Implementing Good Design

- Practical Design Guidelines
- District Health Information Software – What it is
- How to Set-up DHIS2 in a New Context?
- Building Capacity – The Power of Networks
If the first part is about identifying the components, principles and inter-linkages of an IHIA, the second concerns the process dimension, of how by using this toolkit, an architect can start to build the IHIA and make it work on the ground. Primarily, two sets of processes are important – systems development and capacity building. Further, the DHIS (District Health Information System), the software being developed and evolved within the HISP network, is used as a concrete example to illustrate how these processes can be materialised in practice. With this background, the part is structured as a set of 4 chapters.

The first in this part, Chapter 5, “Practical design guidelines”, firstly zooms down from the macro level of the IHIA to the micro level of the system, and how these can be developed and gradually evolved to a “system of systems” or a IHIA. The example of systems thinking, fundamental to this chapter, is provided through a hospital information system. The link between design and practical materialisation is systems development, and more closely the design and development are intertwined, there is a sounder basis for the IHIA. A key focus of these design principles is on Participatory design, and how through the engagement and ownership of users, more appropriate systems can be developed, can help foster local control and ownership and to develop a sense of empowerment amongst users. An incremental approach to design and development is another design principle, exemplified through an example from India involving the reform of the national HIS.

Chapter 6, the second in this set, describes in detail the technical components of the DHIS2, which provides us a concrete tool,
basis, and a set of building blocks to operationalise an IHIA in practice. The DHIS2 is conceptualised both as an instantiation of an IHIA, and also a platform which can facilitate the evolution of architectures. Corresponding to the 3 level architecture articulated in Chapter 1, the DHIS 2 is described at the level of data (standards of interoperability and the data model), the application (the underlying business logic of indicators), and the user with respect to features and functionalities of carrying out Business Intelligence through the Dashboard and Geographic Information Systems modules.

Taking a look into the future, we describe some priority areas for further development and enhancement of the DHIS2. DHIS2 is discussed as a platform which can help foster innovation.

Chapter 7, the third in this set is titled “How to set up DHIS2 in a new context?” and provides practical multi-country cases on how to set up and scale DHIS2 in a new country. Cases from Botswana, Burkina Faso, Bangladesh, Tajikistan, and Sierra Leone are described to illustrate how each country is different in terms of opportunities to use technology, the political environment around which negotiations can take place to define datasets and indicators, and the existing installed base of paper forms and legacy systems. The combination of these conditions helps to define particular strategies for the introduction of DHIS2, in a way that can satisfy both the technical and institutional challenges.

The last chapter of this set, 8, focuses on the other key process element of systems development – capacity building, and is titled “Building capacity – the power of networks”. Networks and networking is described as the central underlying principle for building capacity at both the individual and institutional levels. The Oslo/HISP model of multi-level capacity building including PhD, Masters, and in-service training, is described as a successful model of building capacity in a network framework. Strategies for building capacity into formal institutional measures and hand holding implementation support are described in this chapter using examples from Sierra Leone, India and Ethiopia.
Part I of this book focused on design principles at the architecture level, including related to concepts of architecture, standards, integration, interoperability and scaling models. In this chapter, we zoom down from this macro-level of the architecture to the relatively micro-level when we need to start make practical design choices at the level of an information system – for example, a system for routine health data collection and analysis or a patient-based medical record system. As discussed in our conceptualisation of the IHIA, these two systems and others, need to speak to each other; for example, the aggregates from the patient system need to be interoperable with the facility system, implying the data should be exported from one and imported into the other. Together, building such inter-linkages between these different information systems helps to initiate the creation of the IHIA. As other systems such as ones for human resources or finance feeds data related to human resources and finance respectively into the facility system, the architecture or the system of systems starts to gradually evolve. For this evolution to take place effectively, we need to adhere to principles of architecture discussed in the previous chapters, especially related to standards, interoperability and scalability.

The guidelines discussed in this chapter will help in practically approaching the design of individual systems within the framework of the larger IHIA being evolved. This also then illustrates and supports our approach to architecture as a verb – an activity in process, involving bottom up designing, making small things work in practical settings, slowly linking individual systems with others, within a broad template of how we want the architecture to evolve. This approach is in contrast with a top down view of an architecture – the grand master plan, which is pre-defined, and implemented as one monolithic structure. Our approach emphasises a modular strategy, involving the creation of small bits, which can plug into others, or plugged out as the case may be. We have described the evolution of a IHIA as a process, evolving over time, in an incremental and iterative manner. At the heart of this approach is the social systems thinking, which we have emphasised earlier, but discuss it in context of information systems design.

5.1 **Systems Thinking**

At the micro-level, a system can be conceptualised as a set of interacting or interdependent entities forming an integrated whole. In simple terms, a system can be described as a set of components that are interconnected through processes of input, throughput, output and feedback. A system can be described to have a
structure, defined by the various parts in it and their inter-relations. In the example of the hospital system described in Chapter 1, the structure is represented by the different wards, the allocation of doctors to Outpatient Department, forms of registration, billing and laboratory examination. A system exhibits ‘behaviour’, with respect to their inputs, processing and outputs of material, energy or information. For example, behaviour could reflect how patients are registered, the mechanisms used to define bed allocation to Inpatient Department patients, the manner in which examinations are carried out and how nurses are recruited. A system inherently has interconnectivity with its various components having functional as well as structural relationships with each other. For example, the quality of the throughput (standard of patient care) will have direct implications on the quality of the outputs (percentage of patients achieving cured status). Similarly, the level of inputs (for example, the bed capacity of the hospital) will influence the quality of the output in bed occupancy rates.

5.1.1 The Hospital – Architecture at the Local Level

An information system represents a system that relates to the flow and use of information. In a broad sense, an information system refers to our conceptualisation of the interaction between people, processes, data and technology. It refers not only to the ICTs that an organisation uses to enable the flow of information, but also to the way in which people interact with this technology.

We will use hospital to illustrate both the concept of system and information system, and how they relate. A hospital is a complex ‘system’, which may be regarded as containing input, throughput and output at multiple levels. In our perspective of an integrated enterprise architecture, we may distinguish two key overall ‘systems’, related to patient care and management respectively. At the level of patient care, the individual patients are admitted to the hospital, they are provided care through a number of services, and they leave the hospital, alive or dead either being discharged or they die. At the level of hospital management, the whole ‘machinery’ making up the hospital is the area of concern:

- The ‘input’ is not limited to the patients, but includes the entire support structure of specific services, human resources, money, policies and equipment.
- The management of the above resources for optimal patient care represents the throughput.
- The results in terms of treated patients and their costs of treatment may be regarded as the output.

The hospital is a micro-version of the overall health system and most of the general and specific health system support structures are found as subsystems within the hospital system: human resource management, patient care, laboratory, X-ray department, surgery, pharmacy, and facility maintenance. In a management information perspective, the hospital is comparable to a district. In a district, management is responsible for services delivered at all the health facilities in the district as well as the performance of the health programmes and specific services. In the hospital, the management is responsible for all the services provided by the different wards and departments in the hospital.
While in the previous chapters, we have described the IHIA mostly at the level of a state or a district; however, in this section, we translate these principles of IHIA design to the level of the hospital, and more generally to the level of an individual health facility. For the district and higher levels, the data warehouse and IHIA approach described in this book is well aligned with views and strategies put forward by most actors within global health. Access to essential data and indicators from across health programmes and services, in a district or in a country, is generally regarded as crucial for management, decision-making and monitoring and evaluation. Here we will extend these design principles to the hospital and the health facility; integrated essential indicators targeting management needs are as important in the context of hospital as in the context of district and health programme management and monitoring and evaluation. Given that roughly an estimated 60% of the health budgets in developing countries are going to the hospital sector, one would assume that global and national health communities would prioritise the strengthening of the currently generally very poor hospital management information systems in countries. However, strangely enough, very little co-ordinated efforts and resources from the global donor community are directed to this sector. As the direction of efforts to strengthen information systems is following the money, the topic of hospital information systems in developing countries is also a neglected area in the HIS community. Donors will always tend to direct their funds to disease or service specific areas, where results may seem to be easier to achieve, and document. To strengthen the district hospital sector in Africa, including human resources, equipment, transport, buildings, maintenance, and so on, may appear as too massive a task to embark on. As a hospital is more like a living organism along various interconnected dimensions, it is difficult to single out a particular sub-area for targeted vertical support from a donor organisation, although the maternity wards in hospitals are crucial to the MDGs on maternal health. It is difficult to support the maternity services in a dilapidated hospital with limited ambulance services without targeting such shortcomings. The scale and complexity of the problem is probably the main reason why donors are not much interested in the hospital sector, despite its key role in the MDGs of reducing maternal mortality. The WHO likewise; while having special programmes and offices directed towards numerous specific diseases and service areas, seems to have no coordinated efforts, not even an ‘office’, concerned with addressing the plight of the hospitals in developing countries.

Any effort to improve the hospital sector in developing countries will depend on the quality of information targeting areas where quality, efficiency and management can be improved. Providing high quality and timely data, effective monitoring of a few key indicators may have considerable impact. Mortality rates, for example, perinatal (still births + deaths under one week), under one year and maternal mortality, are regarded as the most effective quality indicators for comparing performance between hospitals regardless of the level of sophistication of the hospital sector. In England, for example, the under one year mortality rate is found to be the most effective way to compare quality across the facilities in the hospital sector. Despite the differences in quality between England and Africa, mortality rates may be used as an ‘universal’ indicator for comparing quality across the hospital sectors in the different contexts.

In addition to the quality of services, the efficiency of services delivered represent key target areas for hospital management. Also in this area, there are essential and ‘universal’ indicators that need to be included in any hospital information system. These are indicators used to measure patient ‘throughput’ and the optimal utilisation...
of resources: While ‘average length of stay’ by patient group and/or service and/or diagnosis is the most effective way to measure patient throughput, ‘bed occupancy rate’ is the most effective way to measure to what extent resources are optimally utilised.

We use these three types of indicators to illustrate that relatively simple indicators can be turned into powerful tools for hospital management. By ‘simple’ we mean that the data needed to calculate the death rates are relatively easy to collect. For example, within the actual group of patients for the actual time period, mortality rate is calculated:

\[
\text{Mortality Rate} = \frac{\text{Number of Deaths}}{\text{Number of Patients}} \times \%
\]

Of course, the indicators can be refined in order to single out causes of deaths due to poor ambulance services or referral system. Infection rate is another key quality indicator, also based on data that is relatively easy to collect. For the bed occupancy rate or average length of stay, the following formula is used:

\[
\text{Hospital Bed Occupancy Rate} = \frac{\text{Number of Inpatients days}}{\text{Number of Active Beds}} \times \%
\]

Note: The number of inpatient days is also referred as bed-nights when the number of days are one more than the number of nights,

\[
\text{Average Length of Stay} = \frac{\text{Number of Inpatients days}}{\text{Total Number of Patients}} \times \%
\]

We see that the data are of different types and have different sources; number of active beds categorised as ‘semi-permanent data’ in the DHIS terminology, and will typically be collected and updated regularly or on change; inpatient days are traditionally collected by midnight census, but can also be derived from a complete patient record system. In Table 5.1, we summarise some key indicators that can be used for hospital management.

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<thead>
<tr>
<th>Table 5.1</th>
<th>Indicators for hospital management</th>
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<tbody>
<tr>
<td>Indicator</td>
<td>Numerator</td>
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<tr>
<td><strong>Inpatients</strong></td>
<td></td>
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<tr>
<td>Activity</td>
<td>Bed occupancy rate (Bed utilisation rate)</td>
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<td></td>
<td>Average length of stay</td>
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<tr>
<td></td>
<td>Percentage of TB patient days</td>
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<tr>
<td><strong>Deaths</strong></td>
<td>Crude death rate</td>
</tr>
<tr>
<td></td>
<td>Infant mortality rate</td>
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</tbody>
</table>
Despite being crucial for hospital management, the data and indicators described above are not easily available in many developing countries. Routine reporting from hospitals is often of poor quality and not well-integrated within the district, state, and national systems. When hospital systems are being developed, the first priority is often patient billing because it has importance for the hospital administrative operations, and the essential indicator approach is often neglected.

| Category            | Indicator                                                                 | Data                                           | Reference                      |
|---------------------|---------------------------------------------------------------------------|                                               |                               |
| Perinatal mortality rate | Maternal deaths                                                                 | Total deliveries                               |                               |
| Maternal mortality rate | Total deaths audited                                                        | Total deaths                                  |                               |
| Death audit rate | Total deaths audited                                                        | Total deaths                                  |                               |
| Nutrition | Percentage of severe childhood malnutrition | Number of children with severe malnutrition | Number of children < 5 years that are admitted |
| Gynaecology | Number of termination of pregnancies performed | Number of termination of pregnancies performed | N/A                            |
| Obstetrics | Low birth weight rate                                                      | Number of live babies with birth weight <2,500 g | Total live births               |
|                     | Percentage of deliveries with WR recorded (tested for syphilis)            | Percentage of deliveries with WR recorded     | Total deliveries               |
|                     | Percentage of assisted deliveries                                           | Percentage of assisted deliveries              | Total deliveries               |
| Obstetrics          | Caesarean section rate                                                     | Number of caesarean sections                  | Total deliveries               |
| Teenage delivery rate | Deliveries to women <18 years                                               | Total deliveries                               |                               |
| Outpatients         | OPD Percentage of referrals from clinics                                    | Patients with clinic referral letter           | OPD + casualty headcount       |
|                     | Percentage of trauma                                                       | Motor vehicle accidents + interpersonal violence | OPD + casualty headcount       |
| Support             | Percentage of stores items out of stock                                    | Number of store items out of stock            | Number of items should be in stock |
| Pharmacy            | Percentage of EDL items out of stock (Essential drug list)                  | Number of essential drugs list items out of stock | Number of items that should be in stock |
|                     | Items per script                                                           | Number of items prescribed                    | Number of prescriptions        |
| Financial           | Cost per patient day equivalent                                             | Total amount spent in last calendar month     | Patient day equivalent         |
|                     | Percentage of budget spent to date                                          | Expenditure to date this year                  | Budget for the year            |
In Figure 5.1, a schematic description of the hospital information system is provided. A hospital is comprised of a number of modules or sub-systems including medical records, laboratory, billing, pharmacy, outpatient, and inpatient. The above schematic of a hospital information system depicts it in the perspective of the management and enterprise perspective of the IHIA.

![Integrated Health Information Architecture: Power to the Users](image)

**Figure 5.1** Data warehouse based architecture at the hospital level. Summary data from all sub-systems are fed into the data warehouse, where essential management indicators can be calculated and disseminated.

We have taken the architecture perspective and applied it to the hospital. Compared to a health district, we may say that the various health facilities and specific programmes and services, in this design, are replaced by wards and hospital services and resources. In developing countries, and particularly in African countries, hospital information systems are basically paper-based, which is accommodated in the scalable architecture depicted in Figure 5.1. According to the suggested design of hospital information systems, the hospital data warehouse for management information should be part of the first phase of any project. Whether the hospital system is totally paper-based, or whether it is a medical record system, or a more simple billing system, the data warehouse should be established. While in the beginning, the data sources will typically be paper-based, new computer-based systems or modules may be ‘plugged in’, integrated and made interoperable with the data warehouse as they are introduced or expanded.

From the discussion above on key indicators for hospital management, it appeared that the number of inpatient days, or bed-nights, as they may also be called, is of particular importance. From Figure 5.1, both average length of stay and bed-occupancy rate is being calculated. Traditionally, these numbers are collected through midnight census in each ward. If a medical record system is in place, or a billing system, which are typically made in order to keep track of how long time the patient has spent in the hospital, inpatient days may be generated from the patient records. However, often, also in advanced hospitals, the old-fashioned manual counting at midnight is being
upheld, because of the complexity of keeping track of the movements of patients between wards. It is a bit like the manual counting of passengers in an airplane before take off. They have computer-based sources, but due to a certain complexity that is inherent they want to be sure and resort to manual counting.

The key quality and management indicators are very useful when comparing performances across all hospitals in a state or country. Therefore, it is important to ensure that each hospital is reporting to the state or country-wise hospital data warehouse, and that they are well integrated in the national health information system framework. As mentioned above, that is not always the case, as information reported from hospitals is often of poor quality and poorly integrated within a national HIS framework.

5.1.2 Health Information Systems – A Broader Perspective

At a broader level, HIS is focused on supporting management processes within the health domain. For example, it can be used to support the monitoring of how a country is progressing on the achievement of its MDGs, say relating to the reduction of infant and maternal mortality. An input to this process can be the monthly registration of data on maternal and infant deaths in the last reporting period. This input is then subjected to throughput processes of storing and retrieving of data, and then dividing it by the appropriate denominator (100,000 live births to calculate the maternal mortality rate), and then displaying this output in terms of charts or graphs that compares the performance of this period with previous periods, and of one district or state against the others.

Taking the example of a routine HIS to support the management of maternal and child health programmes, and conceptualising it within a framework of systems thinking. In this case, the input comes from the recording of the data relating to the services that a field nurse provides (also called Auxiliary Nurse and Midwife or ANM in India). For example, after providing a BCG vaccination to a child, the ANM will note that event in her diary. This and such related figures noted in the diary are then transferred to the primary register (for immunisation) maintained in the facility, and the compiled figures for the month become the input to the HIS computer-based application that is installed in the nearest health facility. Once this data is provided, there is a process of throughput, wherein the software helps to conduct checks on data quality, generate aggregated reports (for example, related to monthly achievement) for the facility catchment area, and its transmission to the next level of the sub-district or district as the case may be. These output reports from the facility becomes inputs for the district HIS, and so on to the state and national systems respectively.

How we define the boundaries of the system under study is a matter of our focus and the questions we seek to answer. We can either conceptualise the entire HIS from the community to the national level as one national system or have it broken up by state, district and sub-district levels. Health information systems can be further divided by the health programmes they support such as for immunisation or malaria, or it be an integrated system including all health programmes. Similarly, the HIS can be segregated with respect to functional areas of human resources, finances, infrastructure and drugs. How we define the smaller components or pieces and their inter-relations are design choices relating to the system and architecture respectively. In Box 5.1, we define some basic elements of a HIS. A HIS can have multiple data
**Box 5.1 Components of a HIS**

*Data Element*: The lowest unit of raw data collected, for example, number of children given BCG vaccinations in this month in the PHC. Data elements can be of different types. For example:

- Routine data element which is collected with a routine periodicity (for example, BCG vaccination figures collected monthly).
- Semi-permanent data elements data which does not change routinely. For example, number of hospitals in a district which should be collected annually.
- Permanent data elements which do not change. For example, number of districts in a province (which could of course also change).

*Each data should have a defined periodicity of reporting.*

*Data Value*: The value of a particular data element, for example, 10, which is the number of children given BCG vaccinations in this month.

*Indicator*: Putting a data element into context of a coverage or target population. For example, Percentage BCG Vaccination Coverage of a district takes the total number of BCG vaccinations given for a district in a month and divides it by the expected live births in the district for a month, and multiplies by 100 to get a percentage figure.

*Dataset*: Represents a set of similar data elements, so for example all data elements related to the services provided by a Sub Centre can be grouped into a Sub Centre Dataset. This dataset can further have groups in it, such as for immunisation and deliveries.

*Recording Format*: Includes the formats in which the primary data is recorded. For example, the primary register in a Sub Centre, where all the services provided by the field nurse in a day are recorded.

*Reporting Format*: Includes the format in which all the data from the recording format are transferred and sent to the appropriate reporting authority. For example, the Sub Centre nurse takes all the monthly data from her primary registers and transfers them into a monthly reporting format and sends that to her reporting PHC after doing necessary data quality checks and getting the required signatures as authorisation from those responsible.

*Organisation Unit*: It is the health facility that provides services within its catchment area or facility, and reports on the data elements representing these services.

*Organisation Unit Hierarchy*: Represents the reporting relationship, defining to which unit a particular organisational unit is responsible for its routine reporting.

The HIS is thus made up of the following “4Ws”:

- **What** – data element.
- **When** – periodicity of reporting.
- **Where** – organisational unit.
- **Why** – The indicator to which a data element contributes.
sources such as emanating from field visits of nurses, records from primary registers, births and death details from the civil registration system, population details from the district authorities.

All the above serve as data inputs to the HIS. In its raw form, this data is not useful for a health manager, as he or she needs to compare this data representing achievements for a month with what was expected, implying this data has to be put into context of a target or population coverage. This requires the processing of data into health indicators – representing information, either manually calculated or through the software. Further, the manager needs to act on this information, that is to use it to take decisions, for example, putting more resources in an area which has been identified to have a poor BCG vaccination coverage. By doing this, the information is converted to useful and practical knowledge. Based on action taken, feedback can be obtained on the relevance of the information used, and whether new forms of inputs are required to take improved action. Such application of systems thinking help us to design based on inputs, formulate throughputs such as for the appropriate generation of indicators, and design effective outputs in terms of presentation reports. Feedback loops help to treat design as an ongoing work in process and to make continuous improvements based on reviewing the impact of the actions taken.

An effective HIS should help users to answer the following types of questions:

What – is the disease profile of a district?

When – are certain diseases more prevalent?

Where – in a district certain outbreaks of diseases are expected?

Why – is malaria more prevalent in this district as compared to others?

After discussing the relevance of systems thinking on HIS, we outline some design principles and how it can support its evolution to an effective IHIA.

5.2 Practical Design Principles

A normative guiding principle in the design of a HIS is its need to support the use of information for local action, which provides the foundation to formulate some practical design principles. System designers possess the agency to develop design inscriptions, which when embedded into the application, shapes system use in at least two ways: 1) System restrictiveness and 2) Decisional guidance (Silver, 1991).

While system restrictiveness refers to the amount of restrictions that the designers want to provide to the user in the use of the system, decisional guidance refers to the degree of step-by-step guidance the user receives from the system. A system can be more restrictive depending on various factors including the assumptions the designers have of the users (for example, of their skill levels), capability levels of the users, and nature of deployment of the application (for example, if it is server-based or standalone). For example, in a HIS, with respect to design choices related to the generation of reports, the user can be provided with pre-configured reports or can be given the facility of excel pivot tables to create their own desired formats. The first is an example of a more restrictive system relative to the latter option. Local control of own data is a key principle, but will depend on a certain level of skill. A
design option would then be to provide both pre-defined reports and do-it-yourself analytical tools.

Given that a HIS is generally used by a variety of users and it evolves over time, the questions of how much should a system restrict or guide are not straightforward questions to answer and rarely ever cast in stone. However, we can be aware of certain principles that can help to guide taking of design choices:

- Integrated independence – Treating the HIS as a component of an architecture, and not as standalone.
- Adopt an incremental approach to design and implementation.
- Adopt a Participatory Design approach.
- Should allow for local control.
- Should provide for a hierarchy of information support.
- Should be action, not data led.

These six principles are described now in detail.

5.2.1 Integrated independence – Treating the HIS as an integrated component of an IHIA, and not as standalone

Especially, fuelled by the successful growth of the Internet, HIS can be arguably conceptualised within an IHIA perspective which emphasises:

- Components are always inter-connected, but applying a modular approach will help managing changes.
- There is always a historically existing technical and institutional legacy – an installed base, which has to be addressed and somehow incorporated in the development of a new system. We can never design from scratch.
- IHIA’s are always in the making and thus never designed for a finite number of users, as the user community always evolves over time. This implies that requirements can never been ‘frozen’. For the same reason, an IHIA never has a finite start and end date.
- There are network externalities to be obtained, because new users will seek to be enrolled into the use of the system as they see others using the system, which serves as an ‘attractor’.

The Internet is a classic example of such an architecture (where roads and power grids are examples of physical infrastructures), which has evolved over more than three decades, starting from specific applications for the United States army to now where users of all kinds are engaged in different types of applications such as e-mail, web sites, music downloading, social networking (such as Facebook) and communication (for example, Twitter). Diffusion of the Internet and other communication technologies have enabled tighter integration, which again, may lead to less independence and flexibility. The case of South Africa has demonstrated a possible way out of this dilemma, by demonstrating that both integration and independence of data standards have been achieved between provinces (i.e. geographical areas) and health programmes (i.e. functional areas). A sort of integrated independence has emerged through the interaction between and within different sub-systems and the overall HIS environment. Key implications of this on the conceptualisation of an IHIA include:
Designing for loosely coupled and modular systems: Given the emphasis on the inter-connected nature of systems where nothing is standalone, we need to allow for different pieces to speak to each other while ensuring the failure of one does not collapse the entire IHIA. This raises the need for designing loosely coupled systems employing bridges and gateways, which allows components to be both inter-dependent and independent at the same time. This need has been arguably the strongest reason for the use of open source systems based on open standards in the health domain.

Develop flexible standards. The IHIA includes numerous interdependent standards, which may easily arrive in lock-in states resulting in whole systems being locked in. It is therefore important to develop standards and their relations so that they can adapt to a changing environment and thereby contribute to the sustainability of the IHIA, meaning that the standards themselves need to be flexible. We distinguish between use flexibility and change flexibility of standards. While the DHIS has gained popularity because it makes it easy to change data standards – change flexibility – the need to know principle of focusing on essential data in contrast to "nice to know" data, illustrates how the same data can be used by many actors in different contexts – use flexibility.

No pre-defined set of users and application areas: A HIS can start as a data entry tool and slowly evolve by linking with different health programmes (for example, Malaria and TB) catering to a variety of users (facility, district, state, national and global levels), and also be used as a medium to provide access to the public. There are no pre-defined limits to users, applications and uses.

Specifications can never be frozen: An IHIA perspective helps to avoid the historical trap of trying to 'freeze' the specifications of a system, when by very definition, the health system is inherently dynamic requiring the HIS to be flexible to adapt to its changing circumstances, and not for the health system to configure itself to the rigidity of the system.

Health information systems are cultivated and not constructed: The emphasis on the installed base cautions to guard against the practice often advocated by consultants to obliterate existing processes and build brand new ones (as is the guiding philosophy of Business Process Engineering). While we may be able to eliminate existing technical systems, killing deeply embedded and historically existing social and institutional processes are by definition not possible. Health information systems need thus to be cultivated to a IHIA from an existing installed base (for example, the existing paper-based systems) and they cannot be constructed from scratch on a clean slate.

An example of the utility of such an IHIA perspective can be seen in the use of mobile phones to strengthen HIS. In India, for example, mobile phones have been provided by some of the States to ANMs to register service data and transmit it using SMS to a server hosting the state HMIS application. If the design of the mobile application had been treated as a standalone activity, then the focus would have been only on the mobile and a failure at that level would have led to the collapse of the monthly facility based HMIS reporting. However, an architecture perspective allows to see the connection between the different components (mobile phone, server, network connectivity, computers, and so on), and design for buffers and backups to minimise these systemic risks of failure. For example, till the reliability of the mobile application is established, states can decide to keep both the flows of information (the mobile
supported and the direct entry to the DHIS2 supported HMIS application) ongoing.

Figure 5.2 illustrates this mobile supported IHIA which includes the DHIS2 which represents the backbone HMIS application in a state.

![Figure 5.2 Mobile supported Health Information Architecture](image)

5.2.2 Adopt an Incremental Approach to Design and Implementation

Radical change is often the aim when introducing ICTs and a new HIS. However, experiences from introducing ICTs in industrial countries, for example in efforts labelled Business Process Reengineering, have shown that full-scale changes in one go is difficult to achieve because of the complexities involved and organizational and system-wise inertia; new solutions need to build on and take the installed base into account. The golden rule is therefore that new solutions need to be designed so that they support existing practices and that these practices should then be modified and changed incrementally. This is a non-trivial task, requiring sensitively carried out design, a deep domain understanding of the work area, and an absence of arrogance on the part of the designers to not dismiss the existing practices of the users as being inefficient and irrational. Incremental development makes it possible to incorporate learning through use in the design and by delaying key decisions, for example on choices of technology, avoiding being ‘locked in’ and not being able to take advantages of future technological opportunities. You achieve more by starting small and growing bigger than by starting big and fail. We may label this approach radical change through small steps.

To start with the ‘easy wins’ and ‘low hanging fruits’ is a related key principle. That approach seeks to provide a good and rapid solutions to important problems for the users. In this way users get interested, and if usefulness is demonstrated, more users will be attracted, momentum may be created, and what started small will
grow bigger. The development of DHIS in South Africa illustrates this principle; the flexible data structure of the application and rapid feedback to the users of their information enabled by the decentralised technology demonstrated how changes could be achieved, how fragmented datasets could be harmonised, and more users and provinces then joined forces and created more momentum; the DHIS approach was developed into an attractor. Important in the case of South Africa was that the relative simple solution provided to what seemed to be a very complex problem worked well for end-users in the district as well as for managers and policy makers at higher levels. With this, more actors became interested and were enrolled in the process which caused the movement to grow further and gain more momentum. The case of Sierra Leone shows a similar development; users in different health programmes did not believe it was possible to unify reporting forms and procedures before it was proven possible in practice. Then they decided to join the process and thereby confirmed that it was indeed possible.

5.2.3 Adopt a Participatory Design Approach

The participatory design approach is a key part of the principle of incremental development. The cases of DHIS development used in this book are all about what we may call incremental prototyping, or an approach to developing the system step-by-step through use. This participatory methodology of prototyping is based on a close and mutual relationship between design and implementation, and between designer, or developer/implementer, and users. A prototyping approach, as contrasted to a system lifecycle approach that assumes a linear cycle of freezing specifications and then development, takes a view of design that is not fixed, but continues to evolve over time. It may also be called a learning approach, as what is learned through implementation and use is fed back to the design and further development of the system. In this way, the knowledge barriers between the developers who know the technology, and users, who know the context and work practices, are gradually and mutually bridged; as users are learning about the technology and the developers about its context of use.

The aim is to design and develop the system in close interactions with the users. First prototypes are developed and shown to the users, who then give their inputs to developers, who can then go and further reform the system based on this feedback. This interaction and process of change takes place in small and rapid cycles, often referred to as a process of agile development. As a result, there is an inherent flexibility in the design process which is able to incorporate new inputs, reducing the risk of having to wait for large development cycles to be completed before realising that the user is unhappy with the system. By being engaged in the process of giving inputs to the system, the user experiences a greater sense of ownership with the system right from its initiation.

A prototyping approach to design also enables an incremental approach to implementation, where first the low hanging fruits can be taken and visible benefits shown to the management. This approach also allows the implementation team to gradually learn about the context, and can then next reach out to the slightly higher fruits. An example of this approach is provided in Box 5.2 describing the approach to the development of a district hospital information system by HISP India, also referred to in Chapter 4.
An Incremental Approach to Implementation

The state of Himachal Pradesh developed a Request for Proposals for the creation of a hospital information system for its 20 hospitals in the state. In response to this, 51 vendors applied; however, the tender could not be offered to any of the vendors because the state had difficulties in evaluating the bid.

Subsequently, the state approached a national technical support agency for the Ministry of Health, who in turn approached their technical support partner (HISP India) to study the requirements and develop the feasibility for its development. On studying the initial requirements document, it was found that the entire system had been conceptualised by the state as a set of about 15 modules, some rather straightforward such as registration and others more complex – both from the design and implementation perspective, such as scheduling of doctor appointments through SMS. Further, the system was planned to be implemented in 20 hospitals simultaneously.

HISP India saw this proposed system to be rather complex, and many of the requirements to be utopian, not fitting in with the reality and infrastructure of what currently existed in the hospital. Instead of taking the whole system and all hospitals in one go, they proposed an incremental approach to design, development and implementation, which was envisaged to take the following small steps.

Select one representative hospital (out of the 20) as the starting point.

In this hospital, develop and implement module by module, and as a module is completed, including its testing, then integrate it with other modules.

The list of 15 modules originally envisaged were categorised into two groups, the first including the core or essential modules which needed to be addressed first and then the second group, which were more complex and not so essential which would be addressed subsequently, if the state required.

Even within the priority core modules, a further priority listing was done, and the management identified what was needed first including registration and billing. The Outpatient Department module was seen as being more complex and to be taken towards the end of the first priority list.

The plan was then to take the registration module first, customise it, implement in the first hospital and then take the next module, thus allowing taking first the low hanging fruit and showing visible results. This builds confidence and trust of the hospital administration with the implementation team. Similarly, the development and implementation team gain an understanding of the hospital context and the inherent challenges in introducing a system. Resource material like training manuals and other, which are developed can then be also used in other hospitals.

The above approach inscribes the HISP approach to development and implementation, which has fundamentally been founded on such a prototyping approach, and has contributed to large scale successes in implementation in South Africa, India and various other countries. This has also contributed to the creation of a software product that is inscribed with a high degree of public health knowledge built upon the practices of health staff in the field.

To develop a sense of ownership to the system among users is the key to sustainability and any form of successful HIS development. The need for local control of information and system is a key to develop such ownership, which brings us to the next principle.
5.2.4 Should Allow for Local Control

Design-reality gaps have been established by researchers to be a primary reason for the failure of many HIS in developing countries. These gaps arise from the physical, cultural and knowledge distance of the technical developers from the reality of the users. This distance firstly leads to inappropriately designed systems, and secondly of user requests for changes going unheeded by the developers. In the context of developing countries, HIS are often designed and developed by national ministries or by international consultants who are far removed from the practical setting of their use. This phenomenon of ‘design from nowhere’ is embedded in larger questions of power and control. With respect to user requests, they can come in the form of making changes in data elements, indicators, creating of data validation rules, incorporating new reports or in some cases even adding other modules and applications. Most often, in the institutional setting of health ministries and departments at the national and state levels, the in-house capacity to make such changes is limited or even non-existent. The important question then is what should be the mechanism by which change requests are logged, how are they responded to by the technical teams, and subsequently received back by the users from where the request originated? Typically, when proprietary systems are used, each change request has contractual implications, and vendors tend to not respond till the cost of which is covered in their contract. And since often systems are developed based on the assumption of ‘frozen specifications’, most change requests are seen to fall outside the purview of the existing contract, and thus not attended or at best done so after a frustrating time delay for the user. In defense, the technical team will argue that ‘users do not know what they want and always come up with new demands’. The disempowered users tend to firstly get a system that does not suit their requirements and capacities, and secondly are chided for raising that as an issue.

Since existing systems of contracting are institutional legacies, and so difficult to change, the challenge for system developers is to provide appropriate tools and approaches to the users to help them exercise greater control of their local conditions. A first step in this strategy is to use software tools and platforms in which the code is under the control of the user giving them the freedom to change and customise based on their evolving needs. Proprietary systems are by definition proprietary – under the control of the vendor and not available for modification without a cost implication. Applications developed on FOSS platforms provide at least the potential to the users to be able to have the ownership and right to modify. However, realising this potential in practice is a challenge due to limited technical capacity in the institution, such as for accessing the source code and making the required changes. To address this challenge, health department needs to try and fill this gap by creating technical support partners either in-house or through external sources in the initial stages, and gradually empower the in-house staff to be able to do so in a more independent manner.

The other implication for enabling local control comes in the form of design, where systems need to be made flexible, easy to use, and allow significant degree of changes to be made through the user interface itself without requiring programming intervention. For example, a user should be able to select from the interface the category of ‘data elements’ and be able to add, delete or modify data elements. Same as is the case with the creation of locally required indicators and data validation rules which should be enabled through the interface. Another important aspect of local control is in the domain of reporting. Users should be able to export data into formats,
such as Excel, which they may be more familiar with to be able to create their own ad-hoc reports, design graphs and charts, and carry out further analysis (for example, to see data trends). Allowing outputs in formats which can be easily imported into other systems, which users may be more familiar and comfortable with (such as EpiInfo which is popular with the medical fraternity), further allows the exercising of greater local control. With advances in technology, various tools are increasingly being made available for not so expert users, such as for report design and presentation, which can again help to empower users as they increasingly gain local control.

In summary, through deliberate design choices, such as providing for flexibility in local customisation, having easy to use systems, and the use of open source and user friendly tools, systems can be so designed to break the monopolistic hold of proprietary vendors, and bring systems closer and more squarely within the domain of users. Strengthening local control of systems by users will go a long way in bridging the design-reality gaps and creating more effective HIS. Once more securely under the control of users (rather than proprietary vendors), the trajectory of evolution of the HIS to a IHIA can potentially become more effective.

In Box 5.3, we provide an anecdote from a training programme that underscores the importance of local control.

**Box 5.3 ‘Play’ as a metaphor for local control: example from Kashmir**

*Building Capacity Through Enabling Local Control*

The members of HISP India team were carrying out a training programme for district managers in the Kashmir division on the implementation of the revised datasets and the use of the DHIS2. While giving the orientation to the software, it was emphasised that the functionalities of flexibility for local customisation of data elements, indicators, validation rules, report; the ability to create local reports that need not be sent to the national level, and checking for locally collected data. Till date, normally the applications they had been provided by the ministry were centrally controlled, and only allowing for data entry for district consolidated reports. With the DHIS2 they could also include their Sub Centre facilities (the lowest level of data collection), which were meaningful for them to shape their local action. What impressed the users was that this software was under their ‘local control’ as they could configure and use it for their local needs.

At the end of the training programme, we asked the trainees how many of them would desire to receive a CD of an offline installer for the DHIS2. They all said yes, and one of the doctors said ‘we can then play around with the software so that the next time you come, we will be much more proficient with the software’. We found the use of the metaphor ‘play’ to be very powerful, as the trainees felt they could locally control the software which would enhance their proficiency.

**5.2.5 Hierarchy of Information Support**

A well established principle of HIS design, discussed in detail in Part I of the book, is that, it should provide support to implement a hierarchy of information needs, implying the lowest point of entry requires the most disaggregated form of data, and at the highest level is most aggregated. This principle has been inscribed in the design of the DHIS from the start and arguably is a key factor in its uptake across the globe in multiple countries.
The principle emphasises that flexibility is ensured by allowing for ‘freedom’ horizontally, as long as standards are maintained vertically. There is a central core set of essential data or indicators required by the national level which all levels below must report on that data and which cannot be deleted. However, every level below has the freedom to add to that core given their local needs. So, while a state can add some data they cannot delete what the national level needs, and the added data need not be sent to the national level, but only used for state specific purposes. Similarly, the level below the State (the district) must report on what the State and National level wants, and in addition can incorporate others essential to their local needs. Similar logic holds for the levels below. This approach of ‘flexible standards’ allows for standards to evolve in a locally relevant manner. This mechanism for local empowerment enables users to view the HIS not as a tool for top down control to facilitate upward reporting, but as a tool to enable local relevance and action.

In Box 5.4, we provide an example of the use of this principle in practice from our experience in Ladakh, in Northern India.

**Box 5.4**

_Hierarchy principle in practice – Example from Ladakh_

**The Hierarchy Principle in Practice**

While conducting a training programme at the district level for sub-district level (block) users in Ladakh on HMIS and the DHIS2, we found users to be extremely proactive and wanting to engage with issues around the HIS. Historically, the users in this district have felt marginalised and neglected by both the national and state authorities.

The training involved orienting the users on a revised set of data elements that the national level had mandated for each district and state in the country to report upwards to them uniformly every month. While carrying out this orientation, the staff pointed out to a particular and significant health condition of acute mountain sickness that the district health services were combating with. The district wanted to monitor this important parameter, which however was not part of the national dataset, and in fact was also not relevant to the other districts in the State. Using the DHIS2, the users were taught to add into the dataset, the particular data element of acute mountain sickness. This dataset was then assigned to the various sub-district facilities of Ladakh and users were trained on how to report on that element for their respective facilities.

To make this data visible to the district authorities, a simple report was designed that provided details of the prevalence of the problem across facilities. Users further demanded that they would like to see a report which showed prevalence across months, as they stated that this problem was more prevalent amongst tourists visiting Ladakh than in the local population, and tourist inflow was seasonal. These reports were designed only for consumption of the district, and not for the national and even the state. Further, this data element was converted into an indicator by including a second data element of ‘tourists visited for the period’ and dividing the number of acute mountain sickness cases by tourists visited.

The district managers felt extremely empowered in seeing how the DHIS2 could be used as ‘their own tool’ and not just for state and national level reporting, which they historically felt as being irrelevant to them.
The example emphasises that the system must be endowed with multiple technical functionalities, such as:

- The ability to assign specific datasets to particular facilities and facility types so as to allow facility specific data collection.
- The ability to define a hierarchy of organisation facilities, which specifies what facility reports into which facility and the different points of aggregation. In this way, aggregation of data can take place based on an entire user defined hierarchy.
- The ability to define health indicators at every level to enable the generation of defined indicators for particular facility types or administrative levels.
- The functionality to define data quality validation checks and analysis of data status at every level so as to enable each level to analyse data coverage and quality for the group of data relevant to them.

In addition to the functionalities that the application must offer, the glue which binds this hierarchy together is, as discussed in Part 1, the three levels of standards, which relate to political agreements on what standards (user level), common definitions of data, similar periodicities of reporting from facility types (semantic level), agreed upon data interoperability, which specifies the protocols of how data is exchanged vertically across different administrative levels and horizontally across various health programmes (data level). Given that the system must cater to a diversity of information needs across administrative levels and health programmes, we cannot adopt standards based on the principle of one shoe fits all, because by definition they will not fit. Instead, the approach is to create flexible standards, where like the hierarchy principle, there has to be an agreed upon central core of standards which everyone must adhere to, and for different levels and health programmes there could be additional standards that are specific to that category. This principle is similar to the use of gateways or bridges that allows for core standards to make different parts of the system to speak to each other, and yet allows for those independent parts to adopt their own standards of working.

5.2.6 Should be Action, not Data Led

Health systems in developing countries, by their institutional upbringing, tend to support processes of data generation and reporting upwards towards the central ministry rather than on how data can be converted into information to support action locally. In short, HIS tend to be data led rather than action led. Given that the aim of an effective system is to process data into reliable evidence to support managers in making health programme improvements, by design the information system should seek to become action led. How does one then work towards this end of making a HIS action led? First of all, as debated in chapter 2, the information should be collected and processed for a purpose, for some kind of action! The traditional approach to this end has been to focus on Goals, Targets and Indicators based on the situation in a concrete local context:

Long term Goals such as “improve the health of mothers and children” are usually political and are set at the national/policy level. The challenge at district level is to translate these general ideas into locally owned operational targets that are SMART, i.e. Specific, Measurable, Achievable, Relevant and Time-bound. All local role-players must
be involved in this target-setting process and become part of the plan to achieve these targets. Indicators measure how far programmes have advanced towards achieving their targets. These can be quite difficult to develop, as they need to be objective, valid, reliable, and sensitive. To start with, select only a few, simple indicators that are important locally! Once these are being effectively used, increase the number and start more complex analysis. The approach would then be to use indicators to measure achievements and evaluate results, leading to new action and eventually new targets and justified and new indicators in an ongoing cyclic process. Two characteristics are key to making the HIS support this action oriented process:

- The system should provide adequate tools to empower the user with the ability to establish that the data is reliable, implying its readiness to be used for action.
- There must be adequate tools available to be able to present data in the form of charts, maps and graphs, which helps to make the data easily interpreted and analysed to aid action taking.

These two conditions are of course inter-linked as good quality data will help build trust of managers to use it, and the easier it is to use data, the more it will be used which will lead to data quality improvements. With respect to the first condition of establishing the reliability of evidence, a number of easy to use software tools can be made available to the user. To establish the completeness of data, the user should be able to ascertain the percentage of reporting by facilities and data element types. Further, the user should have the ability to drill down on facilities, data element types and periods, which are identified as being inadequately reported. Identifying whether data values are within acceptable minimum or maximum ranges, or why for a particular period there may be an aberration further helps to improve the reliability of data. Another functionality to help establish the quality of data is to be able to assess whether it passes key validation checks. Validation checks can be of two types. Absolute validations imply mandatory rules which must be followed. For example, if a dataset includes data elements on total deliveries, live births and still births, we know that the total delivery reported must equal the sum of live births plus still births. This is an absolute rule, and if violated points to a data quality error. The other kind of validations involves expert rules, which imply that we expect these rules to hold in ‘normal’ circumstances. For example, we expect BCG vaccinations reported to be less than or equal to the total deliveries since every child born should be given a BCG vaccination. However, there may be cases when children born in other catchment areas come to a facility and get vaccinated, leading to a violation of the rule since there will be more vaccinations given than deliveries reported. However, this is not a data error, but merely a reflection of a programme condition.

There are thus different functionalities that can be built into the software application to strengthen quality assurance. However, it must be noted that while the software can only help to raise the red flags around quality, improvements or corrections need to be carried out only through human intervention within an institutional framework, something which the software cannot do but is often blamed for. So, when the software through its validation checks raises red flags over quality, the institution must have protocols defined and in place which guides the staff on how to deal with these red flags. These protocols must define, for example, responsibilities for who should carry out these checks, which person needs to drill down and identify the source of the problem, and finally who has the authority to make and communicate the changes.
After discussing these six individual design principles, in the next section we present an example from India of the design of the national HMIS, where some or most of these principles provided an overall framework for design.

5.3 Building and Applying Practical Design Principles – An Example from India

In India, the National Rural Health Mission (NRNM) was established in 2005 with a vision of making architectural corrections within a health system framework in different technical areas including in HIS. Some of the guiding principles that the HIS needed to support included that of decentralisation, integration, and the promotion of evidence-based decision-making. With this as the point of departure, a process of redesign of the HIS was first undertaken, which was then followed by a process of implementation. This process of redesign is now described.

The redesign phase consisted of the following activities:

- Carrying out a detailed situation analysis of existing systems using data from 3 to 4 states.
- Having detailed consultations with national, state, district representatives, and also with academicians, NGOs and international experts.
- Inductively deriving principles of redesign of the HIS.
- Applying these principles to develop the revised HIS.

A brief overview of each of these activities is now presented.

Situation Analysis

Using some sample states for which data was available from their HIS, an analysis was carried out to identify what were key constraints in the existing system. This analysis was then integrated with the empirical knowledge the different participants had of the field situation, and the following constraints were identified:

- An excessive number of data was being collected – ranging from about 1500 to 3000 per month per facility. This created a significant work burden on the health worker and also seriously jeopardised data quality.
- Large number of data elements were being captured simultaneously in multiple forms (for example, Childhood TB was collected in Form 6, Universal Immunisation Programme and Integrated Disease Surveillance Programme) leading to redundancy of work and also to data quality errors at source, and thus contributing to a weak foundation for the overall HIS.
- While a lot of data was collected, there was limited evidence of even 5% of the data being used for the generation of indicators in a systematic way. For example, no State Plan as seen to use indicators related to Scheduled Caste and Scheduled Tribes, disaggregated data even though they constituted about 33% of the data being collected.
- A large percentage of this data being collected (say 45 to 60%) was being systematically reported by facilities and periods as blanks or zeros – raising questions of why they were being then collected.
More than one-third of the data collected represented disaggregated data (breakups by Scheduled Caste/Scheduled Tribes/Other or by age or sex) which could arguably be more effectively captured through annual surveys rather than through the routine reporting system.

Fragmentation and compartmentalisation of systems was rampant, which led to both the missing out of important data (for example, HIV tests of ANC cases as they represented different programmes) and repetition of certain data (like the example of Childhood TB above).

Data only flowed upward and not downwards, implying poor use of data for supervision and feedback. Further, this created a weak motivation for data providers towards improving quality of data as they understood nothing would come back.

The details of these findings were presented in a national workshop in February 2008 in New Delhi, where a number of experts attended and feedback was obtained. In this way, user level inputs were taken into the design process much before the system was designed. Further, since a number of user groups and experts were represented in the whole process right from the beginning, at least to a certain degree inputs from users and other stakeholders were elicited.

Consultation Process

The process of consultations with different stakeholders including national level programme divisions, Monitoring and Evaluation division of the Ministry of Health, states, the National Health Systems Resource Centre, which serves as a technical support group for NRHM and the Ministry of Health, and other experts took place in an intensive period following this workshop, and under the direct leadership and guidance of the then Mission Director of the NRHM. The aim of these consultations was to rationalise the forms and information flows, identify key indicators for different levels, and define the recording and reporting formats. As could be expected, these consultations were politically charged, with each constituency not willing to let go of what existed, even though at a conceptual level there was agreement on the need for rationalisation. An important example was the discussions around whether data with breakups of Scheduled Caste/Scheduled Tribes/Others should be collected through routine data or should they best be captured through annual surveys. The arguments for taking into the survey dataset were:

- It adds on to the burden of data collection (each data element gets multiplied three times).
- On the ground, it is very difficult to actually capture this data.
- On analysis of the Scheduled Caste/Scheduled Tribes/Other data for 3 to 4 states, the data was found to be rather ‘constructed’ reflecting similar percentages of Scheduled Caste/Scheduled Tribes populations in the state as reported in the 2001 Census.
- Since proportions of these disaggregated populations remain relatively stable in an area, it could be more effective to capture them through surveys rather than routine data.

Arguments for keeping the status quo were:

- The new formats have only recently been introduced, and frequent changes would be disruptive.
The data was important for reporting to Parliament and the political constituency. Data quality is good and reasonably complete.

Finally, a call was taken at the highest level and a decision made to move it into survey data. Some other efforts towards rationalisation were not as successful. For example, on the integration of Integrated Disease Surveillance Project data to the HIS, despite a number of consultations with the programme division and also the WHO, they did not agree to integrate the two data flows based on the argument that the ‘logic of a disease surveillance system is different from a HIS. In other cases such as the Routine Immunisation Management System, there was mixed success, with an agreement initially being made to do an integration, but subsequently a resulting ambiguity about what was to be rationalised as clear instructions did not go from the programme division to the states to remove the old forms.

Inductively Deriving Principles of Redesign

These consultative processes were accompanied by a design activity of deriving inductively the principles on which the recording and reporting formats could be redesigned. These principles could be summarised as follows:

- No data should be entered in more than one form.
- Data should be only reported based on service provided by that facility. This implied the previous practice of area based reporting (which arguably led to duplicate reporting) would be replaced by a system of facility based reporting.
- Disaggregated data which was better captured through surveys should not be included in the routine datasets.
- To establish a hierarchy of information needs and required indicators at each level, and to clearly establish the distinction between a ‘data element’ (raw data) and ‘indicator’ (processed information).
- Every report going upwards should have a corresponding report going down to support feedback and supervision.
- Establish clearly the distinction and understanding of a reporting format and recording format.

Applying these Design Principles

Applying these design principles contributed to the following outputs:

- Redesigned facility specific datasets for each facility type: PHC, Sub Centre, CHC, District Hospitals and others. Formats were so designed so that they could be adapted to other facility types such as private facilities based on the correspondence of services the facilities offered.
- Redesigned reporting formats with a focus on the district consolidated monthly report which was to be the standard for national reporting. In addition, there were the quarterly and annual formats for services and financial reporting.
- A defined set of indicators representing a hierarchy for different levels – with a set of about 30 indicators for the national level and 100 for the district.

These outputs were operationalised into a ‘HMIS Tool Kit’ including:

- A book containing all formats including their Hindi translations.
- A data dictionary which provided details of all data elements, their meanings, and data collection guidelines.
- An indicator manual, which provided a description of each indicator including its numerator, denominator and guidelines for use.

Further, National Health Systems Resource Centre in collaboration with its technical partner HISP India also customised using DHIS2 (which was already being used in some states like Kerala and Gujarat) a ‘standard application’ which was capable of meeting all the functionalities for recording and reporting the above defined formats, in addition to providing various functionalities of data validation, analysis, GIS mapping and presentation. This entire tool kit was made available to all states without cost.

The above example of the process of redesign of the National level HIS illustrates a number of the practical design principles that we had highlighted earlier.

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<th>Table 5.2 Applying design principles in practice</th>
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<td><strong>General Design Principles</strong></td>
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<td>Treating the health information system as an infrastructure rather than a standalone system</td>
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<td>Adopt a Participatory Design approach</td>
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The Table 5.2 illustrates an effort to develop practical design principles, and apply them for independent systems, in this case, the routine HIS, while keeping in mind the broader architecture or infrastructure that was being envisaged. The learning from the process of implementation that has taken place from October 2008 to date, helps to further redefine these principles, and create others that are more suited...
to the practices on the ground. For example, we found even though in the design process, the immunisation data was removed from the existing routine immunisation management programme and integrated with the HIS, in practice this integration was at best partial. This was because the child health division at the national level did not buy in completely into this change process, and as a result had not issued clear guidelines to their line departments to affect this change. The learning, thus, is that while technical integration may be relatively easy to carry out, the institutional integration is much harder due to historically existing institutional conditions. Greater amount of negotiations and consensus building needs to be thus carried out at the national level leading to clearer directions to field staff is required to make integration work on the ground.

**Summary**

Some key take away concepts from this chapter are summarised below:

1. Health information systems are designed within the framework of the collective (the architecture, IHIA) in mind.
2. Systems thinking and concepts can help guide design choices as is the case with architectures, conceptualised as systems of systems.
3. Designers have agency in system design. The nature of agency can be understood through two concepts of systems restrictiveness (how much to restrict the user) and decisional guidance (how much step by step guidance to provide to the user).
4. Health information systems design can be guided by analysing design with respect to the 4 Ws: what; when; where; why – that the system should help to answer.
5. Key design principles:
   - Treating the health information system as a component of an infrastructure, and not as standalone.
   - Adopt an incremental approach to design and implementation.
   - Adopt a Participatory Design approach
   - Should allow for local control.
   - Hierarchy of information support.
   - Action, not data led.

**Reference**