were formally established, identified community participation as the fundamental mechanism through which the strategy of “health for all by 2000” could be achieved. The architects of this strategy drew inspiration from China, Cuba, Kerala in India, to emphasize the aims of primary healthcare services to be based on the principles of social justice and equity, and not primarily on economic investments. Particular attention was paid on the experience of Chinese ‘barefoot doctors’ who were fundamentally accountable to the populations they served (Asthana, 1994). Further, it was recognized that this strategy of health for all could not be achieved by the health sector itself, but called for an inter-sectoral approach to try and address the environmental, social, and economic determinants of health status. The aim was to move from a curative focus which the historically existing colonial systems had promoted and institutionalized, to a comprehensive system where the community actively participated in defining their healthcare needs and the means through which they were to be addressed. Decentralization of planning and delivery of services enabled through active community participation was therefore a

fundamental instrument towards this end, emphasizing the need for a shift from selective to comprehensive care.

Within primary healthcare, there are multiple aims of participation ranging from economic and pragmatic concerns associated with project efficiency, relevance and cost recovery to political aims of social equity and empowerment. Arguments have been made for participation based on the view that communities understand their needs best, and further that it can also lead to greater mobilization of resources to support a resource-starved sector. Other arguments have been made that participation should not be treated as an end in itself, and that it should arise from the grassroots rather than being imposed by the bureaucracy (Oakely, 1989). This view is based on the recognition of the differences in political and economic power among different groups and classes, and participation inherently involving a struggle for the redistribution of power and resources. Mechanisms to achieve this in India are enabled through various local structures such as self help groups, community associations, and local political institutions such as the *Gram Panchayats*.² The recently established National Rural Health Mission (NRHM) in India, places community participation as a key part of its guiding principles and core strategies. For example, some of its guiding principles state: (i) decentralize and involve local bodies and (ii) recognize value of traditional knowledge base of communities. Similarly, the core strategies outlined by NRHM include: (i) increasing community ownership by vesting responsibility with *Panchayati Raj* Institutions and (ii) promoting decentralized planning from village to district level through participatory processes.

Within NRHM, and also in the Health Ministries of other developing countries, HIS is being positioned as a key component for attaining the goals of decentralization, integration and community participation (Greene, 2003; Korpela et al., 1998). However, achieving this is a non-trivial task as it involves both an understanding of the primary healthcare context, and the technology itself which can potentially serve as a tool for decentralization. For example, while computers can help in the decentralization of planning processes so as to better focus healthcare delivery to community needs, the manner in which they are designed and implemented, however, can further centralize these same processes due to strong bureaucratic controls (Nhampossa, 2006). Therefore, participation is often enabled in a top-down manner by the government apparatus rather than it emerging from grassroots as a bottom-up activity (Puri & Sahay, 2003b; Warschauer, 2003). There is thus the urgent need to develop more effective ways to engage with the particularities of local culture (Korpela, 1996; Ojo, 1992), including the structures that typically inhibit participatory processes in IS design (Baber, 2001; Braa & Hedberg, 2002; Sahay & Walsham, 1997). While there have been successful examples of participation of communities in HIS design, for example in South Africa (Byrne, 2005), efforts to create and implement similar models failed in Cuba and Tanzania due to political and organizational conditions (Braa, Titlestad, & Sæbø, 2004; Kimaro, 2006). These experiences emphasize the context specific nature of participation.

In summary, the above discussion has brought out several key points of departure relevant for ensuring participation in the context of IS/HIS projects in LDCs. Kensing and Blomberg (1998) pinpointed three main issues in participatory IS design: (i) politics of design, (ii) the nature of participation, and (iii) the methods, tools and techniques for carrying out design projects. While this analysis applies also to LDC settings, these aspects impinge differently on participatory processes due to the inherent multiplicities in respective socio-economic and political settings. Research in development studies questions the value of participation techniques (like PRA and RRA) in addressing the complex socio-historical-cultural conditions surrounding development projects (Chambers, 1994; McGee, 2002) and also in IS design and development projects (Puri & Sahay, 2007). As there are increasing attempts to implement HIS applications aimed at communities in LDCs, there is the need to re-formulate participatory approaches involving community-based ISs within development settings.

This paper is an attempt towards this reformulation of the notion of participation in the context of HIS projects in LDCs. This reformulation is approached at two levels. One, conceptually through the articulation of the concept of “participatory networks” which seeks to shift the focus of participation from a stand-alone user focused actively to one that involves heterogeneous networks with an inherently socio-political nature. Two, to empirically try to cultivate such a participatory network within the context of an action oriented HIS implementation project in the public sector in Kerala.

3. Empirical approach and methods

Qualitative methods within the interpretivist tradition (Klein & Myers, 1999; Walsham, 1993, 1995a, b) were adopted for the research reported in this paper. The approach to field data collection and its analysis is discussed after a brief description of the empirical approach.

3.1. Empirical approach

The empirical work has been carried out by a team of people of which the authors of this paper are also an integral part. The broader implementation team is structured within the framework of HISP India (referred subsequently as HISP), a not-for-profit NGO, working on various aspects of HIS design, development, implementation and use. Diversity arising from involvement of a multi-disciplinary team of individuals from different backgrounds, while helping to develop rich research insights also comes with its own challenges. Researchers carry their own intellectual baggage, for example relating to public health and informatics, leading to quite different interpretations of a particular issue. Klein and Myers (1999) advise interpretive researchers to be deeply reflective, to place themselves and the informants in a historical perspective, and acknowledge that informants are also interpreters and analyze the phenomenon during discussions. The authors of this article have had a long association with the HISP initiative, both as researchers and practical implementers of HIS in various settings in India and other countries. The action orientation of HISP approach (see Braa, Monteiro et al., 2004; Braa, Titlestad et al., 2004) often makes it not possible to take a detached view of unfolding events as neutral observers, since “technological frames of meaning” develop at the sub-conscious level (Orlikowski & Gash, 1994). While demonstrating objectivity is not an aim of interpretive research, we try to present our interpretation in a coherent manner based on elaboration of explicit and implicit data collection methods involved. Making explicit all data collection processes in this case has been complex given the intense and deep level at which the researchers have been submerged in the practicalities of the project over a 5-year period in Trivandrum district of Kerala. This level of active participation (Whyte, 1997) however, helps to strengthen the contextuality of the narrative. With this kind of intensive engagement, a lot of the data gathering is implicit and grounded in experience. Of importance then is for the authors to establish trust and credibility in the narrative, where the reader can feel to be “in the situation,” and experience the narration.

The empirical approach adopted in this research draws its inspiration from the broader HISP “networks of action approach” as described by Braa, Monteiro et al. (2004). The aim within this framework is to direct action to develop networks both vertically (different levels in a district or state), and horizontally (across states, districts and health programs) to enable the sharing of ideas, products, and experiences. For example, we would try to ensure that the application developed by HISP in one state should be shared through the network of action to enable customization for the needs in another state. Same is the principle for the sharing of training material and also the movement of people and ideas. In the same vein, in this research the focus was on trying to understand and create “networks of participation” where various stakeholders with their varying interests and agendas would participate and enable efforts related to system design, development, use and political acceptance.

The HISP project in Kerala was initiated in 2004, and various forms of data collection methods were employed. Some of them included:

1. A situation analysis exercise in which various doctors and health staff were met with in Trivandrum district to understand the nature of health information flows and the existing challenges.
2. Undertaking a study of various documents including registers and reports used by the health staff for various HIS related processes, such as data collection and reporting
3. Software prototyping initiatives as during the process of customization, various prototypes were shown and discussed with the health staff to get their feedback and opinions for making relevant improvements.
4. HISP made periodic evaluation and progress reports including presentations to the Health department, and based further actions on feedback received.

Data gathering was also carried out by the larger HISP Kerala team of which the authors of this paper were also a part over a 3-year period (2006–2008). The process started off with a team of one person, which was extended to four, and then further expanded to 14 members. The team members communicated with the broader network (HISP India and HISP global) over email and also through face-to-face meetings when possible around issues and problems they experienced, how they were trying to deal with them, and to try and find appropriate solutions. The data collection process was further enriched by the research work of Oslo-based Masters and Doctoral students coming to Kerala to do their fieldwork on specific topics. Discussions with them and their thesis outputs also served as very valuable sources of data.

The processes of data collection described above also had deep components of data analysis inbuilt in them. For example, feedback from the Health Secretary on our progress reports while providing invaluable data inputs also helped us to gain different interpretations to our empirical experiences. Further inputs into our data analysis processes came through the readings of the literature and discussions with researchers from Oslo and also in the Public Health Departments of Medical Colleges in Kerala. An initial paper presented in a conference evoked interesting feedback which helped us to further develop our analysis and evolve the paper to its present form.

4. Case study

The case is discussed after a brief description of the research site.

4.1. Research setting

The case study is set in Kerala, a southern Indian state with unique characteristics, summarized as “5 Ms”: Monarch, Maternal Care, Missionary, Marxist Government and a Matriarchal System. Despite low per capita income, several quality-of-life indicators in the state are remarkably close to those prevailing in the developed world, for example related to literacy rate, infant and maternal mortality rates, and the Human Development Index. Kerala *democratically* elected its first communist government (a first in India; also, in the world) in 1957. The communist party has since been re-elected several times, latest in 2006. The people of Kerala are reputed to actively participate in the political processes, are greatly conscious of their constitutional rights and exercise these in the state’s governance by political parties.

Kerala has a unique history of establishing innovative systems for decentralization and local democracy, such as land reforms, a strong public distribution system and the devolution of more than a quarter of the state development budget to local governments. These processes have been substantially enabled by historically existing conditions of high literacy rates and high percentage of women in employment. Decentralization in Kerala was looked upon as a practical measure for administrative reforms to improve delivery of public services that were sensitive to the local needs. These achievements are reflected in Kerala state winning the prestigious national award for decentralization consecutively in 2005 and 2006.

The high quality of life, despite the low per capita income, has come to be known as “the Kerala Model,” and is seen as a basis for an early prototype of sustainable development (Parayil, 1996). However, present day Kerala is experiencing a different set of health problems including rising incidence of hypertension, depression, suicides, diabetes and cardiac problems, ailments similar to those prevalent in Western countries. Further, infectious diseases like diarrhea, hepatitis, tuberculosis and other poverty-linked diseases are still prevalent. Added to this is the economic underdevelopment and unemployment, which has led to a severe decline in the quality of medical care in government hospitals. Other than immunization and sterilization, most of the population health needs are met by the private sector (Vohra, 1999), contributing to the increase in the cost of medical care for the ordinary citizen, and the risk of marginalization of the most needy ones.

The State Department for Health and Family Welfare guides and supervises the field-based programs (such as Reproductive Child Health, Malaria, TB, etc.) related to the whole range of primary healthcare services. A key component of the responsibilities of Health department includes adminis-

tration of the overall data recording, reporting and analysis activities, described as their HIS. Even though the state has good health indicators, there are problems in the current HIS similar to other states in India and also in other developing countries, such as data of poor quality, lack of use of information for action, and weak mechanisms of feedback and supervision (Sandiford, Annett, & Cibulski, 1992; Sauerborn & Lippeveld, 2000). Strengthening the existing HIS through the enablement of stronger participatory approaches is a key focus of this paper.

4.2. Case study

HISP started to explore the possibility of initiating HIS implementation project in the state in 2005, when the state was engaged in initiating a process to strengthen the existing largely paper-based HIS. Specifically HISP approached the Kerala Directorate of Health Services with the proposal to facilitate the setting up a free and open source software (FOSS) application called District Health Information System 2 (DHIS version 2) directed towards supporting the integrated HIS needs of the state, including a significant component of building capacity of the health staff to use information to support local action. A presentation was made to the Health Secretary which elaborated upon the vision and mission of HISP, their prior experience in the field, and its global expertise in the design, development and implementation of HIS. The Health Secretary recognized the potential of HISP to contribute to improve their current HIS, especially their focus on local level capacity building. The Secretary facilitated all required bureaucratic processes for HISP to start a pilot project in Trivandrum district, where, all financial responsibilities for the proposed implementation rested with HISP.

An initial situation analysis was carried out by a three member HISP team which met various doctors, health staff and others within the pilot district to understand the existing state of information flows and the nature of challenges being faced. A starting point was to identify the various stakeholders involved in HIS related issues and how could potential collaboration be developed. In a meeting with different stakeholders, each participant presented his/her strengths and potential areas of contribution. For example, a local medical college said they would be interested in the development of training material, while HISP focused their primary role in software development and implementation. Following this, HISP conducted a detailed study of the information flows from the grassroots level up to the district and state level. The study reported that the existing HIS in Kerala has historically been paper-based and included a great number of forms that traveled through different administrative levels, e.g. from a Sub-Centre to Mini Public Health Centre (PHC)/Block PHC/Community Health Centre (CHC),¹ and then upwards to the medical/administrative hierarchy at the district level. The forms were consolidated at each level and put together manually by health staff for submission to the next level. Apart from the state-sponsored health programs, there were various forms related to the national health programs (for example, Integrated Disease Surveillance Program) which continued in parallel, often involving extreme amounts of redundancy and duplication, and increased workload of the already over-burdened health staff. This contributed to the marginal attention being devoted to the HIS and consequent deterioration in reliability and quality of the data reported.

A key recommendation arising from the situation analysis was to shift the focus from individual data collection to datasets comprising of group of similar data collected by a particular health functionary. Three levels of datasets were recommended:

- (i) Sub-Centre Dataset – including data related to outreach activities (primarily concerning mother and child health) conducted by the Junior Public Health Nurse.
- (ii) Primary Health Centre Dataset – including activities (primarily disease control) performed at the PHC and outreach done by the Junior Health Inspector.
- (iii) Community Health Centre Dataset – primarily including services (such as c-section operations) provided at the facility.

¹ Subcentre is the grassroots level health facility for every 5000 rural people that is manned by two basic health workers. There would be one mini PHC for every 20,000 rural people that have a medical team with one/two basic doctors. In addition, for every 80,000–1,00,000 rural people, there would be a Block PHC/CHC (a first level referral centre) having in-patient services and specialist doctors.

Building of these data sets required HISP to develop a detailed and practice-based understanding of the information flows, including which health staff were collecting what data and when. The underlying principle used for organizing the datasets was to have a single point of data entry which was in contrast to the existing “form” based system which had inherent in-built redundancies. The concept of the dataset was seen as a tool to shift focus from a “fixed” paper format to a group of similar data elements organized in a dataset.

In 2003, prior to the HISP initiative, the Kerala Health Department, with funding under European Union supported Sector Investment Program, had developed an HIS ‘Master Plan,’ prepared by a technical group from a prestigious government agency. This agency was a national centre of excellence, pioneering application oriented research, design and development in electronics and information technology. The master plan reflected the strong technocratic focus of this agency, in which the recommendations included to computerize only the district offices, as they felt that the local level PHC offices were not ready for computerization. It was recommended that the main application would rest on a mainframe, and enable primarily upward reporting of data carried out through the district offices. The capacity building component was restricted to training district staff primarily on data entry and report generation. The advantages of the centralized module were cited as follows:

- (a) Time efficient: a centralized system with online access across the state would enable quick collection and dissemination of information.
- (b) Improved planning: availability of up-to-date information would facilitate more informed decision making.

With respect to challenges in implementing this model, the report mentioned ‘none perceived’.

A health department official coordinating HIS projects in the state introduced HISP to this agency to see if synergies between the two projects could be achieved. A series of meetings took place in which respective systems were demonstrated, and discussions carried out on possible integration mechanisms. No common ground could be found, primarily because these two agencies were following contrary implementation models. While the government agency was large and powerful, HISP was a small NGO. The government agency had adopted a centralized system based on a mainframe architecture and proprietary software, whereas HISP was working with a bottom-up model based in peripheral health centres, and used free software. The government agency had a technocratic view of capacity building (primarily relating to data entry and report generation) while HISP laid significant emphasis on cultivating capacity of the field staff on an ongoing basis for using information for local action. And, most importantly, the government agency saw the HISP effort as a competing initiative. Given the absence of a common ground, both projects proceeded in their own directions, with the government agency focusing on automation at the district level, and HISP on creating a culture of information analysis and use at the peripheral level in designated pilot district.

During the course of the pilot, HISP crossed paths with another agency, this time researchers from a local public health institution, which was working on a project related to community-based mapping in the same catchment area as the pilot allocated to HISP. A faculty member from this institution appreciated the similarities of their work and ideology with that of HISP, and some joint discussions and work started, especially around the mapping of health indicators. There were mutual synergies to be gained as HISP wanted to strengthen the public health component of their system and also to establish a local anchor to steer their implementation efforts. On the other hand, the public health institution was keen to develop a health informatics component in their Masters of Public Health Program, and felt there could be synergies in the collaboration. The alignment of ideology, interests, and empirical approach led to the formal Memorandum of Understanding being signed between the public health institution and University of Oslo to support joint research, faculty and student development, in addition to joint project implementation. This alliance provided the framework for HISP to build network with other local agencies such as the Public Health Department of Medical College and also the village level political bodies with whom the public health institution had built credibility and standing.

The one facility (Community Health Centre – CHC) pilot study taken up by HISP in early 2006 was extended to 19 similar facilities and coincided with the release of a new version DHIS 2, a FOSS application based on Java technologies, which was platform independent and also web enabled. For this phase of implementation, the cost of the computers and salaries to the trainers was borne by HISP. This was a strategic decision made by HISP, as they wanted the opportunity to develop a system for the entire district, demonstrate success to the Health Department, and then subsequently persuade them to support the scaling up of the system to the state level. In this way, HISP tried to leverage upon the global HISP network through two mechanisms. One was through the adoption and customization of DHIS 2, the core of which had been developed at Oslo. The second was through the use of Oslo funds to support this phase of implementation in the 19 CHCs. These global networks integrated with local alliances such as of HISP with the public health institution and their partners.

At the start of this extension phase, two training seminars were organized for all the 19 medical doctors, one from each CHC in the district. Several medical doctors studying for the Masters of Public Health program at the public health institution also attended these seminars. Training focused on the basic concepts of HIS, data collection, the use of maps, data quality, and on the use of indicators for health planning and action. Training was done through hands on sessions which allowed doctors to concretely understand how HIS processes (data entry, report generation and analysis and use of information) unfolded in practice. These seminars and feedback sessions yielded many insights to the software developers which otherwise would have remained invisible to them. For example, it was pointed out that there were problems with data manipulation by field workers due to pressure on them achieving their targets from higher levels. This threw light on the need for the development of some in-built system checks, a requirement which otherwise would have been difficult to get at. Various concerns about data security were also raised, and what kind of access rights should be imparted to which level of workers. Despite these concerns, the participants were very positive towards the use of DHIS 2 as they felt it would alleviate some of their existing HIS related problems, for example relating to data quality. There was also skepticism from some quarters, such as current staff losing their jobs because of automation. HISP tried to address these concerns by assuring the aim was not to reduce staff but to try and enable a qualitative change in the kind of work they did – from reporting to analysis and use of information.

Following these training seminars, computers were placed in all the 19 CHCs in the pilot district, and training processes commenced. Training sessions were held in the local language (Malayalam) by the four field staff (called System Facilitators) hired by HISP, and slowly the health workers started to independently work with the software. While there were gains made on the implementation side, on the technical front working with the new Java based technologies on which DHIS 2 was based within a larger geographical coverage was a non-trivial task for various reasons. Firstly, the DHIS 2 being in its first release was quite unstable and frequently gave exceptions while in use. Frequent patches were released to address the identified bugs, but reflecting these patches in all the 19 CHCs in the absence of a web-based deployment was a non-trivial challenge given the large geographical areas involved.

HISP tried to deal with these technological limitations into different ways. Firstly, a number of the core DHIS 2 developers from Oslo came to India to train the two person technical team in HISP. While this approach was useful in getting a basic orientation to the technologies, it proved rather inadequate in dealing with operational problems due to the limited understanding of the Oslo developers about the context and public health issues. Secondly, HISP tried to create an alliance with a local information technology institution and get their students on development tasks through the mechanism of summer projects. However, this approach did not succeed as students preferred internships with international organizations rather than a local NGO. Thirdly, various electronic means were established for building capacity of the local Indian technical team, such as mailing lists and Wiki-based access to documentation.

The intensive field level engagement of the HISP staff helped them to develop deep field insights which were fed back to the DHIS 2 developers to make necessary improvements. New releases of the application were increasingly inscribed with improvements which helped the health staff to develop trust towards the system and the HISP team that their requests were being heard and responded to. Eight months after the implementation, the health staff gained sufficient competence to independently conduct their routine information processing activities, including data entry and validation, re-

port generation and its transmission to the next level. However, while HISP had made progress at the peripheral levels, it could not establish the informational link to the next level of the reporting hierarchy, the district office, where the processed reports from the CHCs were received. A key reason for this was the parallel activities of the European Commission sponsored government agency initiative which was focused on the district level. For example, the computers at the district level had been procured under the EC project, and HISP was not allowed to install their systems there.

In the meanwhile, as could have been anticipated, a decision point was reached for the government to make a choice between the initiatives of the government agency and HISP as there was a natural duplication taking place. However, the contextual conditions had now changed since the first meeting of the two initiatives, primarily through the health system reform process initiated at the national level under the NRHM in 2005. The reform process aimed at trying to make the HIS in the country to move outwards to the community, and not upwards to the bureaucracy (Ranjini & Sahay, 2006). The NRHM is well funded with a strong mandate to strengthen the community focus of the health services, integrate the different national programs under one umbrella, strengthen the health infrastructure: in short to take a health systems rather than a disease specific approach as a basis for reform. As a part of their implementation efforts, NRHM established offices in different states, including in Kerala, under charge of a State Mission Director.

The State Mission Director was responsible for the evaluation, carried out through a formal meeting in which HISP and the government agency presented their respective systems and implementation models. The government agency argued that they were following the previously approved “master plan” which required a centralized and mainframe based application. Again, they pointed out that the peripheral levels were not ready for computerization, and it would involve very heavy management overheads. In contrast, HISP demonstrated that the peripheral levels is where the computerization focus should be, and backed up their argument by showing a set of the previous month reports that had been generated by the health staff themselves at the peripheral levels. The HISP solution was presented as being about 90% cheaper than the competing and top-down centralized formulation. Furthermore, the HISP free software approach was compatible with the ruling Left party’s ICT policy which explicitly emphasized promoting the use of FOSS in the public sectors. Following the evaluation, HISP was asked to formally scale its activities to all the health facilities numbering 102, including Mini PHCs, CHCs and hospitals in Trivandrum district.

The scaling up phase was further facilitated by some key structural events. Firstly, a district level NRHM officer was appointed, a medical doctor with extensive field experience, who was now responsible for the coordination of the project. He called for a number of stakeholder meetings with different program managers in order to bring in more uniformity in the data items and reporting formats. Version 1 of these requirements was formalized through these meetings in the form of a manual, which became the basis for the first version of the prototype, implemented from September 2007 in all facilities. Through the efforts of the district coordinator, other stakeholders were slowly enrolled in the HIS network, including the village political bodies and other public health entities.

The above-mentioned phase of the project drew to a close in May 2008, and a further evaluation of the HISP project was carried out. Based on this a MoU was signed between the Health Department and HISP India to scale up the initiative statewide to all 14 districts. This implementation initiative has been ongoing since October 2008.

5. Analysis and discussion

The analysis addresses two key aims: One, conceptually developing the notion of participatory networks; and two, empirically discussing the approach adopted to develop such a network within an action research setting.

5.1. Conceptualizing the notion of “participatory networks”

Taking the notion of “networks of action” (Braa, Monteiro et al., 2004; Braa, Titlestad et al., 2004) as our point of departure, we have attempted to conceptualize participatory networks. The concept of

networks of action tried to focus the attention on the need for interlinking various users, developers and other relevant entities so that they can share and learn from each other in the context of HIS design, development and use to enable systems to become scalable and sustainable. Important here was the mechanisms that needed to be enabled (such as circulation of people, money, software, training material and implementing best practices) to allow this sharing and learning to take place within the network. Drawing upon this, the participatory network approach seeks to draw attention especially to processes of participation and how there can be enabled and circulated within a networked approach.

The networks of action approach could be criticized for its focus on the instrumental role of how these action networks can be constructed and grown, while not giving due attention to the constitutive aspects. In line with Sen (1999), we have tried to develop the notion of participatory networks in both its constitutive and instrumental facets. In its constitutive role, for example, health workers through participating in the system prototyping process, could develop their capacity to use ICTs also for other purposes (such as using Excel to make budgets for their home) while simultaneously shifting in a qualitative sense their relationship with work – seeing HIS not only for routine reporting but something useful for their local and everyday work. Similarly, the HISP system developers by engaging in “reverse participation” not only could improve the quality of the DHIS 2, but also built their own understanding of public health concerns and the broader Kerala development model. Instrumentally, developing participation through meetings and presentations of the senior administration process helped to gain a political “buy-in” and ownership of the system which supported processes of scaling and sustainability. For the system developers, participation played a key instrumental role of continuously bringing about system improvements and responding to users’ demands.

Conceptually, the notion of participatory network emphasizes firstly, the diversity of the types of participation that needs to be cultivated in the context of a HIS development project in a LDC setting, and secondly, the multiplicity of the mechanisms through which these are enabled. The types of participation included the inputs from health staff to understand information needs, bring about system improvements and build local ownership. Engagement of administrators helped to strengthen political “buy-in” while the local public health institute participation supported expanding of the knowledge, and in providing a local implementation anchor. The University of Oslo and global HISP involvement provided financial resources and technical expertise to the implementation process, while the different Masters’ and Doctoral students through their empirical efforts provided specialized inputs such as around issues of database design and capacity building.

Arguably, without these various kinds of participation in both their constitutive and instrumental aspects, a complex HIS project in a unique setting cannot be effectively realized. Mobilizing these different participatory efforts is a non-trivial challenge and requires various means such as funds, political access, university scholarships, MoUs and internal relationships based on trust and commitment. How this was empirically achieved in the context of this research is the focus of the next section.

5.2. Empirically cultivating the participatory network

In this section, we outline the nature of the participatory network that we have tried to cultivate and the empirical mechanisms used. First, we start with schematically summarizing the network (see Fig. 1).

The network is comprised of various entities which are discussed.

5.2.1. User community

In our case, we describe the user community are the health workers and medical doctors who are the users of the application to support their various HIS tasks. Various mechanisms were used by us to enable their enrollment in participatory networks. During the initial development of the system, workshops were held with the medical doctors, in which the first prototype of the application was presented to them, and their feedback and suggestions taken and incorporated into the revised application. The health workers did not participate in this process, as the hierarchical structure of the health department was not very conducive to have both the medical doctors and health workers represented on the same forum. However, as the application was made ready for deployment, the health

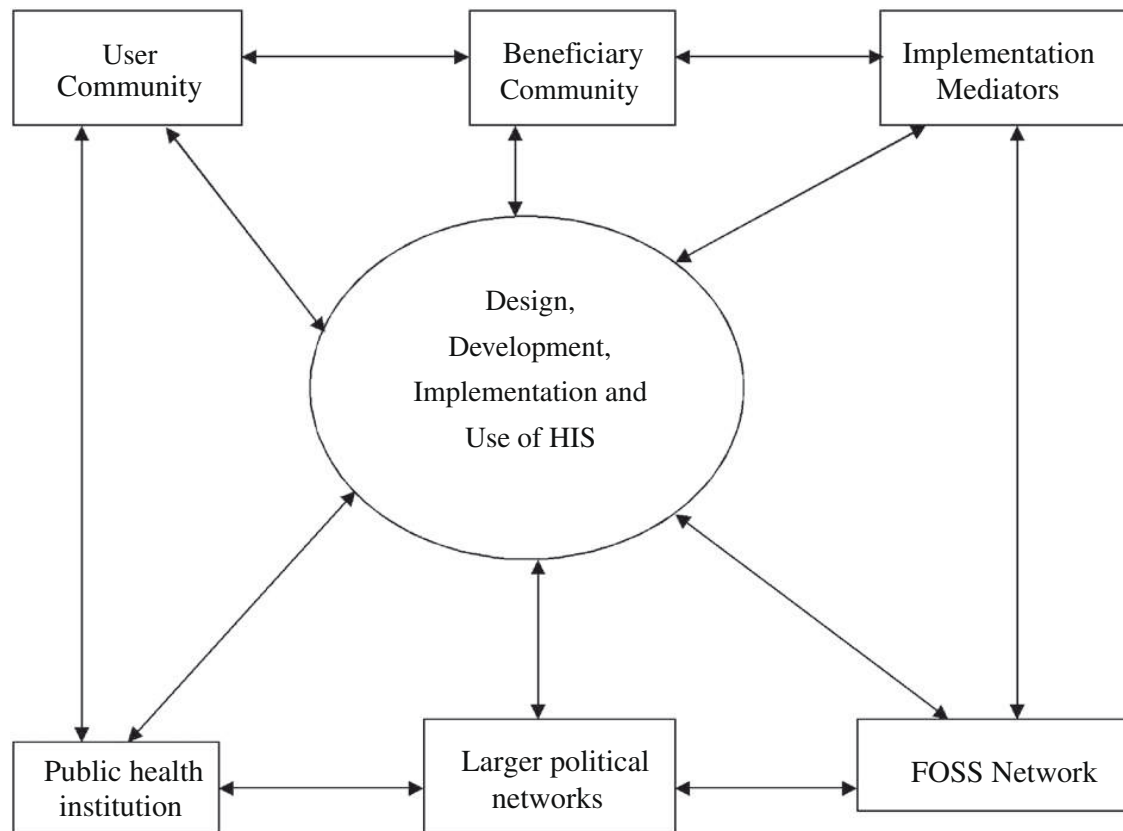


Fig. 1. Participatory networks around HIS in Kerala.

workers started playing a primary and active role in the shaping of the application. The HISP system facilitators directly worked with them in the clinics, building their capacity to use the application independently, and note their comments and suggestions, which they then transmitted to the developers. As the health workers' capacity improved, they even started to use the application for purposes other than their routine tasks. In this way, it can be argued that the mode of user participation extended beyond its instrumental role of creating efficiencies and making system improvements to a more constitutive role where the health workers started to take ownership of the system, and use their capacity towards ends that were valuable to them as individuals. The medical doctors, however, did not engage with the system in the same manner, and saw it primarily as a tool for making their information processing responsibilities more efficient, and exercising more control over the field functionaries.

5.2.2. Beneficiary community

This can be seen to be the village population, the community, who are the beneficiaries of the health services being provided by the public health system. Unfortunately, the system design and development process did not have direct interaction with this community, and they could not be directly enrolled in the participatory network. Two reasons can be provided in defense. Firstly, accessing participation of community dispersed over a large geographical area is logistically problematic to incorporate, and the use of local language further limits the interaction. Secondly, since the health workers are directly interacting with the community in the course of providing their outreach services, we at least experienced some form of indirect feedback through them. Further, through our partner in the local public health institution who was working directly with the village population in one sub-district area in the course of a participatory mapping exercise, we could experience a degree of indirect participation. Further efforts are needed to strengthen direct participation from the community in order to especially improve the constitutive aspects of the participatory network.

5.2.3. Implementation mediators

This can be seen as the HISP team comprised of the system facilitators and developers, who played a crucial role in mediating the participatory processes, given the link role they played between the community, health workers, medical doctors, and also the HISP software development teams, nationally and globally. Initially, this team was engaged in mapping the context through the situation analysis, and then working closely with the health staff in the process of defining the report contents and formats, understanding how the datasets should be organized based around the ongoing work practices, and providing important inputs to the DHIS 2 customization and adaptation processes. By engaging deeply and intimately with the work context, the HISP team could be seen to be enabling processes of “reverse participation,” where they themselves were gaining an understanding of the context, while slowly encouraging the health staff to participate. Through the processes of capacity building, they were also augmenting their capacity in understanding the complex domain of HIS design, development and use, especially relating to the public health domain.

5.2.4. The role of public health institute in building domain knowledge

This particular institute was nationally reputed for its academic excellence with a strong local credibility also. By collaborating with them, HISP could strengthen both the public health component of the HIS under development, and also ensure a more solid and local grounding of the project, something which is quite crucial in the left-dominated thinking in Kerala where “outsiders” are typically seen with skepticism. This institute provided the basis for holding training seminars for the medical doctors from the health services, because they would have otherwise not have responded to a call for training solely by HISP. At the training sessions in the public health institution, the faculty members and the staff from the health services, could speak in a common language (of medicine and Malayalam), which enabled a relatively smoother sharing of opinions. This shared understanding was then subsequently communicated to HISP for further action related to incorporating systemic improvements. Enrolling the institute in the participatory network was enabled primarily on academic considerations. The institute was developing a health informatics stream in their ongoing Masters’ in public health, while HISP was trying to develop a stronger public health understanding. The specific mechanism for this enrollment was a formal inter-university MoU (between the Institute and Oslo University), and complemented by strong inter-personal relationships between the faculty members of the respective institutions.

5.2.5. Larger political networks

Various broader network alliances were attempted to be forged with the view to strengthen and broaden the base of the political support for the project. For example, through the public health institution, DHIS 2 generated outputs were fed into the Gram Panchayat meetings through which they gained an overview of the health status of the villages under their jurisdiction. Further, through presentations and reports, we strengthened our links with the senior government administrators in the State, such as the Health Minister, Health Secretary and state Mission Director. The broader visibility of the project that was created through these meetings was crucial, for example, during the project evaluation process, because before this time the senior officials had already been made aware of the approach and value of the software applications provided by HISP, and its compatibility with Government policies. These periodic meetings and presentations to the senior officials helped to enroll high level of political participation, support and visibility to the efforts.

5.2.6. The FOSS network

The FOSS technology which HISP was working with (DHIS 2) could be seen in itself as an important actor in enabling local participatory processes, and also linking the local HISP organization with broader global processes of knowledge and expertise. The FOSS card played by HISP was in consonance with the free software policy favored by the ruling Left government, and seen to support decentralization processes, and the larger involvement of the field staff unhindered by licensing restrictions. During the evaluation, HISP emphasized the benefits of their bottom-up model enabled through free software, which was argued to be a more convincing implementation model than the centralized one proposed by the government agency. The fact that the design and development of this application was enabled

by a global and multi-disciplinary research and development network was again seen positively by the evaluators of the software, as HISP was seen to serve as a mechanism to incorporate global and current knowledge and state of the art expertise. Enrolling the FOSS software and expertise into the participatory network was enabled through scholarships of Masters and Doctoral students and which drew largely on the electronic tools of communication and coordination such as the software code repository, Wiki, email lists and websites.

In the table below, we provide summary details of the various mechanisms adopted for enrolling different actors into the HIS participatory networks.

Network member	Nature of participation	Mechanism of enrollment
1 User community (field staff, medical doctors, etc.)	<ul style="list-style-type: none"> – Information requirements – Feedback on application – On job use of application 	<ul style="list-style-type: none"> – Training seminars – Eliciting feedback during application prototyping process – Mediated through HISP facilitators
2 Beneficiary community	<ul style="list-style-type: none"> – Comments on efficacy of health service delivery 	<ul style="list-style-type: none"> – Indirect interaction through field staff – Indirect interaction through faculty members of the public health institute
3 Implementation mediators (HISP team)	<ul style="list-style-type: none"> – “Reverse participation” through engaging in the user context – Understanding the work practices of the health staff 	<ul style="list-style-type: none"> – Situation analysis – Conducting training programmes – Informal relationships based on trust and support between HISP team and the field staff
4 Public health institute	<ul style="list-style-type: none"> – Inputs on the public health aspect of knowledge – Inputs on the local context – Plan to develop informatics specialization 	<ul style="list-style-type: none"> – Formal MoU between the public health institution and Oslo University – Strong informal relationships between faculty members of both institutions
5 Broader political support	<ul style="list-style-type: none"> – Providing visibility and political support – Alignment with state IT policy 	<ul style="list-style-type: none"> – Meetings and presentations with senior administration
6 FOSS network	<ul style="list-style-type: none"> – Inputs on FOSS tools and technologies – Developing enhancements to the application 	<ul style="list-style-type: none"> – Scholarship for Doctoral and Masters' students – Thesis outputs – Engagement with the FOSS network

5.3. Discussion

5.3.1. Building participatory networks

In traditional PD theory, participation has implied primarily the involvement of end users within particular organization settings. From case the experiences narrated in this paper, it is evident that this perspective of PD is not sufficient. We argue that a shift from user centred participation to broader stakeholder participation within a network framework is important. In Kerala, for example, these stakeholders ranged from health staff, political groups, community members, government officials, educational institutions, non-governmental and private organizations and globally distributed systems developers. Initiating the development of such systems with the traditional PD approaches would have most likely not been successful, as it would have led to a number of unfulfilled interests and resistance of stakeholders whose support was crucial. The aim should be to create both multi-sectoral and multi-level participatory networks, with due consideration to the multiplicity of interests and the role of the infrastructure itself. Involvement of multiple levels is crucial to soliciting support of decision-making top levels in order to nurture and sustain local level participation and action.

The purpose and mechanisms of such participatory exercises would necessarily be different with respect to the different actors. While with the health workers the aim is for them to take ownership of the systems, participatory approaches need to further the constitutive roles as well. However, with respect to interactions with senior officials, where the aim is primarily to obtain permission to operate

at the lower level, participation could focus more on instrumental objectives by emphasizing efficiencies and material benefits.

5.4. Context sensitivity

In developing countries, the context of participation differs greatly from Western settings, as societies tend to be characterized by a distinct top-down hierarchical structure. We have argued that prior to commencing participatory activities in HIS development the context should be thoroughly analyzed in order to reveal situational issues which may influence these activities. These contextual issues may be of political, social, cultural, geographical or infrastructural in nature and need to be fully comprehended to enable successful inculcation of PD processes. For example, HISP India conducted a detailed situation analysis over 6 months to be able to map contextual issues in Kerala prior to initiation of the project. Through this analysis, hierarchical structures in health administration, political conditions, knowledge needs and the state of infrastructure were understood, without which participatory processes would most likely not have succeeded to the extent they have so far in the project. The particularities of the context need to be included into the participatory design paradigm which stretches far beyond design methodologies and techniques. For example, through “reverse participation,” the system developers immersed into the local context to develop a deeper understanding of the requirements, insights which could not have been gained through formal techniques aimed at getting the user to learn about the system.

5.5. Focus on outputs, not just techniques

Researchers have characterized PD as an important success factor in IS development for acceptance of the system by users. However, often PD is adopted as a matter of form without thoughtful consideration to the desired outcomes expected to be produced. A number of different PD techniques have been developed over the years, for example PICTIVE which produces an initial mock up of the system, intended to be modified by the users (Muller, Wildman, & White, 1991). However, the focus should be on how such techniques work in the context they are introduced to, and what will be the output, rather than merely being used mechanically and in a decontextualized manner. If necessary, the PD techniques should be modified to suit the situation in which they are to be applied. We argue that a re-conceptualized PD should focus on the outputs and results expected through its application, rather than a primary emphasis on the use of the technique in itself. A focus on outputs is fundamental to the scaling of the system, as consideration needs to be given to how these outputs become integrated in the socio-political-cultural-institutional conditions that shape and inform use processes. We may develop a very effective HIS application, but without high level political buy-in, it is quite improbable it could be either scaled up or sustained.

5.6. Focus on structural and behavioral changes

Bass and Shackleton (1979) distinguished between industrial democratic aspirations of the Scandinavian and European strands of participation in workplace settings, and the participative management approaches, for example in the United States. They argued that while industrial democracy movements constituted formal, structured and often legally supported mechanisms, participative management tended to be more informal and its practice in organizations varied as per individual managerial styles and corporate ethos.

Such participative approaches were considered to be behavioral. Therefore, issues that could be addressed using these approaches tended to be different, for example, job satisfaction could be enhanced using participative management, while the issue of increased financial benefits to employees was relevant in an industrial democracy debate.

For example, in Kerala, the introduction of computerized HIS potentially entailed behavioral aspects, for example how health workers participated and gave inputs for finalizing user specifications based on their understanding and knowledge around health issues specific to the locale. Markus and

Mao (2004) also pointed to the relevance of considering behavioral and psychological aspects of participation to address the gap in the perceptions of users around system requirements, and its development as perceived by the IT experts. The structural changes on the other hand facilitate and sustain participation, and determine the outcomes of IS development projects. In the case discussed, structural aspects refer to how the existing work routines need to be modified and embedded into the new computerized environment of primary health management.

The establishment of NRHM as a highly visible political initiative by the federal government, and its subsequent setting up of State level offices (like in Kerala), has created a key structural mechanism to facilitate and promote more effective use of HIS, for example in Kerala the state NRHM has created the appointment of district level officer who now serves as a nodal point to coordinate HIS efforts. Without these structural changes being brought about, behavioral processes of joint participatory meetings and discussions could not have been easily enabled.

6. Conclusions

Participation in a developing country context requires different considerations as compared to initiating similar processes in the Western settings. It is important to approach such environments with considerations of the users' positions, customs, ways of thinking, and the varying institutional and political settings. In order to empower the lower levels, the top echelons need to be included in the process, especially during its initiation, as their formal endorsement helps to create the space for lower level participation. In complex networks such as HIS, many diverse, often conflicting, visible and hidden interests of different stakeholders need to be carefully understood and resolved towards alignment. The building of participatory networks can bring these stakeholders together to achieve a well defined and common objective, such as improving healthcare governance through the use of computerized HIS. Such participatory networks should be constituted of both multiple sectors and levels, enabling both constitutional and instrumental considerations.

Based on the experiences gained in Kerala, we argue for re-conceptualization of PD towards their use in an information infrastructure context. The main areas of re-conceptualization identified are: (i) building of participatory networks, (ii) context sensitivity, (iii) focusing on outputs and not on the PD methodologies alone, and (iv) inculcating a judicious mix of both behavioral and structural aspects of participation. While highly germane to the effective use of PD in developing countries, this re-conceptualization is also applicable to the developed world where there also are differences in cultures and contexts between countries, which need to be carefully taken into account while designing larger, more interconnected and complex information infrastructures, for example Enterprise Resource Planning Systems.

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Paper 2:

The Role of Social Capital in the Integration of Health Information Systems. Mekonnen, Selamawit Molla; Sahay, Sundeep; Lewis, John. *Journal of Health Informatics in Developing Countries*. 2011

The Role of Social Capital in the Integration of Health Information Systems

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Abstract. In recent times, the agenda of strengthening ICTs mediated integration of Health Information Systems (HIS) has been emphasized in research and practice of health reforms in both developed and developing countries. However, its realization remains to be challenging especially in the context of developing countries. The paper presents a case study from Gujarat state of India describing the efforts of a HIS project to implement an integrated computerized system to manage the routine health information. A central argument in this paper is on the role that social capital plays in the process of building such a system, and also the role of ICTs in building such social capital.

Keywords. Health information system, HIS integration. Social capital, social networking

1. Introduction

Integration of health information systems (HIS) has been emphasized both in research and practice of health reforms in both developed and developing countries.⁹ As a result, the identification of 'best' practices has been observed taking the attention of contemporary HIS researchers. While integration in simple terms refers to the linking of various disparate systems and associated practices, its importance is emphasized by the adverse effects of fragmented HIS with respect to data quality, utilization of resources, and the adoption of a coherent and comprehensive health systems approach to health reforms. Integration may not always be the most efficient approach, as there may be particular problems such as the management of epidemics which may be more suited to a management approach around vertical programs rather than a district based geographical area focused approach as advocated by the primary health care model. This then raises the questions of what should be integrated, how and by whom. However, this paper is not schematized to respond to this question. Rather, we focus on how trust, social relation and networking may contribute for integration efforts.

The dominant approach to the research and the practice of HIS integration remains largely technology focused, concerning how newer and more modern technologies can be applied to address hitherto unaddressed fragmentation challenges. So, we tend to find different types of technologies at different points of time such as Enterprise Resource Planning systems, Service Oriented Architectures, Web-based systems, and in the health domain, Electronic Patient Record systems being tried out as tools for spearheading integration initiatives. The unrealized potential of such technology

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focused initiatives have led research to also focus on the social and political determinants of integration initiatives (see for example, ^{6,1,15}). As a result, it is increasingly being recognized that integration of information systems in general and HIS in particular, is as much a technical exercise as it is about addressing the institutional, social and political conditions. In continuing with this line of research, this paper analyzes the role of social capital in the integration of HIS in the context of developing countries.

The notion of social capital has its roots in social sciences, and commonly refers to the investments made to build cooperative activities in organizations that have a potential rate of return.⁷ When we invest in infrastructure, we get infrastructure in return, and in the same vein, when we invest on building social networking, we get more of what makes the infrastructure work in practice and also to enable of the development of the infrastructure itself. Since integration is very much about creating cooperative activities to enable the building of technical and institutional linkages, it is very appropriate to study it within the framework of social capital. We address the following two fold research questions in the context of this paper:

- 1) *How does social capital shape the realization of ICT based HIS efforts in the context of developing countries?*
- 2) *What is the role of ICT in building social capital?*

Empirically, the paper draws upon the study of ongoing efforts of a NGO called HISP India to design, develop and implement integrated HIS in the state of Gujarat in Western India. Specifically, the focus is on understanding the nature and role that social capital plays in the realization of the integration efforts.

The rest of the paper is structured as follows. In the next section, we discuss key concepts around social capital, and the manner in which it has been appropriated in the domain of information systems research. Next, we outline the research methodology employed, followed by a description of the case study. In the analysis and discussion section that follows, we discuss the nature and role of social capital in shaping and being shaped by the integration efforts. Finally, some brief conclusions are presented.

2. Social Capital and Its Application in IS Research

One of the founders of the concept of social capital³, defines the term as “*the aggregate of the actual or potential recourses which are linked to possess of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition*”(pp.248).¹¹ provides a more elaborate definition, saying:

“*Social capital refers to the network ties of goodwill, mutual support, shared languages, shared norms, social trust, and a sense of mutual obligation that people can derive value from. It is understood as the glue that holds together social aggregates such as networks of personal relationships, communities, regions, or even whole nations*” (pp.1). In short they say that: “*Social capital is the value derived from being a member of a society or community. By being a member, people have access to resources that are not available for nonmembers*”.¹¹ Social capital can thus be seen as an important ingredient for knowledge development within and between organizations⁷, with also potential negative effects if there is a condition of high

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dependency on the central actor.¹⁷

In our research what we found more interesting, and which is not given much emphasis in the social capital discourses, is the value derived from being part of multiple network. Why we used social capital is because of its central focus on “trust” but not much of authority.

However, we argue that this trust gained through being part of multiple networks is the source of power and authority for the institutional entrepreneur who wants to bring change let say in organization.

¹² identified three analytical dimensions of social capital: structural; relational; and the cognitive. The structural dimension refers to the overall pattern of connections between actors, who you reach and how. The presence or absence of network ties among or between actors is a key facet of this dimension. When connection and interaction between members of the network gets stronger, other individuals are more likely to be involved⁶. The relational dimension focuses on the particular relations people have, such as respect and friendship, that influence their behavior. Trust and trustworthiness are key facets of this dimension. The cognitive dimension refers to those resources providing shared representations, interpretations and systems of meaning among parties. This framework has been applied by various researchers. For example, ¹⁰ adopted it to evaluate relational computer based change management initiatives.

The concept of social capital is in recent times also being drawn upon in technology studies and information systems research. For example, ¹⁶ in their study of a technology mediated hunting dog breeding community, described how technology helped them to generate and maintain trust, acceptance and alignment, which was necessary for building successful cooperation. The use of information technology was described by the authors to make the actions of the key actors more visible to each other which in turn facilitated the emergence of trust and social capital. In the same vein of understanding the role of social capital in civic engagement, ² explored how participating in virtual community affects social capital in a face-to-face community. Drawing empirical material from a Multiple Sport News group virtual community, the authors argued how active participation in the group positively affected face-to-face social capital and norms of trust amongst members in both the virtual and face-to-face groups. As a result, members were seen to be less attached and obligated to the virtual community as compared to the face-to-face.

¹⁴ argue that unlike determinists who suggest that technology is diminishing or transforming social capital, the Internet is enhancing it. They argued that those who use the Internet also would continue to communicate by phone and through face-to-face encounters. Information technology also can play an important role in knowledge sharing by enabling communication amongst proactive individuals regardless of time and geographic location.¹⁰ Social capital, it can thus be inferred, is not only developed by group actions or collective norms but is also enabled through individual characteristics such as the eagerness and proclivity to share.

In summary, information systems research which has drawn upon the concept of social capital has largely focused on how technology mediated interactions contributes to the development or not of social capital and its various constituting aspects. However, what has not been given adequate attention is the constituting and constituted relation between technology and social capital. This implies the need to understand how the technology itself is a function of the existing social capital, and how the interaction between the two reconfigures both the technology and the social capital.

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This analytical relation is explored in the context of a HIS integration initiative in India.

3. Methodology

The study is framed within an ongoing action research initiative involving the design, development and implementation of HIS within a public health setting in India. Data collection took place through a variety of means. Firstly, the whole process of action research engagement for over a period of 2 years in the state provided us with deep insights into the people involved, their interests, the problems they faced with the existing fragmentation of systems, and what was their visions and expectations of an integrated HIS. For example, we periodically met with the head of the health department to understand the challenges he was experiencing due to the fragmented information channels within the reproductive child health programs, and his vision of developing integrated and cross cutting indicators to allow for more effective monitoring.

To develop more specific insights into the social capital and integration relation, qualitative semi-structured interviews were conducted of key stakeholders. Specifically, we tried to understand the nature of socio-technical challenges to integration, and how they were trying to be addressed by the implementers (HISP India) and the users. The key assumption underlying this inquiry was that integration is a complex phenomenon that is deeply embedded in historically existing technical, institutional and social conditions. This assumption guided us to use largely open-ended questions allowing the respondents to give their views on how they see integration and also the nature of their social networks and interactions around the technology initiative.

Gujarat state, the site for the empirical work, is composed of four hierarchically arranged administrative levels: state, region, district and block. Gujarat has 5 regions, 25 districts, with each having 5-7 blocks. The block is where the computer was placed and where the entire data entry and reporting of all the health facilities in the surrounding catchment area took place. From the block, the aggregated data was sent (either online or manually carried in flash drives) to the district, where further aggregation took place in the online application called District Health Information System (DHIS). The region served as an administrative unit responsible each for 5-6 districts, but where no specific HIS related activities took place. At the region, the person responsible was the “regional program coordinator” (RPC), the “district program coordinator” (DPC) at the district, and the M&E (Monitoring and Evaluation) Assistant or the Block Health Officer (BHO) were responsible at the block.

A series of focused interviews were carried out with staff from the different levels (see Table below), when we visited each of the regions during the period 4-8, August 2008. During each of these visits, the state level team (including us researchers) the State Director made presentations of the new version of the system, attended to problems the district and block level staff pointed out to, and gave them CDs containing the new system. It was during the breaks of these meetings, interviews were conducted with some of the district and block staff. Listening to the overall interactions between the state and district/block teams also served as very useful sources of data.

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District/Block	No. Respondent
Ghandinagar region	1 RPC
Ghandinagar district	1 DPC
Ghandinagar block	1 M & E assistant
Mansa Block	1 BHO and 1 M & E assistant
Baruch District	1 DPC and 1 M & E assistant
Jamanagar corporation	1 M & E assistant
Surat District	1 DPC
Dagen District	1 DPC
Navasari District	1 DPC
Vododra District	1 DPC
Panchmhal District	1 DPC
Amerli District	1 DPC
Total Respondents	14

Table 1: Number of District and Block respondents

There were various other sources of data. For example, emails written from and to the state and district teams helped to understand specific issues being raised. Emails between the HISP India staff also helped to understand how they were trying to find solutions to the issues of support being raised. Practical engagement of one of the authors in some of the technical tasks such as cleaning up the problems in report generation and solving software bugs further helped to gain insights to the technical challenges to integration.

The data analysis was shaped largely within an interpretive framework, where different aspects of the nature and implications of social capital and its interaction with the integration initiative were inductively interpreted. Both the authors of this paper carried out their respective interpretation and then collectively tried to understand the variations in the interpretations. Subsequently, these interpretations were analyzed in the backdrop of the theoretical construct of social capital and integration to understand the specificity of the findings with the research phenomenon studied.

4. Research Setting

The case is set in the public health system of the state of Gujarat. There are two key factors involved in this research: HISP India, a NGO that was engaged in the design, development and implementation of an integrated HIS for the state; and, the Health department of the state who were the users of the system and the information being generated by the system. Since HISP India was a node in the larger global R&D network established by the University of Oslo, Norway, around HIS (called Health

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Information Systems Project – HISP) ongoing in about 15 different countries in Africa and Asia, they drew upon the expertise offered by Oslo research and masters students to address particular technical problems (such as for optimizing server performance). HISP India also tried to draw upon “social capital” nationally, especially the personal networks of the President of the organization, for example, in getting friends in local software companies to look at the software code or in getting their advise on establishing software testing protocols.

Gujarat is a state on the west coast of India with an estimated population of about 50 million (as per census India, 2001). The state is in the forefront of economic and infrastructure (including e-infrastructure) development in the country, reflected in the fact that nearly all district and sub district level health facilities have computers, and there is internet connectivity available down to the sub district (called block) level. With respect to the organization of primary health care delivery, the state is divided in to six sub-national regions, 26 districts, 250 Blocks, 950 Primary Health Centers (PHCs) and 450 Community Health Centers (CHCs). Each PHC has under it about 5-7 Sub Centers (SCs) that are responsible to provide outreach based services to the community.

Generation of health information starts at the SC which is the first contact point between the community and the primary health care system. Field level male and female nurses are expected to visit the villages assigned to them (one nurse typically is responsible for a catchment population of 5000) for providing various public health related services such as related to deliveries and immunizations. Data generated through this service delivery is first noted in the field diaries, then posted to various registers (typically about 15 to 20 in a SC relating to Malaria, TB, Family Planning, Antenatal care, Immunization etc), and finally taken on a monthly basis into the Form 6 which is then sent to the parent PHC for further processing and upward transmission. The health supervisor at the PHC level compiles this Form 6 data together with Form 7, which includes data from the PHC level service delivery, and prepares Form 7A (an aggregate of all SCs and the PHC services) which is then sent to the Block Health Office (BHO). The CHCs in turn compile their service delivery in Form 8 and also send it to the respective BHOs. At the BHOs, Forms 7A and 8 are aggregated to Form 8A and sent to their respective district offices where an aggregated Form 9 is compiled and transmitted to the State office. The schematic below summarizes this rather complex and fragmented information flow.

Hierarchical levels	Roles and tasks	Data and forms	Data flow	Aggregated forms
Subcenter	MHW/FHW Maintain registers/ visiting villages	TB, malaria, Family planning, Antenatal care etc.	→	Form 6
PHC/CHC	Health supervisor Compiles reports	PHC service delivery Form 6 + Form 7	← →	Form 7 Form 7a Form 8
BHO	Assistant compiles, Analyzes and sends	Form 8 + Form 7a	→	Form 8a
DHO	Assistant compiles, Analyzes and sends	Form 8a + Form 8a...	← →	Form 9
SHC Demography and Evaluation dep.	Assistant compiles, Analyzes and sends Health indicator data generation activities	Form 9	→	

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Figure 1: Fragmented information flow in the RCH program

It must be noted that the above schematic is primarily concerned with the RCH program. In the larger picture there are various other programs such as TB, Malaria and Integrated Disease Surveillance Program with their own respective information systems. This was however, not seen as a problem by some, like a district staff who remarked:

It is impossible to mix all the programs since they have their own agenda...what is wrong in working separately. they are working fine and it is very easily to monitor a single program than the whole.

Given this brief contextual background, we now discuss the specific initiative studied.

4.1. Implementation process of the integrated e-HIS

In what can be called as the first phase of the project, in early 2006, HISP India was invited by the State to implement an integrated HIS on a pilot basis at the block level in one district in the state (called Valsad). The notion of integration involved in this phase was taking the data entry forms of the different Reproductive and Child Health (RCH) related activities into one format (Form 6) in order to try and eliminate various redundancies and duplications. The project involved the deployment of the HIS application (called DHIS) at the BHO office computer and training the staff from the different facilities in the block to carry out the basic data entry and reporting activities. Similar processes were also undertaken at the district office. Six months into the process, the project results were evaluated, and happy with the outcome the State Health Commissioner extended the project to four further districts (Rajkot, Surendranagar, Kutch and Baruch). However, in early 2007, for various institutional reasons unknown to HISP, the State terminated the project stating their plan to use another application.

In late 2007, HISP India to Gujarat was recalled by the Health Commissioner as he was unhappy with the application bought in place of the DHIS, especially its weak analysis capabilities such as related to the generation of indicators and their graphical and map-based presentations. In the presentation made when recalled, HISP India emphasized the dashboard facilities of the application, and the value it provided in monitoring both the data quality and health status in the districts. To address the previous unsuccessful implementation of HISP India in the 5 districts, the Commissioner changed the model from a block level deployment to a server based state level deployment arguing that such a “top down” approach would help to develop ownership of the senior state managers who would then be able to provide the impetus for the lower levels of district and block implementation.

In retrospect, this implementation model has in general worked quite well with the

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district level implementation stabilizing to a large extent within a period of 2-3 months. This involved a server based deployment which has been the medium for the use of the integrated application. The very fact that all the districts were required to access the same application over the same internet infrastructure required the need to further integrate processes such as related to data entry and technical support. Further, the integrated application placed additional pressure on the performance of the database because of the sheer volume of data that needed to be stored, accessed and processed at one source. The server based application also created the need for developing new kinds of capacities both for the users (who previously had not worked on an internet based HIS), and for HISP India for whom it was their first such experience of implementation. Three challenges to integration related to server, database and capacity are now discussed.

4.2.1. Server Performance

The DHIS application was deployed on a Windows based server that was rented from a private provider based in North America. The server had a 2 GB RAM, which with time as data started to be entered for a few months became paralyzing slow. The slowness was further magnified by the local Wide Area Network in use in the State which had an extremely limited bandwidth. These technical constraints coupled with the institutional practice of the monthly data being entered by all the users in the last week of the month, meant that the server was significantly overloaded during this period and also with the peak working time in the day (10am to 8pm). For example, we tested that importing a file during this peak period took nearly 10 to 20 minutes, while outside this period (in the night) the same file could be downloaded in less than a minute. In the interviews and email correspondence conducted, the respondents expressed their disappointment regarding server performance, both while entering data and also in using the export-import functionality. The following email extract from a District staff to his state in-charge reflects this problem:

Respected Sir,

This is to bring to your kind notice that most District Blocks have completed of Data Entry in Offline DHIS2.0 for April-May-08 Sir. They export the Data by Data Set Wise as advised by HISP India Sir. But when they try to import the same Data to the online application, they are facing problem Sir... We are getting several calls from the Blocks everyday regarding the above problem Sir. Could you please request HISP India to find a solution to the above problem at the earliest Sir.

A DPC from another district summarized his server related problems in an email:

Subject: Problem in DHIS

Respected Sir,

As per your instruction to finish the DHIS entry, we have completed, 40% of entire, but we are facing a lot of problems.

- 1. Server is very slow.*

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2. *Data is not getting saved.*
3. *Software is not accepting zeros.*
4. *Software is getting closed automatically.*
5. *It is taking ½ hrs to save one entry and for the cursor to move to next column.*

Kindly help us in the above mentioned regards so that we can this entry as soon as possible.

In addition to the earlier problems of server performance, the 3rd problem related to “not saving zeros” was because HISP India in trying to find a solution of the ever expanding database analyzed the database to identify that nearly 70% of the data included was systematically being reported as “zero” or “blank.” This was pointed to the state HIS in charge, and it was suggested that we do not store the zero and blank values in the database.

While he was not agreeable to this suggestion completely, we were forced to do that to prevent the almost complete paralysis of the server application. Further, it was found that the same user name and password were being shared by multiple users which were magnifying the load on the application. To try and work around the slowness of the internet, some of the users tried to use the internet from a cybercafé with nearly the same results. The following email reflects this attempt and the outcome from the same:

On Mon, Jun 23, 2008 at 11:28 AM Hello

As discussed on Saturday since there is some problem with the importing process at my end, I tried to do it from cybercafé on Saturday, but it did not happen because the server was too slow. Then I went there yesterday early in the morning and I tried the same procedure again. But the same problem is still there. Now I did it from our computer for two other centers, it is giving the same message like 57% or 100% import process completed. But in the data entry screen, no such data is seen. Please again look in to the matter seriously. May be there is some problem of importing with my username/password. on Saturday, but it did not happen because the server was too slow. Then I went there yesterday early in the morning and I tried the same procedure again. But the same problem is still there. Now I did it from our computer for two other centers, it is giving the same message like 57% or 100% import process completed. But in the data entry screen, no such data is seen. Please again look in to the matter seriously. May be there is some problem of importing with my username/password.

Since dealing with server related problems was new experience for the HISP India, they tried to draw upon the “social capital” available through the Oslo network of PhD and masters students. Suggestions were made to enhance the server RAM, which was done first from 2 to 4 GB and then to 8 GB. Another suggestion was made to shift the server from a US based provider to one which was local to address the problem of data transfer speed. This was also done to an Indian based provider, whose server was however based in the United Kingdom. While all these measures have greatly helped in

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enhancing performance, the rapidly expanding database size and number of users continue to prove as challenges to performance. Further measures are being worked on including the optimization of the DHIS application, splitting the database and the application part of the DHIS into separate servers, and further moving the server to Gujarat.

4.2.2. Database Size

With time, as first all districts and then block level users started to use the application, the size of the database started to grow exponentially including data for about 8000 organization units. The HISP India team made a systematic analysis of the database, and wrote the following email to the State in charge:

Date: Thursday, August 28, 2008, 4:44 PM

At the end of every month we have 1,15,30,220 records in the database, of which 78% of data belongs to the Sub Centre (the lowest level of data collection). This 78% of sub-centre data decreases the performance of the application to a great extent. To increase the performance and optimization of the application; we suggest that we maintain 3 to 4 level of data in the online system. But if and when State official want to drill down to PHC or Sub Centre level, data can be made available on request. To do this we need to build a new functionality in the DHIS2 called "Aggregated Export" which aggregates the data to higher level from the field and then exports the data. By keeping the PHC and Sub Centre data at the district or block level, we will be reducing 94% of data load on the server. As and when required by the state official, specific PHC or Sub centre data can be made available for further clarification or scrutiny. This could be achieved by exporting the data in normal (Current) mode. At state office we suggest to maintain one high-end computer (which can act as local server or backup server) where all the data can be stored to easy access and retrieval.

The above email highlights a policy issue of what level of data should be maintained in the online database. While HISP India were of the firm view that data from the lowest levels (Sub Centre and PHC) should not be kept in the online database (but in a local server) which would reduce the load by more than 90%, the state insisted that they wanted an "integrated database" including all available data. Even the suggestion made by HISP India on not saving zero values was not acceptable, as reflected in the following comment by a district staff:

If we are worried about zeros at this stage in three months, what about the performance of the system in the long run.

The option of using a commercial database like Oracle was also explored by HISP India instead of the existing free MySQL, but the costs and licensing considerations quickly made the state to discard this option. The problem of the database remains still not fully resolved, but temporarily the situation was made under control with the 8 GB RAM server being able to handle the database load. But as the database size continues to grow, the problem is bound to resurface.

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At this stage, the main actor, in HISP India NGO joined National Health System Resource Center (NHSRC) as a consultant for the HMIS. This enabled the actor to make a suggestion on how to improve the existing HIS. One of the core suggestions were on setting essential data sets which serves as standard by bridging the fragmented program owned information flows. Specialists from the public health domain were invited by the consultant to get input in the process.

4.2.3. Capacity Limitations

There were capacity issues for both HISP India and the users. For HISP India, both the server and database related issues required a kind of expertise which did not exist in the current team. To solve them, they drew heavily upon the expertise of the Oslo doctoral students. Further, personal contacts of the HISP India in charge involving friends working in the sever business in private firms in both India and Oslo also helped to diagnose the problem and consider alternative solutions.

From the perspective of the users, many of the issues concerning the online system or the import and export of data were also new. A user from a district commented on their lack of experience in working with an integrated HIS:

In the current situation, we have specialists to manage each program. And I hope they are effective. If we move towards an integrated HIS, then we need to have multi-skilled professionals. That should be the priority focus

Contractual arrangements were set so that HISP India was seen to be responsible only for the development while the State was to take care of the capacity building processes. As a result, no HISP India staff was physically based at the state level. The problem with this arrangement was that the state staff that was responsible for capacity building did not themselves have the expertise to further do the job. To address this problem, HISP India suggested to the state to hire three technical staff for the areas of server, database and programming. But however, due to the prolonged procedures inherent in state recruitment, this suggestion could not be implemented.

In the absence of these physical support mechanisms, HISP India has relied extensively on electronic mail communication, telephone support and periodic visits by their members to the state. The positive aspect of this arrangement has been that many of the users have really developed skills to be able to work effectively with the application. For example, detailed emails were written by the HISP technical person in Delhi to the state, district and block level staff providing instructions on how to upload a new war file.

In summary, we have discussed issues of server performance, database size and capacity needs to serve as challenges in the implementation of an integrated HIS, which at the present mode is only including the information systems to support the Reproductive and Child Health program. At the national level, there are ongoing attempts to integrate other vertical programs such as related to TB, Malaria, and Blindness Control etc into the HIS. As these reforms are operational and transmitted to the state, there will be increasing pressures, technical and institutional, on the integrated HIS.

We now discuss the case material drawing primarily on the notion of social capital.

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5. Analysis and Discussion

The three dimensions of social capital identified by ¹² – structural, relational, and cognitive – provide an analytical framework responding our examination on the role of social capital in the implementation of the integrated e-HIS. This is now discussed.

Structural: This refers to the overall pattern of connections between the actors involved and the nature of the network ties that exist.

With respect to the case discussed, two aspects of the structural dimension are relevant. One concerns the top down implementation model adopted by the Commissioner, which first helped to create visibility of the initiative at the state level, and then senior state staff themselves took ownership and cultivated the virtues of an integrated system to the lower levels of the district and block. This kind of local ownership, often lacking in HIS implementation projects, helped to create a network of institutionalized relationships and understanding of mutual benefits between the different administrative levels of the health department. The state level saw the benefits with respect to the richer analysis capabilities that an integrated HIS provided, but to realize this they needed the district level staff to take up the system in an effective manner. This mutual relationship was enabled through the structural top down model of implementation adopted, where the authority carried by the state level was crucial in initiating the process, and then the ongoing support and handholding provided to the users helped to cement the mutually beneficial network of ties. This provided the basis for the creation of positive social capital that helped the implementation of the integrated e-HIS.

The second aspect of the structural dimension concerns the relation HISP India has with the health organization. This relation is mediated by the focal actor who is part of three significantly influencing organizations: University of Oslo, HISP NGO and National Rural Health Mission-India. From these organizations, the actor extensively draw advices, human and financial resources that help gaining trust from the health sector about initial implementation in Gujarat and the expansion of the system functionally (e.g. incorporating more health programs in the system other than RH) and geographically (including others states) which are basic to form integrated national HMIS. In general, this ability of the main actor to participate in deferent networks helped to create mutual trust between HISP India and the health department, with the latter learning to value the expertise, positive intention and objectivity of HISP India.

Relational: This focuses on the particular relations people have, including feelings of respect and friendship that influence their behavior. Right at the outset, the Commissioner valued and respected the expertise that HISP India introduced into the initiative. These feelings were enabled by the fact that the President of HISP India was also a university professor with extensive global experience in field level implementation of HIS projects. Similarly, HISP India held the Commissioner in the highest regard, and valued deeply his vision and focuses of an integrated HIS to support his and the State analysis needs. Gujarat undoubtedly is on the forefront of HIS use in India, and the personal status and visibility of the Commissioner nationally also helped to also provide HISP India with useful mileage in being accepted also by other states.

Outside the state networks, HISP India had strong personal relationships with friends who were working in technical positions in software firms both in India and Oslo. Whenever faced with a difficult technical problem such as optimizing server

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performance or using alternative databases, the HISP India President would call on his network of friends for advice, problem diagnosis and suggestions of alternative solutions. This very valuable advice was always made available without cost to HISP India who could then implement cost effective solutions.

Cognitive: This refers to those resources providing shared representations, interpretations and systems of meaning among parties. A key resource in this regard was the use of technology which while serving as the object of shared representations, also served as a medium to circulate these interpretations. Starting with the server based application, the medium of deployment for the integrated HIS, helped to focus the attention of hundreds of users to the same application in the “same physical location.” Frequent discussions on problems related to the server performance had the positive effect of creating a common understanding of the issues influencing the integrated HIS implementation. Common forums (such as of training programs) helped users to discuss similar problems and also to create user groups who could help each other to find solutions. The use of internet also proved very useful for users to directly be able to communicate with the HISP India technical team on the problems they were experiencing and be able to receive advice on how to address them. This direct line of communication was empowering for the users who could now subvert the traditionally existing hierarchical and centralized forms of communication.

6. Conclusion

In this paper, we have argued that the key role that social capital has played in the implementation of integrated HIS in the public sector domain of Gujarat state. On one hand, the existing social capital helped the implementation at many levels from enabling the introduction of the initiative to being able to start including other vertical programs. On the other hand, the deployment of the integrated application and the use of the internet helped the creation of additional social capital, such as personal relationships between the district users and the HISP India technical team based on mutual trust and confidence. This helps us to draw two key theoretical inferences. The first concerns the point that social capital is not something given and static, but is a process that grows over time both shaping and being shaped by the processes of implementation. The second concerns the point that ICTs including internet and the e-HIS itself plays a key role in further building social capital that is helpful to integrate the fragmented HIS. The integrated application provided a common focus and site for people to come together and discuss similar problems and jointly seek and identify solutions. Further, the use of the Internet helped to take these common resources and circulate it across a larger social group enabling the creation of a broader base of social capital.

A major recommendation that can be drawn from this paper for future HIS implementers in developing countries is the realization of the role of central actors. The central actor, with his/her social capital plays a major role in aligning interests of various actors that are involved in the establishment of integrated health information system. This implies that success in establishing a successful integrated information system partly lies on the strength or the social capital of individuals from the

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implementer side. Therefore, implementers need to have an actor(s), who has (have) good social capital in the leading position of their project to bring about the desired change. This is especially important in developing countries where donors have been mentioned to be a contributory factor for the fragmentation of the HIS.

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Paper 3:

Challenges and Approaches in Translating Data to Information and Information to Knowledge: Case Study from the Gujarat State Health System India. Sahay, Sundeep; Lewis, John; *International Federation for Information Processing 9.4*; 2009-05-26 - 2009-05-28. UiO

Challenges and Approaches in Moving from Data to Information to Knowledge: Case Study from the Gujarat State Health System India

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Abstract: In the domain of Health Information Systems (HIS) in developing countries, huge amounts of data being collected by the public health systems and very limited amount of that actually gets translated into “Information for Action”. Converting raw data into comparable frame of references and putting this information effectively into practice, and learning from this experience represents the translation of data to information to knowledge. While in theory, this translation from data to information to knowledge may appear simple and linear exercise, in practice it is extremely difficult to achieve. This process of translation from data to information to knowledge involves addressing various social, technical, institutional challenges. This paper seeks to empirically analyze some these existing challenges inherent in this translation process, and how they may be addressed. Empirically we draw upon experiences of the design, development and implementation of HIS with in the public setting of Gujarat health department.

Keywords: Data, Information, Knowledge, Gujarat State

Challenges and Approaches in Moving from Data to Information to Knowledge: Case Study from the Gujarat State Health System India

1. INTRODUCTION:

Research in the domain of Health Information Systems (HIS) in developing countries has repeatedly lamented that while huge amounts of data is being collected by the public health systems, very limited amount of that actually gets translated into “Information for Action” [Braa et al 2004]. Two important components are involved in this translation: “information” and “action.” Information implies taking raw data and putting it into a frame of reference or context. For example: Number of children give BCG vaccination represents raw data measuring number of BCG antigens administered with in a particular health facility and time period. This data in itself is without a comparable frame of reference, for example in relation to how many children were needed to be given this particular service. As a result, this data is not “actionable”, as it cannot be compared with performance in relation to other health facilities or time period. This comparison done through “indicators” arrived at by comparing the raw data in relation to the target population of children under one year who were to be given BCG vaccination in the above example. This coverage indicator (BCG vaccination given / Target populations) can be compared and evaluated with other facilities/periods, and also with expected performance. A health manager can use these indicator to take relevant “action” such as improving outreach, strengthening supply of required stocks or increasing level of education and awareness related to importance of immunization. Putting this information effectively into practice, and learning from this experience represents the translation of information to knowledge. In this way, knowledge helps us to conduct our existing practices better and also introduce new practices.

While in theory, this translation from data to information to knowledge may appear simple and linear exercise, in practice it is extremely difficult to achieve. A Health Metrics Network (HMN) study categorized HIS into three groups. At the lowest level, we have HIS that are basically sufficient to do the routine data processing activities of registration and report generation. At the next higher level are the systems that show some examples of use of information such as the graphing of indicators and they being pasted at the wall of the health facilities. At level 1, are HIS which primarily process data, in level 2, information is produced and level 3 systems involves knowledge. The HMN report based on a seven country study reported that only Thailand was at level 3 while most others (for example: India, Ethiopia, Tanzania) at level 1. Level 1 or “data led” systems don't often move to “action led” or level 2/3 systems (Sandiford et al, 1992). For various reasons such as the fragmentation of system both manual or computer based [Chilundo 2005]. Heywood and Rhode (undated) describes the “chicken and egg” problem where because data is poor it not used as information, and the more it is not used the poorer the quality of data remains.

This process of translation from data to information to knowledge involves addressing various social, technical, institutional challenges. For example lack of appropriate tools to process raw data into easily useable format for managers can inhibit translation the HIS to support information. Further, managers must have the capacity to analyze, interpret and use data. In an institutional context support such practices of use. This paper seeks to empirically analyze some existing socio, technical, institutional challenges inherent in this translation process, and how they may be addressed. Empirically we draw upon experiences of the design, development and implementation of HIS with in the public setting of Gujarat health department. Learning from this experience can provide useful insights to other states in India

and also other developing countries. Further this analysis can also provide some feedback to the Gujarat health department on how to move even further down this information to knowledge transformation.

The rest of the paper is organized as follows: In the next section, we discuss some relevant literature on data, information, and knowledge and their inter relationship. Following this we present the background and the research methodologies and then the case study itself with the focus on describing the process around the use of information for action. We then analyze the case study with an attempt to abstract the learning in terms of challenges and approaches in moving from data to information to knowledge. Finally we present some discussions and conclusions on this topic.

2. THEORETICAL FRAMEWORK: Data, Information and Knowledge.

The question of “what is knowledge” has been articulated variously, for example as “abstract, universal, impartial and rational,” in ancient Western philosophy (Coakes 2004, p. 408). Knowledge viewed in such a perspective reflects a commodity emphasizing that it exists prior to and independent of the knowing subject. This view is in contrast to the practice-based lens that assumes knowledge is created and distributed in the act of appropriation (Walsham 2001, Yakhlef 2002). Such a contrary viewpoint emphasizes knowledge as being socially constructed, context specific, largely tacit (Polanyi 1967) and situated in practice (von Krogh 2002; Suchman 2002). This view is contrary to Nonaka (1991) and Nonaka & Takeuchi (1995) argument that tacit knowledge may be captured and converted into explicit, sharable form in organizational contexts (Thompson & Walsham 2004).

Arguments have also been made for the adoption of a more human-centred approach (Walsham 2001), which emphasizes acknowledgement of the distributed and multiple nature of knowledge (Blackler et al. 2000). Nicholson and Sahay (2004), in the context of offshoring of software development, argued how aspects of knowledge drawn upon by individuals for successful implementation of such projects was deeply embedded, and could not be seamlessly circulated across time, space and cultural boundaries. The author gave example of the explicit parts of knowledge that could be relatively easily coded and transferred across countries, but its tacit components were not easily shareable, for example the different subjective understanding of time in a cultural context.

Practice-based conceptualizations of knowledge sharing is based on understanding how people follow work routines in everyday organizational life, imbibe key learnings, and how knowledge is negotiated and shared. Gheradi (2000) discusses this concept through the example of a carpenter hammering a nail, which brings forth the relationship between subject, object, the context and knowledge. She emphasizes an emergent idea of practice of people who have knowledge in their heads which is appropriated and transmitted in everyday life.

In the context of public health systems, the subject of this study, we are intended in examining the practices around health information systems. At the level of data, the practices involve how health workers collect data, record it in registers, and then report it in the designated forms and periodicities. At the level of information, the practice concerns how the collected data is processed into indicators, converted into graphs and charts, and analyzed and interpreted. At the level of knowledge, practices concern how the processed information is discussed and acted upon to improve public health system.

The focus of the paper is on studying the various practices around knowledge creation and use within the public health systems in Gujarat state in India. A practice based view is drawn upon for this analysis to understand the relation between users, the different forms of knowledge in play, and the context with in which knowledge is negotiated, appropriated and shared.

3. RESEARCH METHODS:

Both the authors of this paper have been engaged in the design, development and implementation of HIS over the last decade in India. Specifically, in Gujarat the efforts have been ongoing since 2005, starting with 1 district, then 5 districts, and finally at the state level going downwards to the districts and sub-district. In this paper, our primary focus is on the third phase where we started at the state level, trying to build the capacity and tools to conduct analysis (converting data to information), and then follow the practices that try to facilitate the informational processes through which this information is converted to knowledge.

The research has been inspired by the “networks of action (research)” approach advocated by Braa et al (2004) for the development of sustainable and scalable HIS in developing countries. The basic principle underlying this approach has been the need to enable practices that support the creation of networks in which people can learn together, and share experiences and learning within the network. With respect to our case, the focus was on trying to build tools to conduct health information analysis, support the development of capacity to use the tools, present the importance of using health information, and also spreading the capacity and experiences of such analysis from the state to the lower levels of districts and sub districts.

The focus has been on conducting a detailed analysis of the state data on two key parameters: one, data quality and, two, the health status of the state and district levels based on the data collected. For this analysis, data already collected by the state from the months of April to August 2007 in Excel formats was imported into the DHIS 2 (the HMIS software being implemented in the state), which was analyzed on the above two parameters. For example, we could see the % of data elements being reported as “0” or blanks, which allowed interpretations around the non-use of data elements.

Prior to the data analysis, a situation analysis was conducted to understand the prevailing organizational structure, and also the informal working relationships within the organizational set-up. More specifically, we focused on understanding the existing data flows, and the various data input-output formats in use. This helped to identify redundancies in data elements, duplications in data entry procedures, and present these findings to the concerned stakeholders through discussions and consultations. This process was aimed at the development of a “minimum data set,” and then subsequently to the “essential data set” by seeking to link data collection with its use in the generation of indicators. This provided the basis for building a blueprint for how data can be converted into information required for action. .

During the course of the research, both the authors have overtime literally participated in hundreds of meetings, discussions, and presentations with the health functionaries at various levels. Meetings at times were formal to present an overview of the project, or an evaluation. More often there were informal meetings to discuss briefly project status, or to inform

administrators of the problems being experienced (for example, hardware problems in the field which were not being rectified in time). In addition, there were formal presentations to the state administrators or national level program managers on approaches to HMIS design and use. Various other forms of data collection were used including that of the e-mail and mobile phone. Extensive communication over email took place between the authors with and the other HISP team members, or developers in Oslo and also with the Gujarat State HIS team members. These exchanges helped to understand project progress, troubleshooting, dealing with administrative issues, support software development processes by conveying new requirements or seeking clarifications on new development. Mobile phone based conversations played a key role in data gathering especially between ourselves and other HISP team members, and also with State officials. During phone conversations, information was exchanged, problems discussed, solutions proposed, and also important decisions taken. Further, various kinds of secondary data were collected such as State health statistics reports and performance of different health programs.

4. CASE STUDY:

The case study is set in Gujarat state, situated on the west coast of India. The public health care system in the State consists of primary, secondary and tertiary level institutions, including at the primary level 7274 sub-centres, 1055 Primary Health Centres (PHCs) and 259 Community Health Centres (CHCs), district and sub-district hospitals at the secondary level and specialized hospitals and medical colleges at the tertiary level. While health is primarily a state subject, Gujarat like other states also implements various national programmes including for TB, Malaria, Leprosy, Blindness Control, and Vector Borne Diseases. With respect to the HIS, the implementation is managed by Director, Monitoring and Evaluation, and in addition to the state specific analysis, there are various other national reporting needs that the state has to comply with.

Responsible for implementing the HIS in the state is the Health Information Systems Program (HISP), India, a node in the broader global research and development network initiated by the University of Oslo in 1994, and now ongoing in various countries in Africa (Ethiopia, South Africa, Tanzania, Malawi, Botswana, Nigeria etc) and Asia (India and Vietnam). HISP India is a not-for-profit organization which aims to develop sustainable computer-based HIS for public health systems at the state and also at the national level. A key focus of their efforts is to support the “use of information for local action” especially at the state, district and sub district levels. A key tool in this process is the Free and Open Source Software called DHIS (District Health Information Software – Version 2) which in addition to the tools for routine data processing and reporting also provides flexible tools for data analysis and presentation such as through the generation of charts, graphs, and maps. While building the tools is a relatively easy technical task, the harder challenge is the building of capacity and culture of the health department in the use of these tools, and the integration of information generated into action taking processes such as planning and monitoring

Case narrative:

Gujarat State health department approached HISP India after obtaining information about the NGO's experience and achievements in strengthening HMIS in three Indian states through their website (www.hispindia.org). Following the initial presentation meeting which was chaired by the Commissioner of Health, a government order was issued to HISP India to pilot

the HMIS initiative in one of the district. After successful evaluation of the project after 3 months, the project was extended first to 5 districts which took place over 6 months, and then after a 5 month break was reinstated at the state level. A key driver of the reinstated was the design and development of a *dashboard monitoring system (DMS)* to monitor critical indicators (for maternal and child health and family planning) through the use of graphs, charts and maps to monitor these indicators. These DMS also allowed the stakeholders to compare the routine health data against state and national targets, survey figures and also the Millennium Development Goals (MDGs). The development of the critical indicators involved an extensive process of discussions with various health program managers to identify and freeze the indicators. The process also included the mapping of the data sources for the calculation of each indicator. Another significant development concerned the integration of a Geographical Information Systems (GIS) module with the DHIS 2 allowing the users to view all the indicators on maps, which served a very effective tool for monitoring health performance across geographical areas requiring intervention.

At the time of reinitiation, the Commissioner of Health asked HISP India to restart the project as he could not get the desired analysis from the other software applications that were tried in interim. For this, the state provided five months data from 25 districts in an excel format (called Form 9) in which the district reported monthly to the state. It is important to note that this format contained 34 sections, 1128 data elements and NO indicators. HISP India imported this excel sheet data in to the DHIS2 software along with data from multiple other sources (like survey data, population data, targets, and other baseline data) to enable data comparison and triangulation. Further, the 94 critical indicators identified by the State were also included in the dashboard to enable DMS based analysis. These 94 indicators were further categorized in to 6 groups: Maternal Health (26); Child Health (26); Family Planning (9); Program Support (8); Access; and Impact indicators (9). Along with these indicators, the database was populated with 20 data validation rules (for data quality analysis) formulated through discussions with various health program experts in the state. Now the indicators were ready to be viewed by graphs/charts and maps.

On October 13 2007, HISP India presented its analysis to the State officials based on the above data. Key aspects of the analysis are now presented.

Data Input Coverage:

Each district was expected to report monthly on 1128 data elements, corresponding to 67500 data entry points for 25 districts over five months. Table 1 below summarizes the “zero analysis” results showing that nearly 46.91% (31667) of the data values were zero. Nearly 80 data elements (7% of total routine data elements) had zero values for all the 25 districts for five months. Table 2 shows the number of data elements that were consistently reported as zero values in each district over the five months.

Sl. NO	District Name	No of Zeros	Total Entry	% of Zero	Sl. NO	District Name	No of Zero	Total Entry	% of Zero
1	Ahmedabad	2865	5625	50.93	14	MEHSANA	2687	5625	47.77
2	AMRELI	2692	5625	47.86	15	NARMADA	2673	5625	47.52
3	ANAND	2880	5625	51.2	16	NAVSARI	2717	5625	48.3
4	BANASKANTHA	2381	5625	42.33	17	PANCHAMAHAL	2393	5625	42.54
5	BHARUCH	2540	5625	45.16	18	PATAN	2814	5625	50.03
6	BHAVNAGAR	2666	5625	47.4	19	PORBANDAR	3255	5625	57.87
7	DAHOD	2460	5625	43.73	20	RAJKOT	2639	5625	46.92
8	DANG	3546	5625	63.04	21	SABARKANTHA	2105	5625	37.42
9	GANDHINAGAR	2917	5625	51.86	22	SURAT	2574	5625	45.76
10	JAMNAGAR	2459	5625	43.72	23	SURENDRANAGAR	2586	5625	45.97
11	JUNAGADH	2561	5625	45.53	24	VADODARA	2675	5625	47.56
12	KHEDA	2712	5625	48.21	25	VALSAD	2549	5625	45.32
13	KUTCH	2454	5625	43.63	Gujarat		31667	67500	46.91

Table 1: District wise % of zero values

Sl. NO	District Name	No of Data Elements	%	Sl. NO	District Name	No of Data Elements	%
1	Ahmadabad	456	40.53	13	KUTCH	346	30.76
2	AMRELI	353	31.46	14	MEHSANA	395	35.11
3	ANAND	459	40.8	15	NARMADA	377	33.51
4	BANASKANTHA	371	33.06	16	NAVSARI	455	40.44
5	BHARUCH	401	35.64	17	PANCHAMAHAL	296	26.31
6	BHAVNAGAR	361	31.55	18	PATAN	450	40
7	DAHOD	339	30.13	19	PORBANDAR	527	46.84
8	DANG	553	49.16	20	RAJKOT	413	36.71
9	GANDHINAGAR	472	41.96	21	SABARKANTHA	297	26.4
10	JAMNAGAR	367	32.62	22	SURAT	371	32.98
11	JUNAGADH	371	32.98	23	SURENDRANAGAR	345	30.67
12	KHEDA	402	35.73	24	VADODARA	418	37.16
				25	VALSAD	364	32.36

Table 2: District wise % of data element with zero values for 5 months

Dash board Indicators:

Out of 97 critical dashboard indicators, only 47 indicators could be processed and calculated due to the non-availability of required data elements. Only 60 data elements (5.32% of total) were being used for the calculation of the 47 indicators indicating a high degree of mismatch between the data collected and their conversion to information. Table 3 shows the data elements used per indicator category.

Category	Total Indicator	Calculated based on data available.
Maternal Health	26	17
Child Health	26	20
Family Planning	9	6
Program Support	8	0
Access	16	1
Impact	9	3
Total	94	47

Table 3: Group wise distribution of calculated indicators

GIS based analysis: Translation of data to information:

The 47 indicators that could be calculated from the existing data were then mapped using the GIS to identify how different districts were faring on indicators for different time periods. An example of this transformation from data to information is provided below first in a map and then in tables.

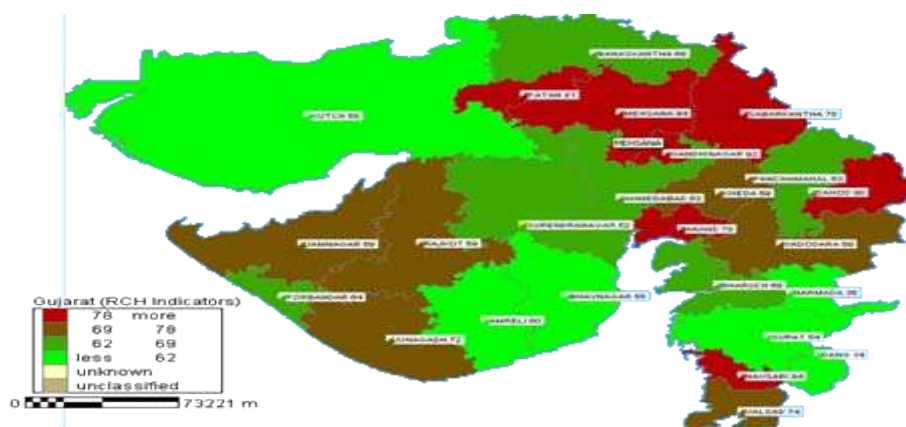


Figure 1: % of Institutional Delivery From Apr-Aug 07

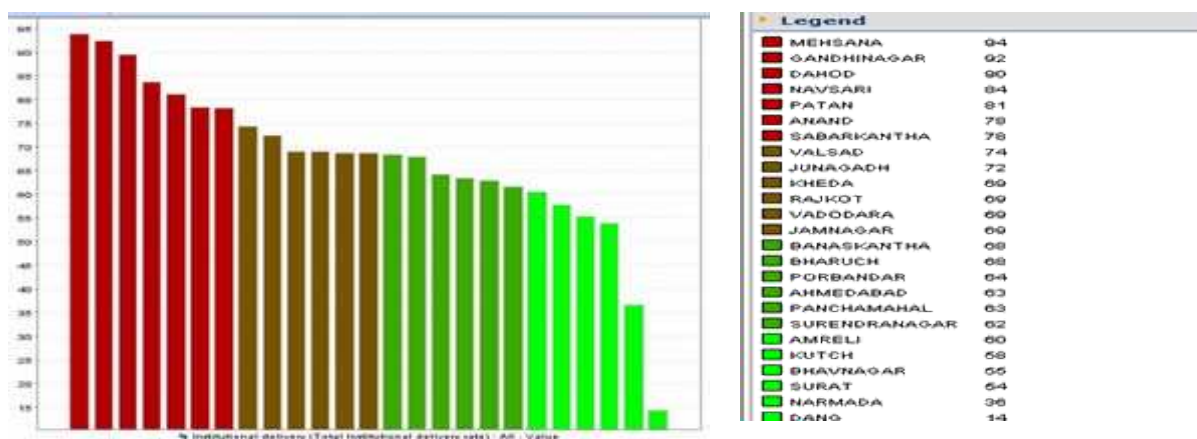


Figure 2: District wise achievement of % of institutional Delivery Apr – Aug 07 w.r.t map colour

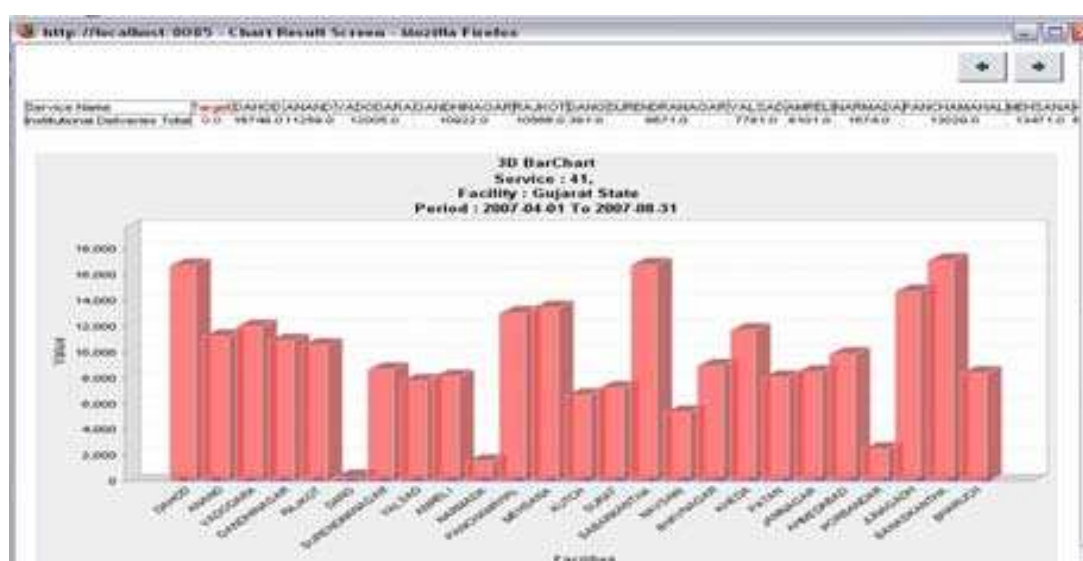


Figure3: District wise achievement of % of institutional delivery Apr- Aug produced by DHIS2

Indicator Name	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Average
% Mamta day sessions held	110.7	107.6	107.5	107.7	105.2	107.7
% Polio Dosage at Birth	32.8	30.0	35.0	31.9	29.1	31.8
% BCG Vaccination	88.6	75.8	112.1	109.9	106.1	98.5
% DPT3 Vaccination	111.7	108.8	102.1	104.2	100.5	105.5
% Polio3 Vaccination	106.2	93.7	100.6	97.8	93.3	98.3
% Vitamin-A Doses	111.2	103.7	105.8	102.1	106.8	298.3
% Fully Immunized Children	48.0	51.1	57.5	60.8	62.1	55.9
% DT-5 Vaccination	1.0	1.4	1.9	6.1	14.7	5.0

Table 4: Period wise distribution of Indicators for Gujarat State

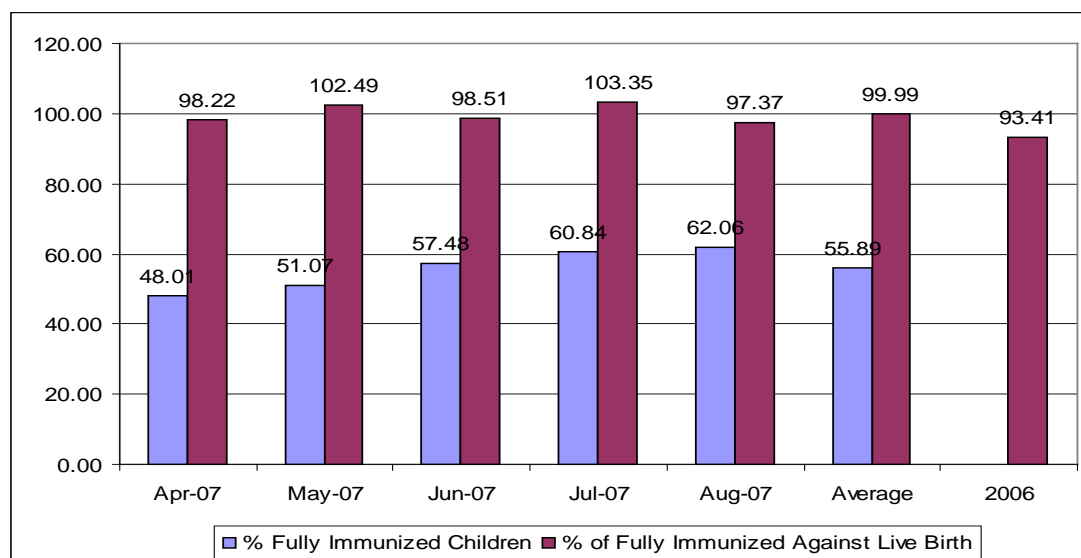


Figure 4: % of fully immunized children against expected live birth and reported live birth

The above Figure 4 describes the use of different denominators in calculating the indicator relating to % of fully immunized children. The first bar takes as the denominator “expected live births” and the second “reported live births”. This variation in values of same indicators due to different denominators used clearly reflects the nature of public health related knowledge that is required by the user in the appropriate use (or misuse) of indicators.

Based on the above analysis, some key recommendations were presented to enable the transition from data to information:

- 1) Need to examine each of the indicators, what the data says, and link with actions of intervention.
- 2) With the existing data elements being captured, many other useful indicators can be calculated for example: % of Post Natal Care third check up in 6 to 10 days to Total deliveries registered.
- 3) Given that only 5.32% of data elements are being used for calculation of indicators, and nearly 50% of indicators cannot be calculated, there is the need to review the present data with the underlying principle of “collecting only that data that contributes to improving action”
- 4) As many existing indicators do not conform to standard definitions (WHO sources for example), due to have spelling errors and are wrongly phrases, there is an urgent need for standardization and there presentation in a standard dictionary.

We now provide some examples on the need for standardization and data triangulation:

I) Standardization need

As per WHO (World Health Organization) definition % of BCG drop outs to Measles = Total children given BCG – Total children given Measles divided by Total Children given BCG. The formula used by the State for the same indicator uses a different denominator than above which is: Total children give BCG. Using these different formulaes yeilds different results as

depicted in the graph below, with the state definition presenting a much more positive picture than that calculated using the WHO definition.

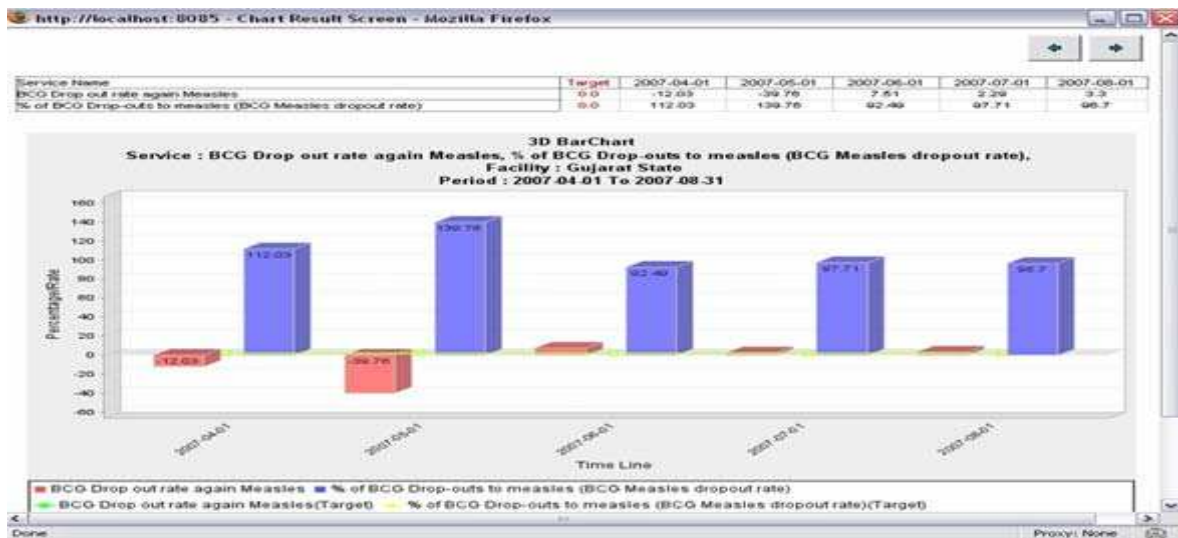
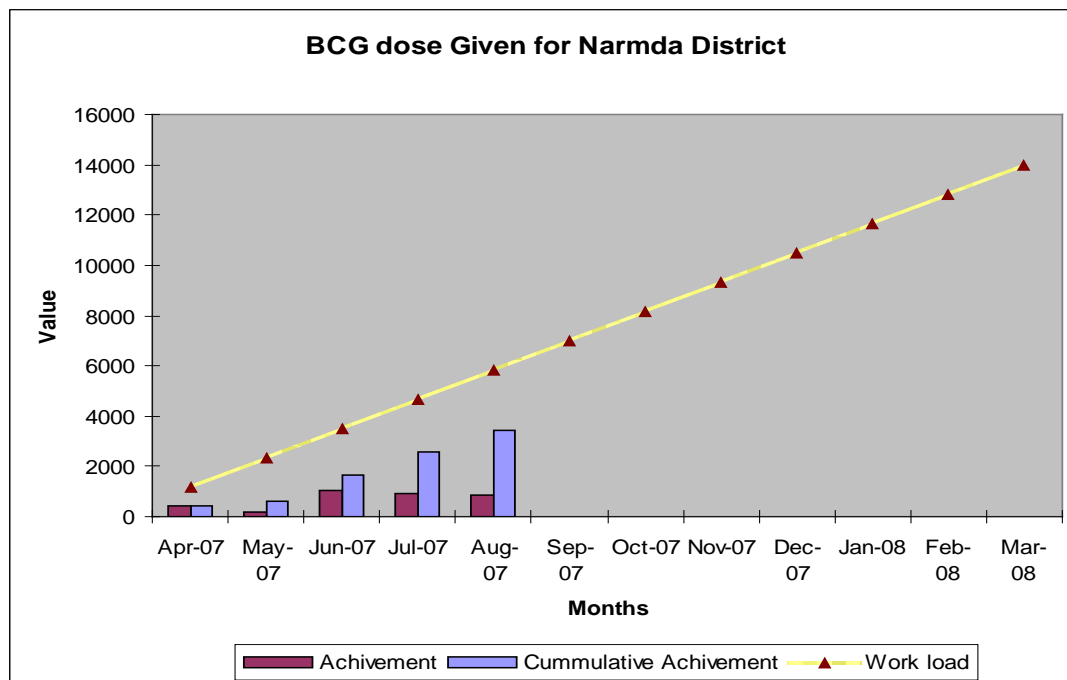


Figure 5: % of BCG drop out against Measles WHO definition Vs. State definition

Data Triangulation need: Comparison of performance with targets:

Another interesting analysis (see Figure 5) shows the achievement for a district against the workload, for example BCG doses given. The first bar represents the monthly achievement and the second bar (blue) represents the cumulative achievement and the yellow line shows the cumulative targets. By projecting the annual workload against the cumulative achievement, the manager can assess the performance of that district and identify action areas.



4) Data Triangulation need: Comparison of routine and survey data:

The National Family Health Survey (NFHS) is a large-scale, multi-round survey conducted in a representative sample of households throughout India. Three rounds of the survey have been conducted since the first one in 1992-93. The survey provides state and national health information on key health parameters. Mutual comparison of routine and survey data (showed in Figure 6 below) provides an indication of the veracity of the routine system (seen to be reasonably accurate with respect to institutional deliveries)..

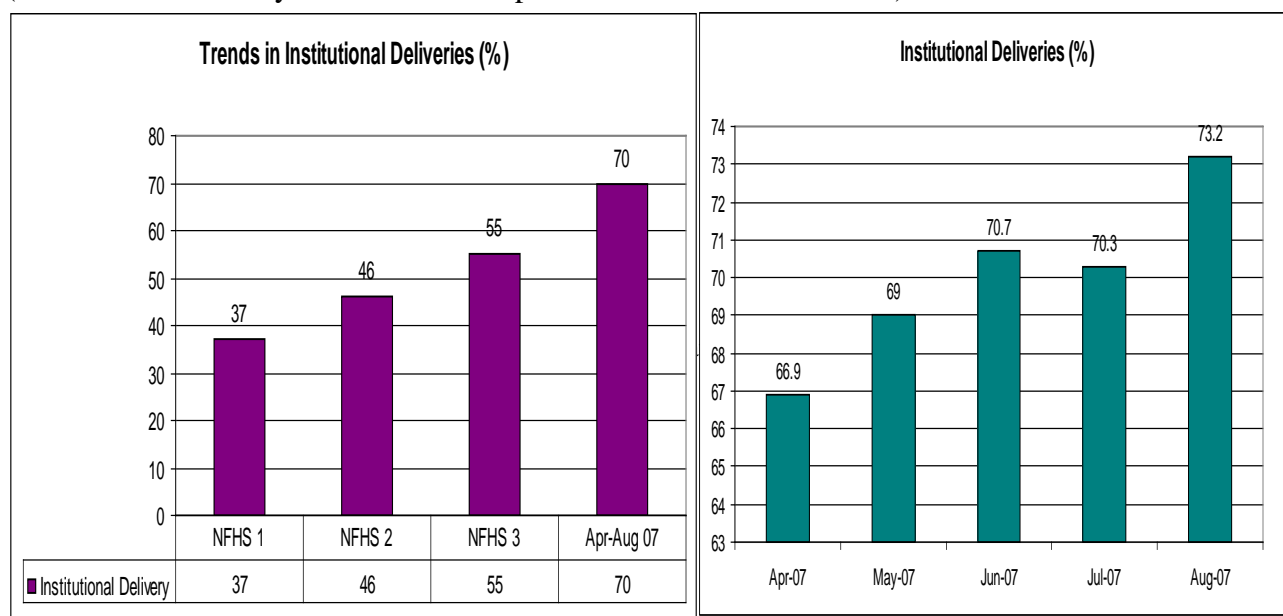


Figure 5: Cumulative achievement Vs Workload of BCG dose for Narmda District, Gujarat State

5. Discussions and conclusions

While understanding the nature of data related problems and the kinds of data-indicator mismatches that exist in the data-information translation, a key challenge concerns “what can we do about it?” In this regards, the usefulness of a simple and practical approach called SDA (Symptom, Diagnosis and Action) was developed. This identification of the problem is termed as ‘*Symptom*,’ through eyeballing raw data by a person with public health knowledge and experience to detect abnormalities. Further interrogation of data leads to a ‘*Diagnosis*’ of the problem to identify causes achieved through drilling down to facilities or periods or with different data categories. Diagnosis leads to the development of ‘*Action*’ to correct the problem through policy implications and establishing protocols for action. Some examples are now provided.

Figure 7 clearly shows the abnormality in the % of total sterilization at the state level for the month of July 2007 where the sterilization rate is 84.32% as compared to the 5% average of other months. This could be termed as the ‘*Symptom*’ of a problem. Figures 8 and 9 shows the ‘*Diagnosis*’ of the problem, where by drilling down shows the abnormality in one district (Vadodara) and one specific data element (Male Sterilization). Resulting ‘*Action*’ could be in the form of developing policies and rules such as related to who has the authority to make changes when violations are identified, how these changes made are reflected back in the original database, what action has to be taken to ensure that such problems do not repeat. More systemic corrections could be in the form of creation of standards in definition, formats, procedures and a comprehensive data dictionary.

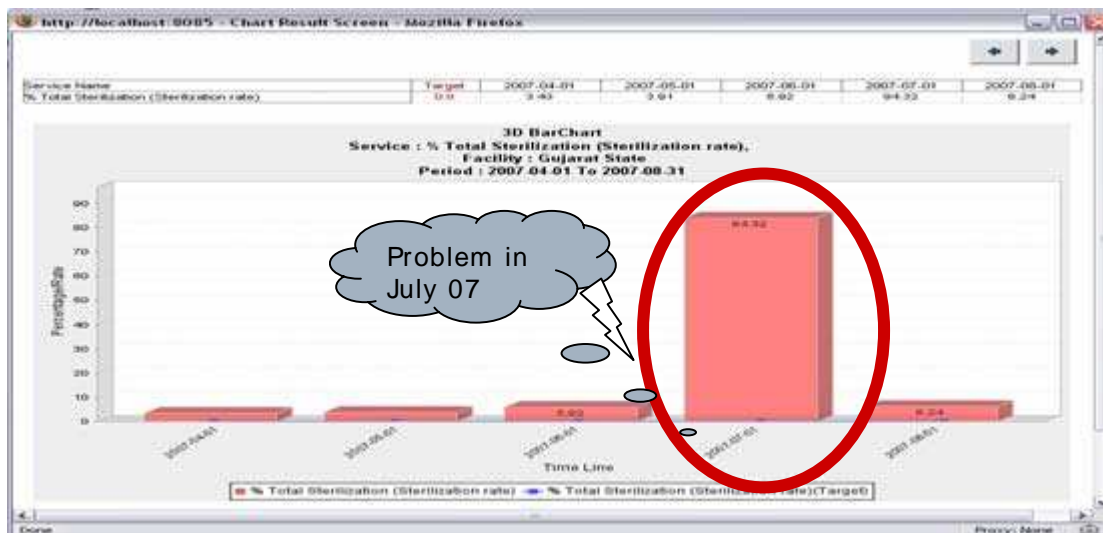
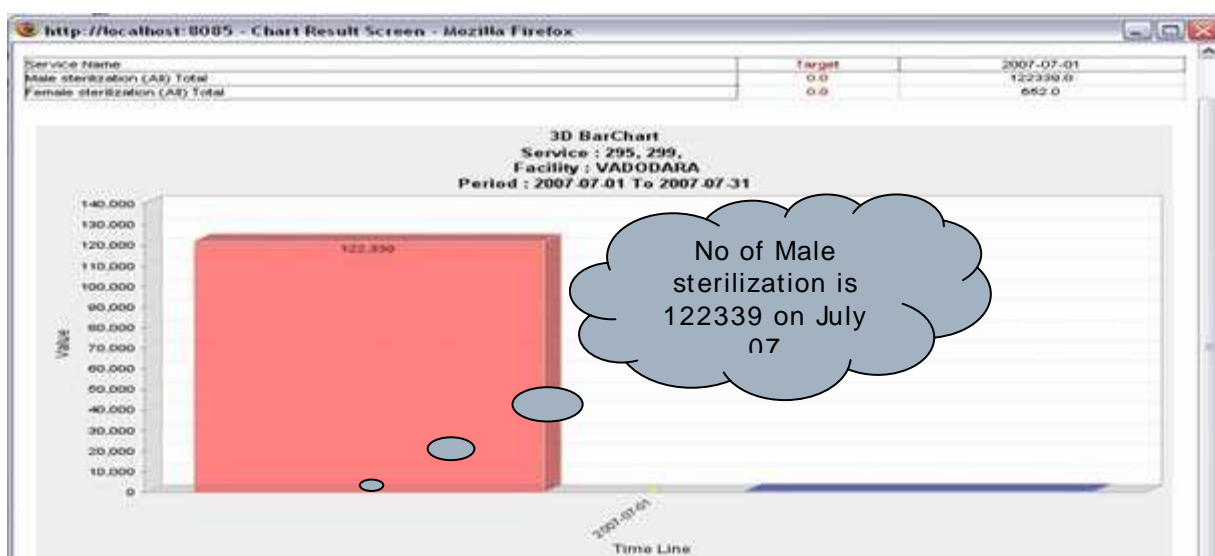
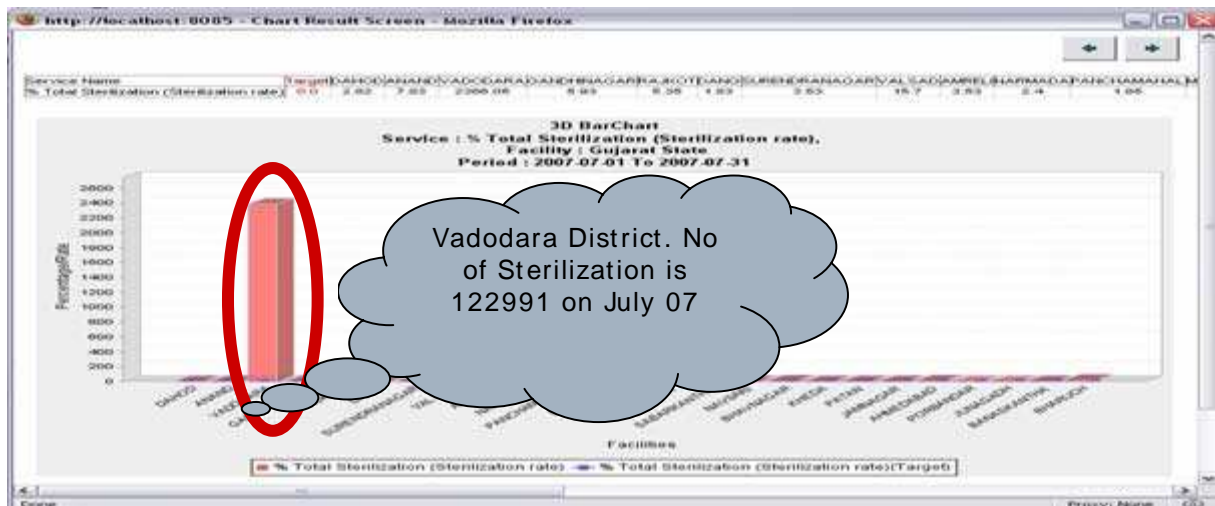


Figure 9: Diagnosing problem: Drilling down to Vadodara for July and with data element category



Technological tools such as the DMS and the GIS can help in the easy conversion of data to information, but to move to the next level of knowledge is a relatively more complex endeavour. Information can be seen as a necessary condition in the translation process, but is

surely not sufficient. This translation, as the “practice based view of knowledge” has argued requires the inculcation of relevant practices. In the context of the case, the Commissioner Health has tried to move in this direction where he personally oversees review meetings in which indicators are discussed and action points are identified. However, this remains a largely formal exercise, while processes of knowing need to be embedded in everyday practices and routines. To enable the cultivation of such practices, there needs to be a culture in which information based action is valued and promoted both through formal and informal means. Without this, as is in the case above, the HIS can only enable the translation to information and not beyond. The need then is to cultivate “networks of knowledge” rather than the “hierarchies of knowledge” that currently exists.

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Paper 4:

Strengthening Metis Around Routine Health Information Systems in Developing Countries. Sahay, Sundeep; Lewis, John. *Information Technologies and International Development* 2010; Volume 6. (3) p. 67-87. UiO

Research Article

Strengthening Metis Around Routine Health Information Systems in Developing Countries

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Abstract

James Scott argues that, in state interventions, there are significant attempts to simplify, standardize, and make legible processes which, by definition, are too complex to realize such changes. Scott also argues that, as a result, many state interventions have led to large-scale tragedies. The alternative provided by Scott is to focus on metis—a form of local and practical knowledge which is aimed at local problem solving. In this paper, Scott's notion of metis is applied to public health information systems in developing countries to examine how the trend of traditional non-use of systems can be corrected. Two sets of implications are developed with respect to metis: the first at the level of system design, and the second relating to institutional agency in creating an environment in which metis can flourish.

1. Introduction

James C. Scott (1998), in a telling account of the use of state power in initiatives aimed at social transformation, argues that these efforts have led to large scale tragedies. Examples used by Scott to demonstrate these failures include the creation of permanent last names, the standardization of weights and measures, the establishment of cadastral surveys and population registers, the design of cities, and the organization of language. The common theme running through all these failures is the attempt by the state to make society legible by trying to transpose complex, illegible, and local social practices onto a standard grid, a place where, in their simplified form, the practices could be centrally recorded and monitored.

Scott's account of the nature of state power resonates with the concept of governmentality proposed by Michel Foucault as the art of government in a wider sense. Government exercises power not only through the instrument of state politics using hierarchical and top-down means, but also through including forms of social control in disciplinary institutions, such as schools and hospitals. Foucault defines governmentality as the following:

The ensemble formed by the institutions, procedures, analyses and reflections, the calculations and tactics that allow the exercise of this very specific albeit complex form of power, which has as its target population, as its principal form of knowledge political economy, and as its essential technical means apparatuses of security. (1991)

Apparatuses of security include means of surveillance and control, as well as particular practices that should lead to these ends. Gyan Prakash argues in his book *Another Reason* that, in governmentality, the chief

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concern is the population, “which becomes available as a category through census classifications, epidemiological surveys and regulations and statistics” (2000, p. 10). Similarly, Scott argues that the state uses mechanism such as censuses, cadastral maps, and identity cards, as well as statistical bureau and internal security apparatuses to simplify society and make it legible. Scott argues that these attempts are doomed to fail for two main reasons: “The proponents of these plans regard themselves far smarter and farseeing than they really were and, at the same time, regard their subjects as far more stupid and incompetent than they really were” (1998, p. 343).

The above statement reflects the power–knowledge relationship, where those exercising these plans see themselves as possessing the power of science and technology, while the recipients of the plans are seen to be ignorant, or worse still, as possessing irrational knowledge which would prove to be counterproductive to the implementation of the plans (Puri, 2006). In the field of public health, the use of statistics and epidemiological analysis represents this form of knowledge, based on which, only the government can apply public health interventions. This represents a form of governmentality aimed at exercising simplification and legibility on a population and their relation to diseases. Hacking (1990) describes how statistics were used in Europe in the mid-19th century for the “taming of chance,” and for making the world more apprehensible. Statistical data and laws help to make the world more controllable by discerning order and regularities in indiscriminate events, such as epidemics, so as to control natural and social processes. Prakash argues that, in colonial India, statistics were thus used by the British in a relentless fashion to create order and form the basis for public health reform. For example, he writes the following:

The desire to bring diseases and deaths under the statistical gaze represented an effort to relocate the indigenous population, to bring it under the colonial complex of men and things, where its irregularities in relation to climate, topography, habits and habitation could be observed and acted upon. Government officials searched for agencies that reached down to the village in order to collect vital information on births and deaths, and complained that inaccurate diagnoses and medical treatments provided by indigenous practi-

tioners enabled sickness and mortality to escape the net of statistics. (2000, p. 135)

While Prakash’s account is from colonial Indian times in the mid- to late 19th century, we find in contemporary times, too, that many developing countries, including India, continue to harness and use statistics to simplify complex phenomena, such as maternal deaths, into mortality indicators which can be measured and controlled. Complex social and health-related processes, such as underage marriage of women, the prevalence of diseases like HIV and malaria, existing conditions of anemia, and the absence of effective access to basic emergency obstetric services—all important determinants of maternal deaths—are converted into output indicators of “maternal mortality rate,” which the state will then seek to control and manage. This issue is of contemporary and urgent importance, as most developing nations are pursuing their Millennium Development Goals (MDG) for addressing problems such as maternal and child health. While the state needs to monitor macro indicators at the national level (such as of maternal mortality and infant mortality rates), these macro figures represent aggregates from sub-districts, states and districts. Unless the local level is empowered with systems and capacities to monitor these indicators at the field level, the national level will never be able to generate reliable indicators at the macro level.

Scott would warn us from taking a centralized approach based primarily on statistics, as such attempts to simplify and make the world legible are doomed to fail. The substantial legacies of health information systems which have failed to provide significant improvements in public health delivery (Braa et al., 2004) are arguably examples of the outcomes achieved from attempts to use statistics to control the world and make it legible. What, then, is the alternative that Scott provides to deal with complex social phenomena, such as public health? While not directly touching upon the domain of public health, Scott argues for the development of “metis”—a form of practical skills that underwrite any complex activity. Scott writes, “Metis represents a useful array of practical skills and acquired intelligence in responding to a constantly changing natural and human environment” (1998, p. 313).

The questions that become relevant for us to explore in the context of this paper are the following:

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- a) What is the relevance of the concept of metis to the context of health information systems to support public health management?
- b) How can health information system be appropriately designed and used to support the effective use of metis for public health management?

The paper aims to address these two central research questions, answers to which we believe could help increase the relevance and utility of health information systems in the developing world—especially in such critical areas as the monitoring of MDG progress. This issue is of urgent importance to both the research and practice of public health. There is an increasing acknowledgment of the important role that information should play in strengthening management, and yet simultaneously, there is also the stark realization that, practically, computer-based health information systems have failed to deliver their promised benefits. Huge investments of money and resources, which developing countries can ill afford, have literally gone to naught over the past two to three decades, with more than 90% of such efforts having been termed complete or partial failures (Heeks, 2002).

The empirical basis for this investigation is more than a decade of engagement on the part of the authors in the design, development, and implementation of health information systems in various countries in the Global South. In particular, for this paper, the empirical focus is on action research efforts in a large Asian country (which is kept anonymous) that has been conducted since 1999. The rest of the paper is organized as follows: In section 2, the theoretical ideas surrounding metis are elaborated upon, including how it has been used to inform this analysis. Section 3 elaborates on the empirical approach, while section 4 describes the case study, which is presented in the form of examples of data analysis from the contrasting perspectives of state control and bottom-up, user-driven efforts. Section 5 contains the discussion, which develops the ideas of metis to consider the research questions being pursued. Finally, some conclusions are presented in section 6.

2. Theoretical Idea: Metis

The section on theory is divided into three parts. First, we discuss the challenges of statecraft while trying to render complex social phenomena legible,

and in a simplified form. Second, we discuss the phenomenon of public health management and its supporting information systems, and we examine some of the reasons for their lack of success in the developing world. Finally, the concept of Metis, as articulated by James Scott, is discussed. We examine the ways in which it can help to inform our analysis of health information systems to support public health management.

2.1 Statecraft: Can Complex Phenomena be Made Fully Legible?

Scott, in his analysis of the workings of the state, identifies legibility as a central problem and comes to the conclusion that the state “always seemed to be the enemy of people who move around” (1998, p. 2). A central effort of the modern state is to make a society legible, which is in contrast with the pre-modern state, which knew little about the subject. Making society legible requires the state to rationalize and standardize, which makes administration more convenient, and also enables the making of more fine-grained interventions in areas such as taxation, public health measures, political surveillance, and relief for the poor. However, in this process of simplification, the realities of the complex underlying social processes are abridged. Scott provides an interesting example in discussing cadastral mapping:

These state simplifications, the basic givens of modern statecraft were, I began to realize, rather like abridged maps. They did not successfully represent the actual activity of the society they depicted, nor were they intended to; they represented only that slice of it that interested the official observer. They were, moreover, not just maps. Rather, they were maps that, when allied with state power, which would enable much of the reality they depicted to be remade. Thus a state cadastral map created to designate taxable property-holders does not merely describe a system of land tenure; it creates such a system through its ability to give its categories a force of law. (ibid., p. 3)

Taking from various diverse examples, Scott identifies four elements that contribute to making various attempts of the state into large-scale failures. The first concerns an attempt at conducting social engineering through administrative ordering and simplification. The second concerns an adherence to a highly modernized ideology, one which

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emphasizes the value of using technical and scientific progress to master nature and create natural laws to apply to social processes. The third element concerns an authoritarian state using its coercive powers to bring a high-modernist design into being. For this to happen, there is the fourth condition of an incapable civil society which is passive in resisting the design of the state. Taken together, these four conditions, Scott argues, help to create the "imperialism of high-modernist, planned social order."

In the area of information systems, there are various examples of such high-modernist attempts to create social order. Raghvendra and Sahay (2006) report the efforts of one state government in India to generate a unique, multi-purpose household number to help trace by homes the demographic details of its citizens, including their caste, income levels, and various disease-related health profiles. A centralized software system was an essential component of this high-modernist design, as the state instructed health programs to collect their health services data using these ID numbers. This involved a radical shift of collecting data not as aggregate statistics, but by individual names. The state tried to enforce these directives by stating that reports not based on these ID numbers would not be accepted.

This attempt by the state to reduce the individual households and the complex social processes intrinsic to them to a 17-digit number so that they could be better managed represents a classic attempt by the state to make social behavior legible using a process of rationalization and standardization. Raghvendra and Sahay (2006) elaborate on many social-technical-cultural conditions that contributed to this effort becoming a large-scale failure. These were problems in the concept of the ID number itself, which was based on the household, rather than on the individual. This static number was insufficient to capture the dynamism of the real, on-the-ground family, where in the joint-family structure there were constant movements due to births, deaths, marriages, etc. Since no support system had been designed to deal with the complex process of updating the database, the rhythms of change in the reality (of the household) were incompatible with those in its representation (the 17-digit number). Further, since this 17-digit number created through household surveys was based on revenue boundaries which did not directly apply to health

boundaries, its relevance for public health was limited. The centralized software designed to support this system of data collection and reporting was extremely rigid, and it could not respond to the various change requests made by the users. For example, the introduction of a new health program required new data elements and reports to be included in the software. The rigid design of the software and the contractual limitations with the vendor, who needed to be paid for services outside the scope of the original contract, further made continued use of the system untenable.

At the heart of Scott's argument is that efforts of the state to make a complex social world legible require a tunneling of knowledge involving standardization, careful measurement, and calculation. This abridges reality to the extent that state plans for social change end up as tragedies. The use of statistics is an important form of knowledge that is used by states in this process of simplification.

While Scott does not provide similar examples from the field of public health, we can see the relevance of his arguments, as the public health world is complex and dynamic, while the use of statistics to control it tends to be rather abstract and far-removed from reality. In the next section, we discuss how health information systems in the developing world have failed to deliver practical benefits, as well as some of the underlying reasons for that outcome.

2.2 Public Health Information Systems: Designed for Disagreements

In the field of public health, Bowker and Star's classic 1999 study on the issue of representations is based on an empirical study of ICD 10 (International Classification of Diseases and Related Health Problems, Version 10). Classification systems are assumed to be consistent, unique, and complete, and the categories are assumed to be mutually exclusive. However, in practice, no system is ever "complete," and different groups continue to be in disagreement. The important point made by the authors is that any kind of classification system tends to keep some aspect of the human interaction invisible. Each category thus valorizes a certain point of view and keeps the other silent, and as such, it gives advantage or suffering to different groups of people. They argue further that the choices of who are valorized and who are silenced are not neutral

ones, and that intrinsic to such choices are moral and ethical decisions. If classification systems are always a site for disagreement and lack of consensus, the information systems that are used to represent them also suffer the same fate, which is the reason why many of them are doomed to failure.

Information systems in general are devices that are used to represent the reality of a situation. An indicator is an informational construct that might be used, for example, to represent the reality of HIV/AIDS prevalence. It could indicate the percentage of the population which carries the virus or exhibits the disease in a particular time period (Chilundo & Sahay 2005). The information system then helps to create and circulate the representation by the functions it provides to record, process, analyze, and present the data. Chilundo and Sahay go on to argue that the field of public health, because of the dominance of medical doctors and epidemiologists, tends to work within a positivist framework, where the primary focus is on using advanced statistical techniques to model diseases. Such a statistical focus tends to take the attention away from the local and social processes that surround the construction of data and the indicator. Various authors have criticized the dominance of the positivist epistemology in health and public health, including the limits of computers to represent medical work (Berg, 1997) and how politics shape processes of representation, including implications on when computers make aspects visible (Suchman, 1995). Latour (1999), using the concept of circulating reference, draws our attention to how aspects are both lost and magnified in the process of constructing a representation—which then can never construct a mirror-image of “reality.”

Chilundo and Aanestad (2004) discuss the issue of integration of public health information systems in the context of Mozambique. They bring out the challenge arising from the multiple rationalities that are inscribed in different public health systems. Rationality refers to an underlying logic, and they discuss three kinds in the context of health information systems in developing countries. The first concerns the rationalities on the ground, which refer to the conditions at the point of service delivery, including high patient loads; the capacities of the field staff, who are the users of the systems; and the nature of their interaction with the different constituencies, including the community. In contrast to

this, there is the rationality at the “top,” which includes the agendas and interests of the donors who, for example, seek to support disease specific programs, or of the Ministry of Health officials who may need to appease the donors in order to ensure that the flow of funding does not dry up. Then, there is the rationality of the diseases themselves, which have their own specific implications on the supporting information systems. For example, the HIV information system would need to have specific functionalities for securing the names of patients, which is not an issue with malaria patients. When these different rationalities need to come together and be reconciled within particular empirical sites, disagreements and lack of consensus will abound, which of course will have implications on how the health information systems get designed and used.

Relations between the different actors in the health system are, by definition, asymmetrical (*ibid.*). So, the entities at the top (namely the donors and central ministry officials) have more power than users at the peripheral level, due to status and resources. Similarly, some disease programs (such as HIV/AIDS) are better funded than others (Malaria, for example, in Mozambique), which means they will have more resources for systems, training budgets, and other infrastructure required for the running of systems. With these inherent asymmetries, which are beyond the scope of an information systems designer to modify, the entities with power then have the capacity to direct the health information systems to suit their specific interests and agendas.

An example of the above is of routine health information systems in developing countries, which tend to be controlled and directed by statisticians at the national level. Under the statistical paradigm, where more data is preferred as compared to less, data is collected typically for hundreds of data elements, which are then processed (normally aggregated), converted into reports, and successively transmitted to the level above, from the community to the central level of the national ministry. Historically, the focus of this reporting system has been to satisfy the various needs of the central bureaucracy. One is the extensive engagement of donors who drive various data-collection efforts, which is needed to ensure continued funding support (Haga, 2001). Within the framework of this top-down, centralized approach, the peripheral level is only seen as

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a source of passive data provision, and not as active consumers of data for their everyday local action. Data collection instruments and reporting formats are usually designed by centrally-located epidemiologists, statisticians, and administrators (Lippeveld, 2001), which again reinforces the bias of upward reporting. Various researchers (Kimaro & Nhampossa, 2005; Monterio, 2003; Chilundo & Aanestad, 2003; Braa et al., 2001) have criticized the donor-driven efforts aimed at creating parallel systems, as they contribute to overlaps and gaps in data collection, to a lack of standard definitions of data, and to a huge work burden on the peripheral worker, who ultimately becomes the target for most data collection.

The other pertinent characteristic of a routine health information system is that it needs to be flexible, as an extreme dynamism is inherent in the demands of the health system. For example, a new disease may become relevant. Such was the case with the recent swine flu epidemic, which required new data elements to be collected and fresh indicators and reports to be generated. Or, there could be a situation where there is a reorganization of political boundaries which requires a revision of the organization unit hierarchy. Such changes in requirements are the norm, rather than the exception. As such, we need health information systems to be customizable and adaptable; we cannot expect that requirements will be frozen and the health system will adapt to the rigidity of the information system. In addition to being dynamic, the changes are of an uncertain nature. We never know when a new disease may come, or when there could be a political decision to reorganize the health system in a particular way.

In summary, public health information systems, by the nature of the contexts within which they operate; the existing structures of power relations; and the technologies of knowledge production that are used, primarily related to statistics, are inherently problematic as regards creating simplifications and legibility. Due to the multiple stakeholders involved, these systems are, by design, about disagreements.

2.3 How Metis Can Help to Inform Public Health Information Systems

Scott differentiates between *techne* and *metis*, saying that *techne* represents technical knowledge that can be expressed precisely and comprehensively as

"hard and fast rules (not rules of the thumb)" (1998, p. 319). Its rigor is informed by its process of logical deduction, based on self-evident first principles. For example, in Euclidean geometry, a right angle represents 90 degrees of a circle; or in physics, the freezing point of water is always zero degrees centigrade. *Techne* is universal, and "even chance itself, which *techne* was designed to master, was eventually, thanks to statistics and probability theory, transformed into a singular fact that might enter the formulas of *techne*" (ibid., p. 321).

In contrast, *metis* is always contextual and particular. Scott argues that high-modernist interventions, by ignoring *metis* in their plans, deprive themselves of the most valuable source of knowledge. The proponents of high-modernist attempts would argue that, since *metis* is local and varies from place to place, it is not relevant for their universalist efforts. In *metis*, the logic of classification used is one of practical value. For example, Scott writes the following:

The classification of flora . . . what matters is local use and value. Thus, the categories into which various plants are sorted follow a logic of practical use: good for making soup, good for making twine, helpful in healing cuts, effective for settling an upset stomach . . . and so on. (ibid., p. 323)

Given this purpose of *metis*, its test is practical success. For example, was the farmer's harvest abundant? The aim is not to contribute to and make some form of universal knowledge to solve the concrete problems being experienced. This does not imply that people practicing *metis* do not produce innovations, for on the contrary, they surely do that—by combining and recombining different elements and approaches which they observe very closely and astutely in empirical settings. This approach of problem solving has also been acknowledged in the domain of policy, illustrated clearly by Charles Lindblom in his expression, "the science of muddling through" (1959). This approach is incremental in nature, often disjointed and comprised of a series of trials and errors, followed then by revised trials. So, *metis* is not only relevant in practical domains like farming and carpentry, but also in public policy formulation and implementation.

Often, in the context of ICT for development projects, officials from the World Bank and funding agencies assume local knowledge to be rigid and

monolithic. Scott argues that this is not so, as metis is extremely plastic, local, and divergent. Since metis is contextual, fragmented, and based on empirical observation, it tends to be extremely permeable and open to new ideas. Since there is no underlying doctrine of a monolithic centralized training, there is the potential of a thousand flowers blooming, and with them, new innovations emerging.

Given this brief overview of the underlying principles of metis, the aim of the article is to examine how metis becomes relevant to public health information systems, and if metis is a proposed way forward, then how we, as system developers, can design and implement information systems that can support the nurturing of metis. The practical purpose of this metis is toward supporting the use of information to make improvements in public health delivery systems.

3. Research Methods

The empirical material presented in this paper is drawn from longitudinal experiences gained during the design, development, and implementation of an ongoing action research project, in a large Asian country (the name of which is being kept anonymous). For reasons of confidentiality, the name of the country is anonymized. However, it would be pertinent to add that the country under study here is extremely advanced in its adaptation of IT for various application areas, including public health. The country is characterized by an extremely large bureaucracy with a deep-rooted hierarchical structure and way of functioning. This, indeed, has implications on the design, development, and implementation of health information system within a centralized state control framework of bureaucracy.

This action research initiative aims to support the strengthening of health care systems in developing countries by enhancing the capacity of health systems to “use information for local action” and with it, to further the broader agenda of supporting evidence-based decision making. Two sets of software implementation have been ongoing in the country, one of which was designed and implemented by the state using a largely top-down model. The other initiative, which was begun through a non-profit agency, in collaboration with a quasi-governmental technical support agency, was aimed at primarily strengthening systems at the district level and

below. Experiences gained from both of these implementations and their contrasts have provided the basis for the empirical data.

The NGO, of which both the authors are members, has worked in the country for over a decade at various levels, from the community to the outreach facilities, to the district, state, and national levels. This NGO is part of a global research and development program on health information systems, putting it in an advantageous position to leverage global learning using its network resources and incorporate that learning into the local systems. The decade-long experience of the authors in the design, development, and implementation of systems provided useful empirical learning that was also taken into the processes of the national system’s redesign. The research has broadly been conducted within an action research framework, popularized as a “network of action” (Braa et al., 2004) which focuses on creating enabling mechanisms by which ideas, software, experiences, training material, etc. can be shared freely between different members of the network. This approach is based on the principle that people learn more effectively in networks than they do compared in singular settings.

Data collection primarily consists of examples of preliminary analysis of routine data by the authors, followed by discussions of this analysis with the health staff. This occurred alongside the action research pursuits. For example, during the course of training programs carried out in the states, we would observe, investigate and analyze the routine data by districts or sub-districts and discuss our findings with the participants. The broader aim was to help develop in the users the capacities to actually carry out such analysis on their own. During this interaction, we would try to understand what the user needs for analysis were, and what kind of information support they would require to be able to carry out local analysis. We would further try to understand the level of general public health understanding users had, and what the gaps might have been that needed to be addressed with more effective technical support.

Another form of data collection, done through the study of national and state reports, was intended to help understand the nature of data analysis done at these higher levels and its relevance to district and sub-district levels. Participation in various meetings; conducting situation analysis, obser-

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Table 1. Administrative Level and Its Key Services Provided.

Administrative level	Key services provided	Responsibility of
Outreach facility	Routine, preventive, promotive, few curative and referral services in addition to all the national health programs as applicable.	Field nurse-para medical staff
Primary health facility	Routine, preventive, promotive, curative and emergency care in addition to all the national health programs.	Medical officer
Sub-district facility	Routine and emergency care in surgery, medicine, pediatrics, and obstetrics and gynecology, in addition to all the national health programs	Senior medical officer
District administrative office	Monitoring of all national health programs, maintains the logistics of drug and supplies, collects statistics	District medical officer
State administration	Strategies planning and monitoring	State health commissioner
National ministry	Policy and program level interventions	Central bureaucracy

vation, and assessment during project management activities; obtaining feedback from users during system prototyping; and various other sources provided very rich empirical qualitative data. All this helped to develop a rich account of the various practices that made use of information at different levels, to determine the structure of the flow of information, and to understand the capacities required for promoting information use.

Our data analysis was geared at understanding the issue of metis—reflecting the practical skills required to strengthen information utilization. The strategy used was to compare the two forms of implementation—one more national-driven, and the other with a greater bottom-up focus—and examine the kind of skills they were promoting or suppressing, as well as the natures of the identifications that users have with the systems. This helped to develop insights into the characteristics of systems and their implications on metis, along with the institutional conditions required for a form of metis to flourish.

4. Empirical Story

4.1 Case Background

The health system studied here has six levels of health administrative hierarchy, an arrangement which is depicted in Table 1, along with the services each level provides.

Two parallel implementations of health informa-

tion systems have been engaged with during the course of the empirical work. One was a national system implemented through the central ministry, and the other was supported collaboratively by a national technical support agency and a local NGO. With respect to the first system, the authors were more observers, although we did engage in some of their capacity-building exercises. In the second case, the authors were actively involved in the design, development, and implementation of this system. From the vantage point of having closely experienced the unfolding of both these systems, examples are drawn from both and compared and contrasted.

4.2 Case Examples

The empirical story is presented in the form of examples that the authors have been engaged with over the past two years across the two systems. The analysis is grouped into five thematic areas, with two examples given for each area, respectively representing the two systems. The five thematic areas covered are:

- Information flows
- Managing data quality
- Software characteristics
- Design for monitoring
- Knowledge spread

In each case, the example of the national system is given first, followed by the more local.

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4.2.1 Information Flows

a. Cylindrical structure flow:

The National Ministry routinely collects data on different health programs relating to reproductive and child health, immunization, family planning, neonatal care, stocks, communicable and non-communicable diseases, laboratory services, and various other centralized schemes. In most of these programs, the forms tend to be centrally designed in accordance with the specification of the data elements that are to be collected. Most often, data elements are disaggregated across various dimensions of age, sex, and caste. Disaggregations multiply the number of data elements that need to be individually collected. In the case studied here, the number was about 3000 per month per facility for the routine health system. The forms, by their very design, support centralized monitoring. The data is expected to flow upward, with little or no feedback system.

b. Pyramid structure flow

Another approach to designing health information systems is a pyramid-shaped flow based on the principle that not all information is needed or relevant at all levels of health administrative hierarchy, and that only data required for decision making should be reported. For example while data collected at the outreach center will include all services provided by the facility, not all details of that data (for example, the names of the pregnant women) need to be reported to the higher level of the district, and surely not to the state and national levels. Similar principles of flow need to be worked out for each data element and facility type—what should be reported and what retained by different facilities. As a facility needs more at their level than what they send above, a pyramid information flow of information is structured.

To try and design such a flow, an interdisciplinary team of experts from international, national, state, and district agencies was formed. A detailed situational analysis was conducted of the existing system. Also, extensive consultation with various program divisions of the national ministry and international donors was involved. Some guiding design principles were adopted:

- *Shifting the focus from data forms to data set*
- *Moving disaggregated data elements to surveys*
- *Reciprocity between the provider and recipient*
- *Shifting focus from data element to indicators*

4.2.2 Managing Data Quality

In recent years, the issue of data quality has become significant with respect to health information systems, both to improve the quality of patient care, and to strengthen management processes, including budgeting and maintenance of health services (WHO, 2003). Through our examples, we describe two contrasting approaches by which data quality improvement as is being practiced.

a. A centralized approach

Routine health data aggregated at the district level is uploaded into a national database using centralized, Web-based software. A centralized group in the health ministry has adopted a statistical approach to identifying “statistical outliers” and informing the states about the “probable” problems they face and that they should make the required corrections. This communication between the center and state is through official letters or meetings in the capital, which the states were asked to attend. On the technical side, the approach adopted was of the boxplot statistical method, which computes first the median of a particular data element over the last 12 months, multiplies the median by a factor, and adds or subtracts to calculate the upper and lower quartiles and the inter quartile ranges, and classifies all data outside the range as outliers. Statistics assumes that data values are clustered around some central value, and that the data points that lie “too far” from the central values become “outliers.”

However, a public health perspective will always demand that we look at similar data elements in conjunction, so as to identify data abnormalities. Outliers are not necessarily only statistical artifacts, but could reflect abnormal program-related conditions. For example, we may have children coming from other districts to be weighed, or other child-health interventions. Thus, when compared to the number of children born in that facility, the figure may look abnormal, but nevertheless it might not be a data outlier, but an actual reflection of the situation on the ground. Without a public health interpretation of statistical outliers, we get a different picture than what exists on the ground. When the power of the ministry is behind a letter to the state to correct an error, even if it says “probable” outlier, they will tend to “normalize” the data, so that it does not show in color in an Excel sheet, rather than try to present a public health-inspired defense of their data in front of the senior officers, and thereby avoid the gaze of statistics and control.

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b. A decentralized approach

The DHIS2 software, adopted by various states to meet their local data entry and analysis needs, provides an alternative, user-driven approach to data quality checks that contrasts with the centralized, statistically-driven one described above. The DHIS2 incorporates various data quality checks through the user interface, allowing users to view the quality of their own data. For example, there are min-max checks, and the user also has the ability to add a comment to justify a data value going out of the range. Further, there are validation rules that are developed by public health experts to help compare like data elements, so as to identify abnormalities and raise queries on data. We describe these options in the subsections which follow.

Min/Max and comment option. Before starting data entry, the supervisors can fill an acceptable range (min. and max. values) for particular data elements, based on their local knowledge and contextual understanding of the data element. After data is entered, the user can check if the entered data is within the range. If an entry is out of the range, the user has the option to add an explanation—for example, “This month the staff was on leave.” In this way, the user can incorporate a contextualized and local explanation for the eye catching data element. Data value aberrations are thus not always “data artifacts” reflecting a data error, but can be a “program artifact” which is a problem in the program and yet still reflects the situation on the ground. Such data does not have to be corrected, as the statistical outlier technique tends to assume.

Run validation option. Data elements in a data set are interrelated. These relations can be expressed in the form of rules—absolute or expert—that are defined by public health experts. For example, that total births should equal live births plus stillbirths is an absolute rule which should never be violated, and if it is, then it reflects a data quality error. In contrast, an expert rule—such as that BCG vaccinations given must be less than or equal to live births—may not always hold true. For example, if more children come for vaccines from surrounding catchment areas, more vaccines may be administered than the number of local births which were recorded. Here, when the system raises a query, it requires the user to investigate the reason for the possible incongruity, while not necessarily implying a

data-entry error. Once data entry is completed, the user can click on the “run validation” option provided on the data entry screen, and the system runs the data through defined validation rules, identifying validation queries which the user can then correct or explain with comments.

4.2.3 Software Characteristics:

a. Use of centralized, rigid, and proprietary software support systems

The national level uses proprietary software developed by a commercial vendor. Two features of this software are pertinent to explain:

1) Rigidity. The centralized, Web-based software used by the national ministry is proprietary, designed, developed, and maintained by a private vendor. Further, the Excel sheets used by the software are encrypted, and data from external systems cannot be exported into the software. When, during a presentation, the vendor was asked to explain why they have adopted such an approach when the whole world is adopting an approach of integration and interoperability, the vendor explained that their aim was to develop “a single window of truth.” Further, as the national level wants to standardize the data being reported by all facilities in the country, standard data sets have been created for all facilities, with no option for the user to incorporate locally-required data. Often, the government mandates changes in the reporting units, such as the creation of new districts or sub-districts. The user is not allowed to make any changes, and requests have to be sent to the national ministry, who, in turn, will instruct the vendor to make the necessary changes. This process takes time to complete (if it ever does get completed).

2) Limited data visualization. The existing software allows for data entry and report generation in formats defined by the central level. Additional options are provided for the user to view individual or groups of data elements over periods and across districts. The software does not provide built-in capability for users to generate graphs and charts to visualize data, either across facilities or over time. Further, users did not have the option to generate their own locally-defined reports, and additional functionalities required need to go through central requests, who would then contract the vendor. The software does not differentiate between raw data

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and indicators, and both are even called by the same title. The generation of indicators or creation of validation rules requires programming interventions, so they are not possible through the user interface.

b. Free and open source software

Flexibility: Some of the provinces (states) in the country decided to use the free and open source software program DHIS2 for their intra-district data entry and analysis needs. An electronic bridge was created between these two systems in order to export the data from the DHIS2 to the national data repository, where the reports were required to be stored. The DHIS2 is Web-based software designed and developed under a large and ongoing global action research project which has endorsement of the World Health Organization. The DHIS (versions 1 and 2) is being used in about 20 different developing countries. The system has evolved over 15 years of extensive testing and use experience, enabling significant public health knowledge to be inscribed in it. The software is developed in a modular approach, allowing for both online and offline use to accommodate infrastructure variations across health facilities, as well as within and across countries, and is multi-language enabled to promote local identification.

In the country studied, the application has been customized in a manner which meets all the national reporting requirements, while still being able to give states the freedom to add their own locally-required data elements and indicators. The multi-language facility made it easy for the field staff to use the application, as some of them were not as well-equipped to use English. Districts with limited or no Internet connectivity could install the software locally on their desktop, enter the data, and transfer or upload to the state server through the export/import functionality inbuilt in the DHIS2.

The DHIS2 offered two clear benefits to the states. First, because of the ability provided to customize the organization unit hierarchy to the level desired (including to the lowest level of the outreach facility), states could collect data to levels of management relevant for them rather, than just to the district level, which the national portal provided. Secondly, all the state data was stored on a server which the state could easily access, thus making it easy for them to use their data—something that

was very difficult to do from the national portal, which was described by one state official as a “black box.”

Detailed and intensive technical support was organized not only for the software’s use, but with a strong public health focus on using information for local action. Engineers were always on hand to respond to user queries and requests for customization. This stood in contrast with the national system, where users were asked to send requests for technical support to an impersonal email ID which gave an automated response amounting to a thank-you and a promise of a future review.

Data visualization: A well-equipped dashboard is an integral module of the DHIS2. It allows users to conduct various kinds of analysis and visualizations. A two-option strategy is adopted for reporting. Through the functionality of predefined reports, user could generate all the reports specified by the Central and State authorities. Through the dashboard, the user could generate all kinds of ad hoc reports, view them by periods or organization units, and drill down to diagnose problem areas. Users could generate these reports either by data elements or by indicators, and could also view them as tables, charts, graphs, or maps offered through the GIS module, which is integrated with the DHIS2.

4.2.4 Design for Monitoring:

Maternal and infant mortality are key public health problems facing the country under study, which is striving hard in making progress toward their MDG benchmarks. One intervention in this regard, taken by the national ministry, has been to monitor by names all pregnant women and children for immunization. Two approaches to this monitoring are described below.

a. Centralized identification of individual beneficiaries

The national level is concerned with the idea that the local level peripheral nurses are manipulating numbers of antenatal care and child immunization, which is skewing their statistics. As a form of surveillance and control, they now want all the cases under care to be monitored using a unique identification number. To enable this, mobile phone numbers of both the care providers and the beneficiaries are to be recorded, and the national level plans to give these numbers to a call center, which will randomly call them to cross-check

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whether the service which has been recorded has actually been received by the beneficiary. An Excel workbook having a table with multiple columns has been created, one for pregnancy tracking, and the other for immunization. States have been instructed to download those sheets and start to fill the data for each case. All this data is expected to be uploaded on the national portal every month, including the names of individual pregnant women and children.

Elaborating on the magnitude of the complexity of this task is worthy of a separate paper, but in summary, it can be said that challenges relate to infrastructure, work practices of the field staff, tracking of migration cases, absence of privacy safeguards, and the need for a uniform and unique identification system where none exists right now in the country. As seen from the national lens, the aim of the system is primarily seen as improving the quality of data by imposing a regime of individual-level monitoring, and instilling a sense of fear in the field workers whose work is now made visible and trackable by placing data on a Web portal, including their phone numbers.

b. Localized support to improve service delivery

The logic adopted in the tracking system developed here is similar to that of the DHIS2 in that, at the local level, the forms are designed in a way to support improved local service delivery, while at the same time, ensuring compliance to national reporting standards.

The system is based on a detailed understanding of the work practices of the outreach worker who is responsible to provide care to a population of about 5,000. The outreach worker is supposed to maintain and update all the name-based information on pregnancies and immunization-related services in her catchment area. In the past, such information was maintained in her primary registers, and what the nurse reported upward was the aggregate information out of her facility for each specified period. Now, the new system demands that she sends all the name-based records to the levels above. Naturally, this system instills a sense of fear and apprehension in the outreach staff. First, they believe that it will add on to their already heavy work schedule, and second, as their work becomes visible, they will be subject to discipline and punishment, which is the normal practice in the health sector in the country.

To assuage her fears, the system designed comes with two promises. One, that the work done will not go above and beyond what the worker already does, as in the longer run, the name-based data will be aggregated and imported into the facility reports. This way, the worker will not have to enter data twice. The second is that the system is not only designed for national reporting, but will provide local reports, which will help both improve the worker's quality of care and also help her to schedule her activities in a better way.

4.2.5 Knowledge Spread

a. A centralized approach

The national-level software uses an external and expensive statistical package to support processes of data analysis. Some underlying characteristics of this package encourage a centralization of knowledge. First, being Web-based software, it can only be accessed over the Internet. Due to the paucity of good Internet connection (especially to access a heavy package like this one), the use of the package naturally gets limited to the national level. Second, being extremely expensive and restricted by licenses, the package can only be accessed by a small number of users. Third, the package is complex and not easy to use, and only those who have received specialized training on it are able to use it. Since training is also expensive and restricted, just a few staff members have received training to date, and even fewer (less than a handful) actually have the capacity to use it. Given this scenario of restricted and complex access, knowledge of analysis becomes extremely limited and centralized. In practice, then, if a district manager requires a locally-specific analysis, he or she must send a request to the central ministry (the "expert"), who is then expected to generate the analysis and send it back by email. The next time a similar analysis is required, the process must be repeated.

b. A decentralized approach

The entire DHIS2 implementation approach is based on the ideology of "promoting local use of information for action." The guiding principle here is that the user knows best which analysis they need, and that we must provide the tools and capacity necessary to carry out local analysis and use it for everyday action. Also, it supports the principle that data quality will be improved if it can be interrogated and used at the point of collection. Further, the

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approach is not to use complicated statistics for analysis, but more simple analysis and comparison of indicators and infrastructure across periods and facilities. This primarily involves aggregations and computation of indicators using percentage and other calculated factors.

The focus here is to provide appropriate tools for carrying out such report generation and data visualization in the form of graphs, charts, and maps. This is accomplished using the functionalities of the dashboard and GIS described earlier. Through continuous capacity-building programs, the aim is to equip the users with the ability to be able to use the tools for his own local action area.

5. Discussions

This article is concerned with the capacities of dealing with health information, which can contribute to better utilization of information aimed at strengthening public health care delivery. Specifically, the focus on capacities is around the nurturing of practical skills—a form of metis that are capable of taking on the more complex problems of public health, such as designing interventions for reducing maternal deaths, by leveraging the ability to use rules of thumb to arrive at meaningful and relevant decisions. The assumption made here is that public health practitioners are the experts in their own field, and that, based on their experience and local contextual knowledge, they have an in-depth understanding of both the health situation and the kinds of interventions that may work in practical field situations. However, the further assumption made is that this in-depth knowledge of the field situation on its own is inadequate, and that it requires information support provided that is appropriate and well-designed. This can then help to **complement**, not **replace**, their metis, so that more effective action can be taken. Information is taken as a necessary condition to strengthening public health systems, but however, not a sufficient one. Sufficiency will come when the information is combined with the existing practical skills of the user, contributing together to a more powerful metis.

Our underlying argument is that only if practitioners find information systems locally relevant to them will they identify with them and commit to their use, and that only then will the efforts to implement these systems be effective. Also, only

with continuous and committed use can the practitioner be able to inform the designer of the kind of information needed to further strengthen his or her metis, inputs which can then lead to making improvements in the system. With these underlying principles, we have, through the case study examples based on our empirical experience, tried to highlight different approaches to designing, developing and supporting health information systems in five thematic areas. In each area, two contrasting types of examples were presented. The first represents a more traditional approach in developing countries, an approach which contributes to promoting a form of state surveillance and control system using simplistic design assumptions (such as “building a single window of truth”), which, we argue, effectively kills metis. The second set of examples seeks to illustrate how the onus of responsibility is placed on the user (not the state), and how the information systems then try to provide information support in ways so that existing metis can be strengthened, not replaced or killed. From these examples, we discuss two sets of implications on metis. The first concerns the underlying design characteristics of systems that help to either cultivate or suppress metis, and why. The second relates to the role of the institution in this regard.

5.1 System Characteristics and Implications on Metis

Different characteristics of information systems have implications on how information generated from the system is geared toward supporting public health action and interventions at various levels. A key aspect here is how the system supports the nurturing of user capacity in data management, including skills to carry out data analysis, health status analysis, and being able to integrate this analysis into practical health program improvements. An important characteristic, then, is where the primary focus of the system lies—on the means (the supporting technology), or on the ends (what the generated information is to be used for). Typically, we find that the means become more important than the ends, usually by constraining the perspective and efforts to issues of data, rather than to how this data can be converted to useful information, and more importantly, into knowledge which implies putting the information into practice and action. Further, along with this focus on technology, another key

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end is the reporting needs of the central ministry, which displaces local action.

While a state-supporting statistical system focuses primarily on data, with the outlook that “more data is better,” a metis-supporting system will focus on “information for local use,” with the goal of supporting contextualized action. It becomes important, then, to unpack the characteristics of health information systems and how they go about nurturing or suppressing metis. The following characteristics are discussed:

1. **Focus on information use—technology for information and information for action:** A metis-supporting system, by definition, will have its primary focus on enabling information use, rather than on the tool and on upward reporting. Supporting this information’s conversion into action and knowledge requires motivating the user and privileging his or her local knowledge and experience, rather than resorting to the use of fear and reprimand—a tactic common among systems designed to promote a pan-opticon environment. In contrast, central supporting systems do the reverse in terms of metis. For example, identifying statistical outliers at a central level and sending the report back to the levels below for “corrections” is ineffective in building a local, process-related understanding of why data problems arise. This also goes against the basic principle that data quality problems are best understood by those who collect the data, at source.
2. **Promoting decentralized information for decentralized action:** Decentralized information is based on the globally-established principle of hierarchy of information (representing a pyramid) discussed earlier, where the lowest level requires the most disaggregated information (e.g., the field-level health service providers need to know the names and addresses of pregnant women), while the national level requires its information to be the most aggregated (e.g., indicators such as percentage of institutional delivery). The cylindrical structure of information flow, where all data (including disaggregations) flows to the highest level is counterproductive, as the national level does
3. **Integration of information flows in the data warehouse approach:** Globally, research has established that integration of information systems represents the largest challenge to effective health information management, and some have advocated the data warehouse approach (Titlestad et al., 2009). Integration of information from different sources allows richer decisions. For example, by combining service data (e.g., of institutional deliveries) with infrastructure data (e.g., the number of beds available), the user is allowed to probe into effective utilization of facilities which single data sources do not enable. A state-sponsored approach of creating “a single window of truth” which does not interoperate with other systems runs counter to this thinking of integration, leading to further fragmentation in the long run. As fragmentation tends to decontextualize and compartmentalize, there are adverse implications on metis which by definition is concerned with contextualization.
4. **Collaborative participatory design: Promoting flexibility and user control:** Research has emphatically established the key role of participation of end users into processes of system design helping to promote ownership, build capacity, and make design more relevant (Titlestad et al., 2009). Further, research has established that more than 90% of health information systems are complete or partial failures because of “design-reality” gaps, implying a deep schism between the worlds of technology development and use (Heeks, 2002). This gap relates to the design assumptions that are inscribed in the technology and their dis-

not have the technical capacity to process this information, nor do they have the conditions to influence action. Structuring the information flow as a pyramid, based on the varying information needs of different levels, can help achieve a model of decentralized information for decentralized action, rather than one of centralized information for limited or no local action. An upward-focused system runs counter to this thinking and suppresses metis.

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tance from the reality of the use context. The example of using a high-priced statistical package which is centrally designed and allows only Web-access is indeed distant from the reality of the user who does not have required access. The DHIS2 approach has been founded on a participatory methodology, where design is seen to be never frozen, but representing versions which are fluid in time and space. A guiding principle of participatory design is to have flexible systems aimed at developing user control—where users can customize their data and reporting needs within their local context while simultaneously adhering to the mandatory requirements of the levels above. Inflexible systems, both in terms of technical design (one fixed dataset for all districts, for example) and contractual arrangements, will suppress metis entirely.

5. **Learning by doing: Promoting networks of action:** Some guiding principles of metis are those of learning by doing and of sharing similar experiences with other people engaged in like pursuits. The networks of action approach surrounding DHIS2 (Braa et al., 2004) seeks to create collaborative linkages wherein users and developers of the technical and public health systems support and strengthen each other by sharing experiences, advocacy, ideas, products, software, and training resources. This network model necessarily stands in contrast to the centralized, bureaucracy model based on principles of discipline, surveillance, and reprimand—all of which contribute to the suppression of local learning. The DHIS2 network model is enabled through the active use of “open source” systems, implying no license restrictions. This allows all to have access and contribute to the growth of these community resources, and it also allows learning to grow in a cumulative manner.

Thus, system design has implications on metis. In the next section, the role of the institution in contributing to the nurturing of metis is discussed.

5.2 Institutional Implications on Metis

While the institution has various roles and responsibilities when it comes to nurturing or not nurturing metis, such as leadership, capacity building, estab-

lishing infrastructure, providing resources etc., we focus on one aspect which is significant—establishing a sense of trust and confidence in the routine health information systems, so that users develop the freedom and practice to use information. What research has repeatedly pointed out is that the lack of a culture of local information use in developing countries serves as a serious impediment to the use of information. How such a culture gets nurtured is a very pertinent question to address.

There tends to be a vicious cycle of lack of trust and data non-use, a historical problem in which routine health information systems data is seen to be of poor quality and thus not to be trusted or used. As a result, for reporting purposes, governments tend to rely on survey data, rather than on the routinely collected data. Such data is, however, not of the required granularity to be of relevance for conducting everyday action. The more that routine data is not used and is formally ridiculed, the less attention is given to its process of strengthening metis. Breaking this vicious cycle of data non-use is a key responsibility of the institutional leadership.

An approach of “satisficing,” rather than optimizing, is the required use of existing data, which is also primarily about learning to live with the limits of historical inefficiencies that health information systems are so often confronted with. This is not at all to be seen as an argument for doing nothing to improve, but for focusing on what is there, seeing how it can be used, and that, with use, the quality of data will also improve. Satisficing can be done in a number of ways. First, it is often seen that the district level has higher coverage of data than the facility level. As a starting point, then, district-level analysis can be encouraged, and once district users see the value of this process, they will initiate efforts to improve data quality from the levels below. The second principle of satisficing would be to focus on essential data elements. Typically, we see that, while the routine system could be processing about 1,000 data elements monthly, maybe only 15–20% of those are essential and required for program management. These could be related to antenatal care, immunization, deliveries, and infant and maternal deaths. The remaining data could concern stocks, outpatients, childhood diseases, etc.—which, by their very nature, are difficult to collect with qualitative certainty. Typically, because of national reporting requirements, we find that these essential items are of reasonable coverage and quality. By focusing on

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what is there, and not on the bad quality of the remaining “non-essential” data, we can try to promote use.

Further, from a planning perspective, the question can be pertinently asked whether we really need the levels of data which the national statisticians demand? For answering this, we need to examine the kind of information support that is required for health planning. Taking maternal mortality in high-focus districts as an example, we still need to have figures on district and sub-district facilities provision of deliveries, emergency obstetric services, health worker to population density, estimated pregnancies, and such related data. Within the essential data perspective, we will tend to find most of this data available in the health information system. And often, that which is not can be easily obtained by a phone call to the district. There thus arguably exists a level of sufficiency in the existing system to meet the required level of information support for urgent planning needs.

We can further attempt to break out of this vicious cycle by having districts report only on actionable indicators, rather than on raw numbers. For example, with respect to deliveries, it may be more effective if districts give figures in terms of percentage of different facility types which are not providing the expected level of services. The details about raw numbers of deliveries will always be available at the local levels, and they can still be called upon when needed.

Such a satisficing focus will also help to redirect attention away from being continually locked in data, and onto the data’s transformation into information and knowledge, bringing the project closer to improved public health delivery. The argument, thus, for a satisficing, rather than optimizing, approach is that it could help to break the cycle of lack of trust and data non-use, helping, instead, to create another trajectory or cycle of data use leading to improved quality and more use. Such a cycle will help to usher in an environment where metis can flourish and prosper.

6. Conclusions

While our case has specifically related to the context of health information systems in developing countries, we acknowledge that these issues are of wider relevance, and that they also apply to many devel-

oped countries, as well as to sectors outside health. For example, in a recent book by Dunleavy et al. (2006), the authors argue that technology is providing the driver to usher in a new paradigm of public management that focus on “self service” rather than state-controlled services. The authors argue that many states are failing in their attempts to manage vast amounts of information due to problems of their own making, problems primarily concerned with the relationship between government and private IT corporations. Dependency on the private sector—because the modern technology requires the empowerment of expertise—leads to a breakdown of many initiatives. Further contributing to this is the presence of monopolistic markets and the lack of activism on behalf of state offices. Countries like the UK have been heavily affected by the dependence of the state on a small number of private firms that have seriously undermined their new public management reforms.

Further, the authors argue that cloud computing offers possibilities of individual (rather than state) control, where personal data can be hosted and managed by individuals themselves. Technically, given the properties of scalability and portability, such models may be well-suited to developing countries. But if the likes of Google are supporting the cloud infrastructure, the question then arises: Can we trust them? Similar parallels can be seen with mobile computing and m-health, where vast amount of individual data can be circulated through networks provided by mobile operators. But then, how much can we trust them, and are we protected from our data being made commercially available to pharmacy firms or the like? These issues, which have not been directly addressed in this paper, are linked to larger questions of democracy, the relationship between the state and the citizen, and models of governance not only in sectors of health, but also in others, such as education and development, where, to date, the state has played a defining role.

This paper has argued that the development and encouragement of metis is key to strengthening information support in public health. This argument is founded on the assumption that field practitioners—nurses, supervisors, medical doctors—have, as a result of their experience and practical knowledge, a good general understanding of the public health problems their local area faces,

as well as of how to deal with them. This practical knowledge, if combined with sensitively and relevantly designed information support, can contribute to the development of a more effective metis, which can, in turn, help address pressing public health problems faced by developing countries. Three important factors in creating this effective information support are appropriately designed systems, institutional agency that seeks to break out of the historical mistrust characteristic of health information systems, and basing the data approach on a principle of satisficing, rather than optimizing. ■

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Paper 5:

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“Outliers”: A Public Health inspired perspective

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ABSTRACT

Data quality is an important aspect of an effective health management information system, and improving it is the effort of any government. This paper discusses two approaches to improve data quality, one that is based on statistics, and the other which is grounded and inspired in the domain of public health and based on local knowledge. Drawing upon empirical examples of the use of statistics to identify “outliers” it is argued that this approach is inadequate and even misleading, and necessarily needs to be integrated with public health and domain knowledge of the context. Further, such analysis need to be carried out in context where data is generated rather than at the central level of the national ministry by which time of the data reaching there it is decontextualized and loses its local meaning. Such integration of knowledge domains is arguably the basis for furthering the agenda of “using information for local action.”

Keywords:

Data quality, health management information systems, statistical outliers, box plot method, public health knowledge

INTRODUCTION

Health Management Information System (HMIS) seeks to provide accurate, timely, reliable and accessible data for planning and management of health care services. A routine HMIS- which deals with data around the provision of routine health services- typically deals with hundreds and even sometimes thousands of data elements [21] (Sahay & Latifov, 2009). To help efficiently process these large volumes of data, many developing countries have adopted computers, but with in general limited levels of success in providing health administrators with relevant and reliable data for them to be able to take effective decisions regarding monitoring or planning

of health interventions. A key limiting condition to the use of data is its poor quality. Poor data leading to weak use and continued poor quality represents a chicken and egg situation, where at one end the health administrator says: “will look at the data only when the quality is good”, and another one says “no one is looking at the data so quality is poor”.

The term data quality is much used and abused, and in the domain of health information systems especially in the context of developing countries has been the subject of much research [18,19,20,21] (Makombe et al. 2008, Otworld et al 2007, Ronveaux et al 2005, Mavimbe et al 2005). Data quality has become an important issue, not only because of its importance in promoting high standards of patient care, but also because of its impact on government budgets around health services [26] (WHO 2003). At the level of district administration and health programme management, data quality should be available at decentralized levels of acceptable quality for it to be usable for planning, monitoring, evaluation, resource allocation and to support health care delivery.

A working definition of data quality which we use in this paper is by Karr, Sanil and Banks [16] (2005) who describe data quality as the capability of data to be used effectively, economically and rapidly to inform and evaluate decisions. Data quality is multi-dimensional, going beyond data entry, accuracy to include such factors as accessibility, relevance, timeliness, metadata, user capabilities and expectations, cost and context-specific domain knowledge. Given the focus of data quality on its ability to be made usable in the context of health management, an important challenge then becomes how do we make data quality acceptable?

Various tools and methods are available to diagnose data quality problems, and bring in improvements to

them – such as related to their correctness, completeness, consistency and timeliness. Two key paradigms or approaches can be identified in this regard. The first one concerns the use of methods that derive its origins within a paradigm of statistics, This approach primarily adopts techniques like outlier analysis or statistical interpolation for missing data to try and make improvements in data quality, The second concerns a public inspired approach which sees data not like a statistical artifact but representing a public health event which needs to be interrogated and understood. The aim of the paper is to empirically examine the effectiveness of these techniques in bringing about data quality improvements.

A STATISTICAL PERSPECTIVE ON DATA QUALITY: USE OF OUTLIERS

This section provides a brief elaboration of the statistical techniques that we have empirically studied being used in the context of data quality management in public health. The section is comprised of three sub-sections. In the first, we describe what underlies a statistical perspective on data. Following this, we discuss the techniques of outlier analysis for identifying and normalizing data quality. In the final sub-section, we discuss a particular technique – the boxplot method – which we have empirically studied being applied to public health.

The statistical perspective on data

To identify abnormalities in data or to find missing values in a data set, statistical methods have been adopted in health information systems [6,7,15,17] (Broeck et al. (2005), Levy & Stolte (2000), Kadane & Etzioni (1995), Brookmeyer & Stroup (2004)). Typically, the national health ministry in most developing countries is comprised of a monitoring and evaluation division which in majority of cases are dominated by statisticians. This division or group in national ministries have the mandate to provide reliable, timely and credible social and economic statistics to assist the bureaucrats in the ministry and the technocrats who lead the health programme divisions. Further, they generate statistics on national health indicators and infrastructure also for public consumption. Like in health, respective statistics divisions in different ministries also collect data on other areas such as agriculture, education, infrastructure, social services, public finance, environment, and the corporate sector. In general, the detailed purview of the subject and sectors is

determined by the statistical paradigm or “the way statistical offices see the socio-economic life of people” [13] (Hirway, 1999).

Statisticians have their particular 'conceptual spectacles' and tools which they use in their work. These conceptual spectacles shape particular views around data, which often boils down to “more is better”, and process it using different forms of statistical software. Statistical systems round the world collect the huge amount of data in their attempt to derive abstract knowledge from the society, to help make society and associated social processes legible, in order to support reporting and decision making. Scott [23](1998) explains this exercise of gathering statistical information of complex social phenomenon such as forestry, social welfare and epidemics in the health domain as a form of simplification aimed at making society legible. Scott argues officials of the modern state seeks to assess the life of their society by a series of typifications based on this information that are always some distance from the full reality these abstractions are meant to capture. Scott concludes such efforts of the modern state to simplify and make legible social processes that are inherently to complex and dynamic to do so, tend to end as large scale failures.

Managing data quality is a big task of the statisticians as they deal with large datasets on different phenomenon. A commonly used statistical method in this regard is of “statistical outliers.” Examining how this technique of outlier is used within the health sector and its implications on the public health interpretations that we draw as a result is a key focus of this paper. In the next section, we discuss outliers.

Statistical outliers: an approach to normalizing data

Creating statistical models that seek to simplify and standardize social worlds, requires the data to conform to statistical distributions. Non compliant data are classified as “statistical outliers” which need to be then “normalized” before they can be modeled. Statistician's concerns with outliers is historical, dating back to more than 200 years when first attempts were made to base conclusions on a set of statistical data. In 1777, Bernoulli's comment indicating the practice of discarding discordant observations [3](Beckman & Cook 1983). They write:

No observation can be guaranteed to be a totally dependable manifestation of the phenomena under study.....Intuitively, the probable reliability of an observation is reflected by its relationship to other observations that were obtained under similar conditions. Observation that, in the opinion of the investigator, stand apart from the bulk of the data *have been called "Outliers", "discordant observation", "contaminants"and "dirty data"* (pp.120)

Some other definitions of outliers are given below:

"Discordant observations (outliers) may be defined as those which present the appearance of differing in respect of their law of frequency from other observation with which they are combined." [9](Edgeworth, 1887)

"An Outlier is an observation that deviates so much from other observations so that it aroused suspicions that it is generated by a different mechanism" [11](Hawkins, 1980).

"An Outlier is defined as an observation that "appears" to be inconsistent with other observations in the data set" (Barnett and Lewis, 1985) [1]

"Statistical Outliers are unusual points in a set of data that differ substantially from the rest" (Caroni, 2005)[8]

In summary, an *"Outlier"* is described in reference to a collective indicating a contaminant where any observation is not a realization from the target distribution. Further, it could refer to a discordant observation wherein any observation appears surprising to the investigator.

Statisticians use various forms of statistical formulae to identify, classify and normalize outliers in the data (Barnett and Lewis 1994)[2]. There are various methods for detecting and identifying outliers including z-Scores, box plot, histogram, and so on. Barnett and Lewis (1994) [2] provide a comprehensive treatment, listing about 100 discordancy tests for Normal, Exponential, Poisson, and Binomial distributions. Discussing these various methods is not the aim of the paper. We discuss in greater detail the basis of the "Boxplot" or "Box-and-Whisker Plot" method which we have empirically studied being applied in the domain of public health.

Boxplot Method

Box-and-Whisker Plots is a popular univariate data display technique developed by John Tukey [23,24]1970,1977) and has been made available in various statistical software packages [10](Frigge, Hoaglin and Iglewicz 1987) and also included in Microsoft Excel. Boxplot was originally called as "schematic plot," followed by the Box-and-Whisker plot and it is now customary to refer to this plot as Boxplot [4] (Yoav Benjamini, 1988).

Boxplot allows the user to explore data and to draw informal conclusions when two or more variables are present. The boxplot technique is relatively simple and yet powerful for displaying single batches of data to study symmetry, longtailedness, and distributional assumptions. It can also be used to compare parallel batches of data, and to supplement more complex displays with univariate information. It shows only certain statistics rather than all the data. These statistics represented as a Five-number Summary includes the median, the first or lower quartile (Q1), the upper or third quartile (Q3), and the smallest and greatest values in the distribution. These five summaries of the data are graphically presented in a way that makes information about the location, spread, skewness and longtailedness of the data available with a quick glance [4] (Yoav Benjamini, 1988). The box in the boxplot contains, and thereby highlights, the middle half of the data point.

The basic principle in creating the boxplot is to arrange the collected data in a numerical order so as to find the median of the data collected which helps to divide the numerically ordered data into two halves. Further, if we take these two halves and find their respective medians, we obtain three points which divide the entire data set into quarters called quartiles (Q). Statistics assumes that data values are clustered around some central value, and the inter-quartile range (IQR) provides an indication of how spread-out the values are, and whether "too far" from the central values. Data points identified as being "too far away" are called "Outliers, as they "lie outside" the expected range. Specifically, outliers represent any value that lies more than one and half times the length of the box from either end of the box. That is if the data point is below $Q1 - 1.5 \times IQR$ (lower limit) or above $Q3 + 1.5 \times IQR$ (upper limit), it is classified as being too far from the central values and thus as outliers.

The Boxplot method of analysis of outliers, using the above technique can arguably be effective in the detection of particular spikes or troughs in data. However, in the context of public health the interesting question is what happens if these data

aberrations are not just abnormalities in data but actually represent the reality of “health programme aberrations.” To explain using an example. A clinic provides BCG vaccinations to children born in its catchment area, and we expect about 25 children to be given this

vaccine every month. One month the figure shows 5, and the Boxplot method identifies this data point as an outlier. But however, this figure is low for that particular month because the vaccine is not in stock, thus there is an “immunization programme aberration” rather than a “data quality aberration.” This raises the real danger of the user taking the output of the Boxplot method to make the correction in data rather than alerting the authorities in making a correction in the programme, in this case improving the supply of BCG vaccine to the clinic.

In this paper, we thus seek to problematize the notion of statistical outliers as used for data quality improvements in public health. The use of Boxplot and other such techniques based on statistical formulas for the for identification and normalization of outliers on their own without inscribing in it domain and contextual knowledge, can provide us with misleading inferences on data quality.

The aim of the paper is thus to understand through the use of empirical analysis the implications of using the Boxplot method on data quality inferences. Secondly, we analyze how public health related contextual knowledge can and needs to be integrated with such statistical analysis to provide for richer and more meaningful interpretation of data quality. In the next section, after briefly summarizing the empirical context, we describe the empirical examples.

EMPIRICAL SETTING

The empirical setting for this study is a large Asian country (whose name is held anonymous) in which both the authors of this paper have been engaged with in the design, development, implementation and use of health information systems for over a decade. The authors have worked within an action research framework where a key component of their tasks is helping to make improvements in the quality of data and furthering the agenda of using information for local action.

As a part of these efforts, the authors have worked both at the national level and with the state level. Data has been collected through various means including interviews, participation in training programs, conducting analysis of data collected, and the dissemination of analysis to the states. The study of various secondary sources of data, including

related to data analysis reports have also provided key inputs on data. The authors have participated in various seminars and training level where the national level statisticians have demonstrated the use of outliers, and the dissemination of it to the states.

The key data source used for the empirical analysis in this paper has been examples of outlier analysis conducted by the national statisticians and published in the form of reports that were disseminated to the respective provinces for taking action on to improve data quality.

EMPIRICAL ANALYSIS

This section has two sub-sections, the first dealing with a background for the empirical analysis which is followed by specific examples from the outlier analysis conducted.

Background of outlier analysis

As a step towards strengthening capacities for data collection and its analysis to support processes of monitoring, evaluation and reporting, the Statistics Division in the Ministry of Health of a large Asian country established a dedicated web based system (web-portal) to capture all health related information from health facilities of the country. This application was so designed to capture data (in revised recording formats¹) from the district level so that the data could be easily aggregated from the districts and then transmitted to the province, further aggregated and sent to the central level of the Ministry of Health.

From the introduction of the system in late 2008, significant amounts of training and capacity building efforts were made in all the districts to build user capacity in understanding these new formats, to enter data into the online application, generate the required monthly, quarterly and annual reports, and be able to transmit these reports up the hierarchy from the district to the province and national. In summary, the information flows involved a paper based form of data from the peripheral levels to the district, where it was manually aggregated and the district wise data entered into the online web-portal which was deployed for the nation through a centralized server. The district users accessed the system using their district user name and password (issued centrally),

1 Before introduction of the HMIS web-portal, a significant effort went in at the national level to rationalize all the formats and to try and integrate the various disparate information flows.

and after verifying the data pressed a button to electronically “forward” the data to the province level, where the state level administrator further verified the district data and then electronically “committed” the data to the central level. Once committed, the data was considered to be in the “public domain” and not subject to any modification by the district or state unless necessary permission from the Statistics Division at the national ministry was not obtained.

Leading the entire effort of implementation of the web portal was the Statistics Division of the Ministry of Health which was the agency responsible for monitoring and evaluation of all the national health programmes. This Division had also been responsible for the development of the web portal through a third party vendor who had used proprietary tools (based on Dot.Net) as the platform. It is also pertinent for the purposes of this paper to note that a large, commercial and expensive statistical package was used as the platform for analysis. This package, available only through online access, was not integrated within the portal, but instead the data needed to be externally accessed. The portal on its own was not capable of producing any representations (charts, graphs, maps) other than tables.

Intensive training efforts backed up with a decisive leadership ensured that by the end of the financial year (March 31, 2009), nearly 90% of all district level data in the country was committed to a national database. This indeed was a significant national achievement as it was for the first time, the national level had received electronic health data for such a large coverage of district level data. In the past, only state consolidated reports were received by the national level, and that too mostly in paper form.

Now that for the first time all district level data was available electronically, it became visible and was thus ready to be subject to a close data quality analysis. At the end of the 2008 financial year, the Statistics Division of the Ministry of Health, analyzed data for the entire year available in the national database, and presented their analysis to all the provinces. The means of communication from the national to state levels was a letter signed by a senior Director, which enclosed Excel sheets of outliers identified for the state, and with instructions to urgently normalize the data. In addition to the Excel sheet of outliers, another sheet containing “totalling errors” identified for the state was also enclosed and states instructed to make corrections.

While the Statistics Division did not describe the statistical technique used for the analysis, it was evident from looking at the output sheets that the Boxplot method had been used for the analysis. Data for the entire financial year (April 2008 to March 2009) reported from the districts were consolidated at the state level and exported to Excel. The statistical formula were applied to this consolidated state figures. The identified totaling errors and outliers were highlighted in colours (red and brown) on the Excel sheet. A couple of issues are worth noting in the manner in which the Boxplot method was applied:

- The same method was employed to identify outliers for all kinds of data (for example, stock figures, deliveries and immunization) even though the data may follow different distributions.
- The same method was applied irrespective of the level of completeness of the data (how many months data was actually entered).
- Blank values in the dataset (which technically to that “service not available”) was treated as “0” (implying that the service was available but none was given that month). This would mathematically skew the computation of the median.
- While the text books recommend the use of factor 1.5 for the computation of the inter quartile range, in this case the factor 2 was used. No explanation was given for the same.

Examples of outlier analysis

Example 1: Newborns weighed must be seen in relation to children born

Table 4.1 below shows the monthly consolidated data at the state level for the whole year. When we apply the IQR formula for the data element “Number of newborns weighed at birth”, it shows data for the months of May, November and March are “too far” away from the central value, being either below the lower limit (93914) or above the upper limit (139895). Thus they are identified as “outliers” in a statistical sense (represented in shaded box).

Now, from a public health perspective the data element “Newborn weighed at birth” is an extremely important parameter to assess the quality of delivery related health care services. It is necessary that all newborns must be weighed at birth, to identify whether they need special care (if Low Birth Weight – LBW – less than 2500 gms). The higher the % of new borns weighed at birth (in relation to children born) indicates higher quality care for newborns. A basic public health practitioner will tell us that the number of newborn weighed at birth directly

corresponds to the total births occurred. Thus examining the data quality of one in isolation of the other will necessarily be incomplete and even be flawed.

Now if we take the same data, and apply the principles of looking at the data quality by combining the two data elements, then what was statistically identified as an outlier is not. In the month November, we see that the data is not an outlier as we cannot have more children weighed than what were born. This may be either a data entry mistake or over reporting of number of newborn weighed at birth. The outliers identified for May and March, if seen in their percentage forms (82.6% and 81.2% respectively) don't come through as outliers as compared to the other months. Further if we look at the data, the month of July shows a decrease in % of newborns weighed of total birth. Thus this data is arguably what requires further investigation whether all the data were reported or underreporting is taking place.

Data Element	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1>Total Birth	113075	92899	141472	150015	140608	138072	134182	136887	131979	130627	130742	109452
2)Number of Newborns weighed at birth	101103	76348	113314	116384	125462	125425	122085	157086	114152	118572	119043	89418
1% of new born weighed of total birth	88.8	82.6	84.3	77.6	89.2	90.2	91	114.7	86.5	90.8	91.1	81.2

Table 4.1: Newborns weighed in relation to children born

Example 2: Failures and death following sterilization – do not follow statistical distribution

Table 4.2 below shows the monthly consolidated figure for Failures and Deaths following sterilization broken-up by gender (male and female) for the year 2008-09. On applying the IQR formula for these data elements, we see that all the non zero values are represented as statistical “outliers.” This happens because these non zero values fall outside the lower (0,0.25,0) and upper (0,0.75,0) limits. In contrast, the data for number of deaths following sterilization-female, the non zero values are classified as “non-outliers” because data from April to September are blank which makes the non zero values fall within the lower (1.75) and upper (5.25) limits. If these blank fields are filled by zeros, then these nonzero values fall outside the lower (0.25) and upper (0.75) limit and will get classified as outliers.

From a public health perspective, Failures following Sterilization are not common occurrences, and implies that a woman who had accepted a sterilization method becomes pregnant or a man

whose wife becomes pregnant despite him having had a sterilization surgery. In both these cases it can be claimed that there has been a “sterilization failure.” From a public health viewpoint, this failure needs to be investigated, supported, the patient offered care and even compensated. These nonzero data have to be carefully investigated and studied, and not treated as an outlier and normalized. As discussed earlier, in a public health context there is a significant distinction between zeros and blanks, which a statistical method tends to suppress. In this case, since the data is collected at the district level and consolidated at the province, a blank implies that no deaths following sterilization were recorded in the whole province for the period April to September 2008. This might not be true, and further public health oriented investigations need to be carried. However, data related to failures and deaths following cannot be expected to take place every month and follow a statistical distribution. The application of a statistical outlier technique to such data is thus suspect.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Number of failures following sterilization												
Male	0	0	0	0	0	0	0	0	1	0	0	0
Female	0	0	0	0	0	0	0	1	0	1	2	0
Number of deaths following sterilization												
Male	0	0	0	0	0	0	0	0	0	1	0	1
Female							0	2	3	0	1	0

Table 4.2: Failures and deaths following sterilization

Example 3: Institutional deliveries and discharge- a problem of primary recording

Table 4.3 below reports on two data elements collected and consolidated monthly at state level for the year 2008-09. The first is “Delivery conducted at public institutions” which refers to deliveries conducted in all different type of public health institutions including primary health care centers, Community health centers, District hospitals, and Medical Colleges. The second describes how many cases were discharged from these public institutions under 48 hrs of delivery. When we apply the IQR formula described above, the data for the month of October is identified to be far away from the central value (outside the limit 16434-61638) and thus classified as an outlier.

According to the public health guidelines, deliveries conducted at public institutions should retain the

mother and the new born in the institutiona for at least for 48 hours after a normal delivery. If a delivery case is discharged under 48 hours, it may reflect on the heavy load the institution is experiencing and also a poor level of quality of delivery care in that institution. According to the figures presented in the table below nearly 62 to 77 % of the deliveries were seen to be discharged under 48 hours of delivery, which raises serious questions about the infrastructure (number of health facilities and their available bed strength) and also quality of care. While the figure for October month seems feasible, that of the other months requires investigation. But our outlier analysis actually classifies the October data as an outlier seeking normalization. The problem seems to be of reporting, and most likely the facilities are not maintaining the primary registers in which the discharge figures are being recorded. Ot these figures could be recorded by the labour room, but is not being made available to the clerk responsible for the monthly data entry. What then needs to be investigated is the work practices and the use of registers, which will not be identified through a statistical outlier analysis.

Data Element	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Institutional Delivery	51358	35458	53092	59511	60639	60960	53374	61137	55614	57688	57549	44503
Discharged under 48 hours of delivery	0	0	0	0	0	0	14001	47556	34804	43783	43372	34255

Table 4.3: Institutional deliveries and discharge

Example 4: NSV/Vasectomy figures reflect institutional practices of year end surge

The Table 4.4 below shows the monthly achievement of a province for NSV/ conventional vasectomies conducted at public facilities broken-up by different types of facilities. On applying the statistical formula, nine data values, shown in shaded colour, are identified to lie “too far” from the central value, and hence are “outliers.”

NSV/conventional vasectomy are particular surgical procedures adopted for male sterilization. Public health trends indicate roughly less than 5% of all married couples in their reproductive age group adopt this procedure while about 15% of couples rely on

female sterilization methods for birth control. Hence, we can expect the number of NSV/conventional vasectomies to be comparatively less than female stertization. Often, NSV/ conventional vasectomy operations are carried out at outreach camps on particular days rather than in the facilities themselves on a routine basis. All the potential cases from the catchment area for the procedure are guided by the health staff to attend the camp and undergo the surgery. Normally, (monetary) incentives are provided to the person undertaking the surgery and sometimes the motivators of these cases (field nurses and doctors) may also receive some incentive. Normally, the centre defines achievement targets for provinces, districts and even hospitals, which provides additional motivation (and fear) to achieve targets. Often, these camps are organized towards the end of the financial year to achieve the unmet annual targets. As a result, we find in the table below that there is a spurt in the figures towards the closing months of the financial year. And since camps do not take place on a routine basis but are especially organized on particular days, spikes in the end of the year figures (and zeros in earlier months) may thus be reflecting the reality on the ground of particular institutional practices, rather than as “outliers” identified through statistical techniques.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Number of NSV/Conventional Vasectomy conducted at Public facilities												
At PHCs	0	0	0	0	0	8	0	0	0	0	158	80
At CHCs	0	0	2	0	0	0	0	0	0	51	75	103
At District Hospitals	0	0	1	0	0	0	0	1	0	0	3	0
At Other Public Institutions	4	3	0	0	2	10	0	31	35	0	2	5

Table 4.4: NSV/Vasectomy figures

Example 5: : Do all deliveries qualify for incentives?.

Table 4.5 below reports on two data elements relating to number of mothers paid incentives for home deliveries and total home deliveries. This data is consolidated monthly at that the province level for the year 2008-09. The statistical formula is applied to both the data elements which helps to identify data for the months of November and January as outliers.

Incentive schemes are commonly used in many developing countries to promote particular health service programs such as deliveries. The government of the country under study launched a program to promote safe motherhood and safe-birth outcomes. One of the guidelines under this scheme was to provide cash assistance for home deliveries to poor rural pregnant women who are below the poverty line. The rationale being that the beneficiary would be able to use this cash assistance to meet incidental expenses around delivery. Under this scheme, not all the home deliveries would receive the cash assistance, including those under 19 years or above the poverty line.

The figures in the table below indicate that for almost all months except January, the cash incentives given is higher (by nearly 200%) than the number of home deliveries. In January the situation is reversed implying possibly that not all home deliveries were qualified for cash incentives, If that be the case, then this data cannot statistically be classified as an outlier.

Data Element	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Incentives for home delivery	520	641	1305	999	709	679	754	1905	646	50		
Home Delivery	500	474	541	422	408	378	348	386	357	284		

Table 4.5 Home deliveries compared to incentives

Example 6: Eyes collected and utilized- need to examine them in conjunction

Table 4.6 below reports on monthly consolidated province figures on Number of Eyes Collected and Number of Eyes Utilised. Using the same statistical procedure as described earlier, data for the month of January is represented as an “outlier.”

A public health perspective will encourage us to look at these two data elements in conjunction and not in isolation. Then, when we compare the two data elements for the months of January and February, we see a 80% utilisation while in March it is 10%. A matter of concern then is the month of March for its poor utilization rather than January where the utilization is reasonable. Another matter of concern is

the lack of data being reported from April to September indicating either a poor reporting system or poor utilization of eye care facilities in the province. Health administrator of this state would be concerned about this utilisation rate. A public health inference may ask us to consider the data for January and February as non-outliers and the others as “outliers”.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Number of eyes collected	0	0	0	0	0	0	14	66	56	71	30	80
Number of eyes utilised	0	0	0	0	0	0	2	18	27	57	24	8

Table 4.6: Eyes collected compared with eyes utilized

Example 7: Pregnancies registered and TT2 dose- link with social rhythms

Table 4.7 below reports on monthly consolidated province figures on Pregnant Women Registered for Ante-natal care and Pregnant Women Given TT2/Booster Dose. On applying the statistical formula, data for Pregnant Women given TT2/Booster dose for the month of October (49861) is represented as an outlier as it is outside the identified range (lower limit 41638 and upper limit 46674).

The data reported in the table is from a province which reports a high trend of migration- both in and out, with sometimes the outward trend exceeds the inward because of social patterns around harvesting which occurs during the months of August-September. Therefore it is expected that there will be a higher number of pregnant women being registered for ante-natal care during this period which can lead to higher number of TT2 booster doses being given in the subsequent months. Sudden dip in the figures can indicate a short transit stay. Other probable reasons for spikes in data relate with women going to visit their home towns during festival seasons, and may be the explanation for the October figures.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Pregnant women registered for Ante-natal care	45474	47895	48857	52095	50767	52661	50868	51525	47645	49066	47996	47052
Pregnant women given TT2/Booster dose	43555	44322	42667	44510	44312	44433	49861	46434	44709	44258	43450	42409

Table 4.6 Pregnancy registration and TT2 booster dose.

DISCUSSIONS

Based on the above observations and analysis, we argue that applying purely statistical methods on data values when not accompanied by a public health interpretation may lead to inadequate or even incorrect inferences of an outlier. Outliers are observations that “appears” to be inconsistent with other observations in the dataset. We argue that considering linear observations of raw data across periods may lead to erroneous inferences if not related to associated data elements. In a routine health management information system dataset, most data elements are related with each other, as shown in our examples total births and newborns weighed, eyes collected and eyes utilized, ANC registered and TT2 booster doses given. Examining the interplay of related data elements within a public health framework is essential to identify outliers and to improve data quality. For example, if the contraceptive prevalence rate is increasing then the birth rate should be decreasing, and if home delivery rate is decreasing that implies institutional delivery performance is increasing. A purely statistical analysis which excludes a public health interpretation will necessarily be inadequate and even incorrect.

Data does not get created in vacuum and is a product of the social and cultural context within which the health services are being provided and received. Social customs such as harvesting seasons, migration patterns, festivals, all are shaping the patterns of data. Such social rhythms cannot be modeled into statistical models but need to be incorporated by public health staff who have an in-depth understanding of the social and local context. Without this contextualization of data, we are most likely to make incorrect inferences of what are outliers and what are not. On the other hand, incorporating such local and contextual knowledge can provide us with richer and more accurate

Knowledge of data elements, indicators and the interplay between them form the fundamentals of public health knowledge, and arguably play a key role in the identification of outliers, assessing services delivery and health program impact. Further,

local knowledge of the context in which the data is being generated is also expected to be present with the health practitioner in the area by virtue of him or her being based in that context. It is thus imperative that this public health and contextual knowledge is integrated with statistical analysis in the identification and interpretation of outliers. This will undoubtedly improve the richness of analysis, and with it the use of information for local analysis.

In the examples presented in this paper, the analysis of outliers has been done at the central level. We argue that such a practice is flawed as a simple principle in this regard is that data is best understood in its context. As data moves up the hierarchy – from where it is collected and registered to the national statisticians – it increasingly becomes decontextualized and loses its local meaning. To address this problem, it is imperative that local practices be created – at the facility level – where the outreach nurses and facility doctors routinely discuss the data, ask questions about it, make verifications about potentially “abnormal” data, and make corrections where required. These facility staff need to thus take ownership of the data and be accountable for its quality. At this level, identification of aberrations in data need not be carried out through the use of statistical techniques, but by making simple comparisons of data across facilities and periods, and the drawing upon public health and contextual knowledge. The inculcation of such practices will undoubtedly further the agenda of “using information for local action.”

CONCLUSIONS

In this paper, we have discussed two approaches to data quality, one which is statistically based and oriented to the identification of outliers. while the other is grounded in a domain understanding of public health and the local context. While we don’t argue that statistical methods are inappropriate, three points of caution are made. Firstly, use of statistical techniques need to be necessarily integrated with this domain understanding of public health and local

context. Secondly, statistical analysis may be appropriate at the central level where large volumes of data are processed. At the local level, where we argue such data quality needs to be carried out, sophisticated statistical techniques are not required and instead software tools that allow for simple comparisons of data across facilities and periods, and their presentations in easy to understand graphs and charts would be more effective. Thirdly, statistics can lie if not used appropriately. For example, the Box Plot method if applied without following the required assumptions on which the technique is based (in terms of data distribution, data values completeness, and the factor for calculating the IQR) will lead to erroneous results and thus are dangerous in informing action.

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