Challenges and approaches in moving from data to information to knowledge: Case study from the Gujarat state health system India

Sundeep Sahay (sundeeps@yahoo.com)
John Lewis (johnlewis.hisp@gmail.com)
Department of Informatics, University of Oslo.

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 there 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 perspectives 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 emphasize 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 subjection understanding of time in a cultural context.

Practice-based conceptualizations of knowledge sharing is based on understady how people follow work routines in everyday organizational life, imbibe key learnings, and how knowledge is negotiated and shared. Gheradi (2000) discuses 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 concern 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 d*ashboard 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 mangers 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 toal) 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.

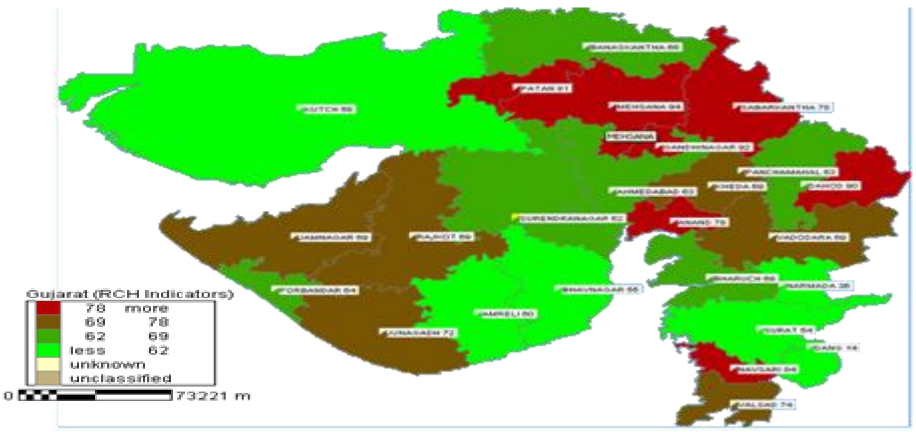


Figure 1: % of Institutional Delivery From Apr-Aug 07

Figure 2: District wise achievement of % of institutional Delivery Apr – Aug 07 w.r.t map colour

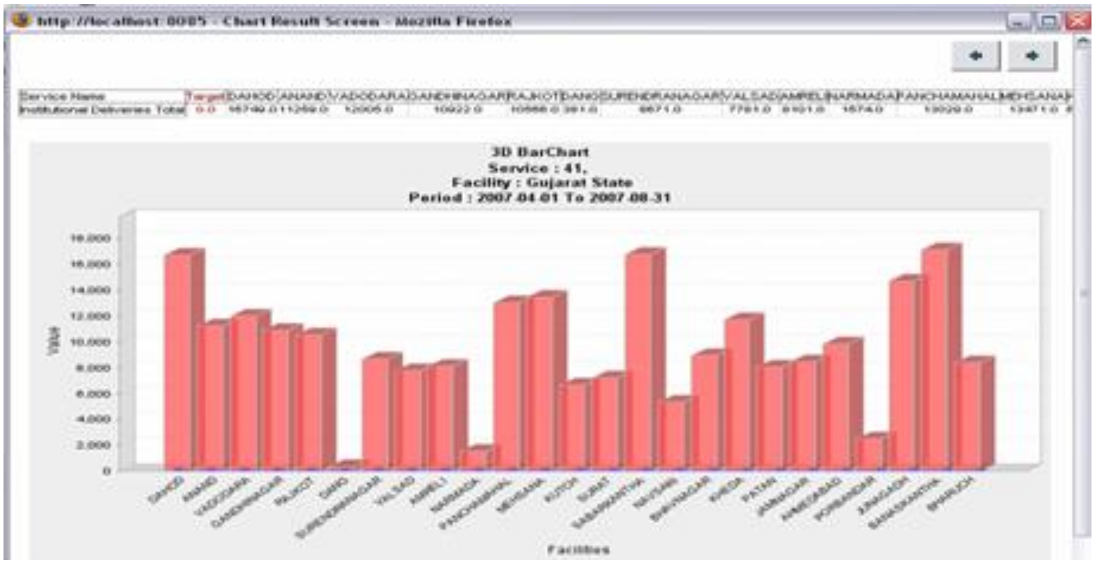


Figure3: District wise achievement of % of institunal delivery Apr- Aug produced by DHIS2

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	1068.8	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

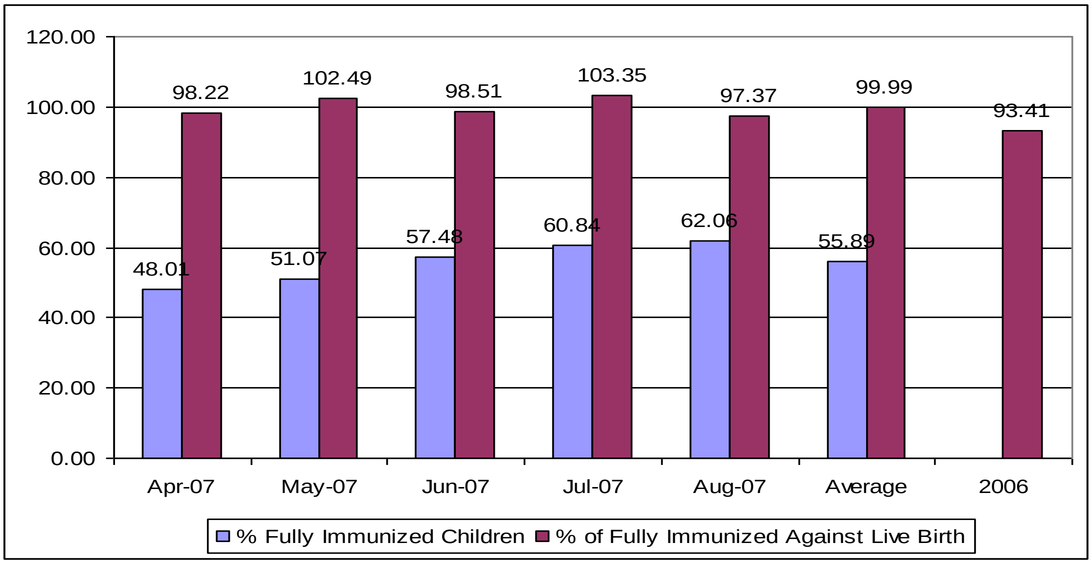


Figure 4: % of fully immunized children against expected live birth and reported live birth

The above Figure 4 describers 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.

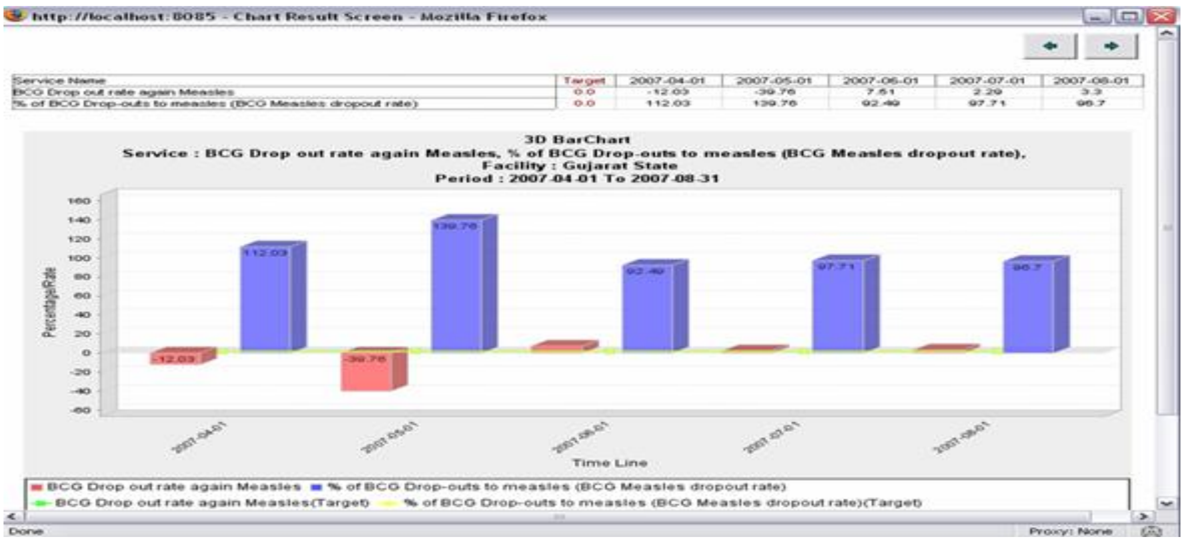
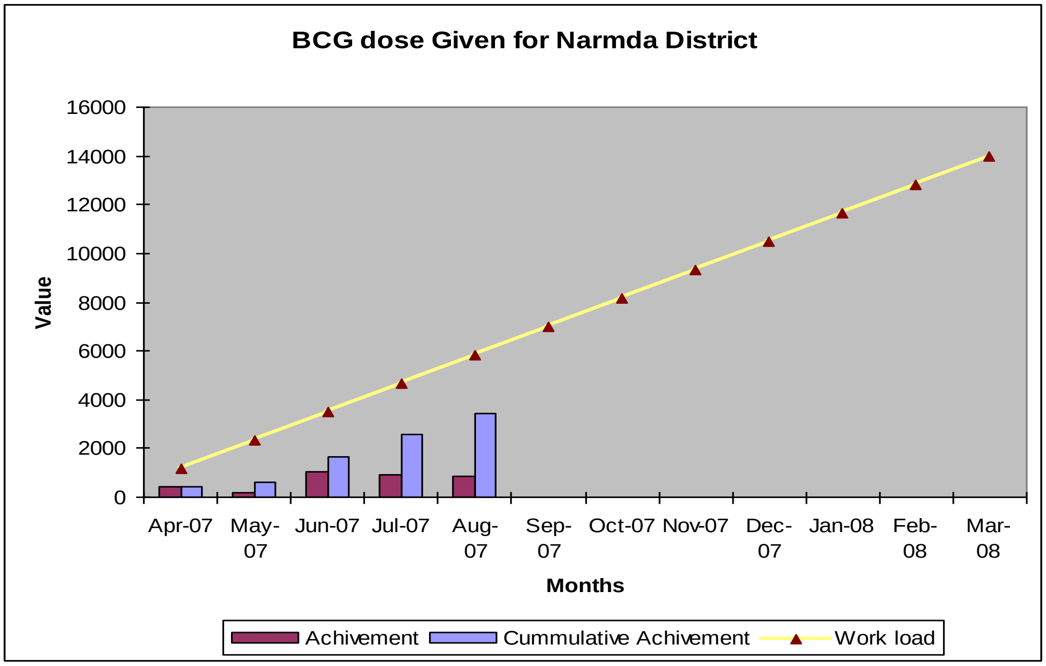


Figure 5: % of BCG drop out against Measles WHO definition Vs. State definition

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 6: Comparing NFHS data with routine data for % Institutional Delivery

5. Discussions and conclusions

Figure 5: Cummulative achievement Vs Workload of BCG dose for Narmda District, Gujarat State

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 usefullness 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 abnormaility 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 7: Abnormal state % of Total sterilization rate

Figure 8: Diagnosing the problem – drilling down to district level for the month of July 07

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.

REFERENCES:

Blackler, F., Crump, N., and McDonald, S. (2000) "Organizing Processes in Complex Activity Networks," *Organization*, 7(2), pp. 277-300.

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

Chilundo, B. (2005) "HIV/AIDS reporting systems in Mozambique: the theoretical and empirical challenges of "Representations", *Information Technology for Development*, Volume 11, Issue 3 (Summer 2005) Special issue: Information technology for health care in Mozambique, pp- 245-272

Coakes, E. (2004) "Knowledge Management – A primer," *Communications of the Association for Information Systems*, 14(??), pp. 406-489. available at: http://web.njit.edu/~bieber/CIS677F04/coakes-cais2004.pdf

Gherardi, S. (2000). "From Organizational Learning to Practice-Based Knowing," *Human Relations*, 53(8), pp.1057–1080.

Heywood A, Rhode J. (undated) "Using information for action: A manual for health workers at facility level". *EQUITY Project Publication*.

Nicholson, B., and Sahay, S. (2004) "Embedded Knowledge and Offshore Software Development," *Information and Organization*, 14, pp. 329-365.

Nonaka I (1991) "The knowledge creating company," *Harvard Business Review*, 69(6), pp. 96-104.

Nonaka, I., and Takeuchi, H. (1995) *The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press, New York.

Polanyi, M .(1967) *The Tacit Dimension*, Routledge and Kegan Paul, London.

Sandiford, P. Annet, H. and Cibulskis, R. (1992) "What can information systems do for primary health care? An international perspective", *Social Science and Medicine*, Vol. 34, No. 10, pp. 1077-1087

Schultze, U., and Leidner, D. E. (2002) "Studying Knowledge Management in Information Systems Research: Discourse and Theoretical Assumptions," *MIS Quarterly*, 26(3), pp. 213-242.

Suchman, L. (2002) "Located Accountabilities in Technology Production," *Scandinavian Journal of Information Systems*, 14(2), pp. 91-106.

Thompson, M.P.A., and Walsham, G. (2004) "Placing knowledge management in context," *Journal of Management Studies,* 41(5), pp. 725-747.

von Krogh, G. (2002) "The Communal Resource and Information Systems," Journal of Strategic Information Systems, 11(2), pp. 85-107.

Walsham, G. (2001) *Making a World of Difference: IT in a Global Context*, John Wiley.

Yakhlef, A. (2002) "Towards a discursive approach to organisational knowledge formation," *Scandinavian Journal of Management*, 18(3), pp. 319-339.

Yanow, D. (2000) "Seeing organizational learning: A cultural view," *Organization*, 7(2), pp. 247-268.