Integrated Health Information Architecture to Facilitate
State-wide and National Evidence-Based Public Health
Monitoring: A Case Study based in India

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Integrated Health Information Architecture to Facilitate State-wide and National Evidence-Based Public Health Monitoring: A Case Study Based in India

Abstract

The fact that significant investments are made toward large-scale health programs both at national and state levels requires close scrutiny of such programs based on routine surveys and data collection operations besides increased use of data for decision making and policy formulation. In order to effectively meet diverse data needs of various stakeholders, accurate and timely information exchange among information systems becomes a pre-requisite. To facilitate information exchange among different levels of health system an Integrated Health Information Architecture (IHIA) is required especially when the national health system and the health information systems are comprised of state level systems. However, the Health Information System (HIS) landscape in India, unfortunately, is highly fragmented and operates in silos. As a result, data-based health policy and program development has become tedious. Interestingly, the proposed national health policy of India envisions to expand universal health coverage, and strengthen health information systems for effective monitoring and assessment of policy implementation. Furthermore, this health policy aims to develop an IHIA to drive evidence-based monitoring, evaluation and quality improvement efforts at all the levels of healthcare system. In the backdrop of the health policy mandate and lack of pertinent knowledge and in-country experience, conducting a research study on health information architecture for improved policy decision making is a timely and useful exercise. For the purpose of this research study the Indian state of Bihar, one of the poorest states in the country, was selected as a case. It is a high priority state not only for the national health programs but also for international donors like Department for International Development, United Kingdom, and the Bill and Melinda Gates Foundation that are implementing innovative health information technology interventions.
The objective of this research study was to analyze the current state level health information systems landscape in Bihar and then suggest an integrated, but decentralized, health information architecture that will encourage information system innovations at the district and sub-district levels while meeting the data and information needs of healthcare providers, and health policy and program leaders. Besides, such an architecture will enable both vertical and horizontal scalability. Two principal research techniques namely secondary literature review and primary data collection were used in this study. The literature search was conducted in PubMed and Web of Science. The primary data collection involved eleven key informant interviews in Bihar.

The research findings highlight the fragmented HIS landscape and describe the a) health system of Bihar, b) HIS in Bihar, c) key stakeholders of IHIA, and, c) organizational mapping. Based on the research findings, the paper presents an IHIA for Bihar state. In the penultimate section, the paper describes the factors that are most likely to influence implementation and sustainability of the IHIA in a low resource setting. The paper concludes with few suggested next steps to take forward the output of this research.
Introduction

Gearing for the change in the post-2015 era of the United Nations declaration and the Millennium Development Goals (MDGs), India has taken an affirmative step by deciding to redefine its national health policy. The proposed new policy acknowledges the achievements of the Indian health system, largely due to the National Rural Health Mission (NRHM), now called National Health Mission (NHM) during the last decade and sets new goals for the post-MDG scenario (Ministry of Health and Family Welfare, Government of India, 2015). According to this policy, India is most likely to achieve its MDG target for Maternal Mortality Ratio (140/100,000 live births) and under-5 mortality rate (42/1000 live births). Undoubtedly, these are commendable accomplishments.

While India has made good progress in improving its health infrastructure, human resources for health, health financing, regulation, medical technologies and supplies, and health information systems, significant gaps exist in the national and state health systems (Gudwan, Mitra, Puri, & Vaidya, 2012; Ministry of Health and Family Welfare, Government of India, 2015). Continued reliance on large periodical surveys to gather data for policy and program formulation and assessment is a bottleneck to the development of dynamic health system which can respond to the diverse health care needs of the population. Growing health disparity and slow pace of progress among the most populated and less developed states like Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh continues to hamper India’s overall health indicators (Kumar, Singh, & Rai, 2012).

The rising burden of non-communicable diseases like diabetes, cancer and cardiovascular problems are challenging the Indian health system which is oriented towards infectious and communicable diseases (Ministry of Health and Family Welfare, Government of India, 2015). Increasingly, the burden of non-communicable diseases (39.1%) and injuries (11.8%) have increased as compared to
communicable diseases which contribute to 24.4% of the entire disease burden (Ministry of Health and Family Welfare, Government of India, 2015). However, national health programs for non-communicable diseases are very limited in coverage and scope (Ministry of Health and Family Welfare, Government of India, 2015). The situation is further aggravated by growing health inequity among rural and urban population in terms of health outcomes and access to health care services. For example, the infant mortality rate for urban population is 27 as compared to the Infant Mortality Rate (IMR) of 44 among the rural population (Ministry of Health and Family Welfare, Government of India, 2012). This inequity is further aggravated by the high (60%) out of pocket expenditure on health services (Ministry of Health and Family Welfare, Government of India, 2015).

Acknowledging the challenges confronting the health systems in the country, the proposed national health policy outlines the strategies to accomplish the policy objective (Ministry of Health and Family Welfare, Government of India, 2015) of assuring universal availability of free, comprehensive primary health care services, as an entitlement, for all aspects of reproductive, maternal, child and adolescent health and for the most prevalent communicable and non-communicable diseases in the population. To achieve policy objective a robust mechanism to monitor, review, and evaluate access to and impact of quality care is necessary. In other words, an effective Health Information System (HIS) that caters to the information needs of state and national level stakeholders is essential to guide policy implementation. This paper aims to contribute in this area of the policy mandate. This paper is divided into the following sections:

- Introduction.
- Research Objectives.
- Research Methods.
- Health System of Bihar- A brief overview.
• Health Information Systems in Bihar- A brief overview.

• Key Stakeholders for Integrated Health Information Architecture.

• Organizational Mapping.

• Proposed Integrated Health Information Architecture.

• Implementation and Sustainability Challenges.

• Next Steps and Conclusions.

*National Health Information Systems- An Overview*

During the last 10 years, India has implemented nation-wide HISs to monitor and review national rural health mission, now rural component of the NHM, and vertical disease programs like malaria, blindness control, etc. These information systems are in addition to the periodical surveys like the Annual Health Survey, Sample Registration Survey, Rural Health Bulletin, National Family Health Surveys, etc. (Ministry of Health and Family Welfare, Government of India, 2011). Two of the key HISs which are implemented up to the health sub-center level are the national Health Management Information System (HMIS) portal (“National Health Mission Health Management Information System Portal”, n.d.), and the Mother and Child Tracking System (“Mother and Child Tracking System”, n.d.)

The mother and child tracking system collects individual patient data and seems to operate like a mini electronic health record. This system is used to track antenatal care, pregnancy outcomes, and postnatal care services to women of reproductive age group and also to track immunization services provided to children under five years of age at the health sub-center level. This system collects data on more than 100 data elements. The national HMIS portal is designed to aggregate data based on health indicators compiled by rural health care workers. At the system’s core are approximately 200
indicators related to the areas of child and maternal health and infectious diseases. The data are collected at the facility level and fed progressively up to block, district, state, and national government levels, where it can be analyzed and used to make decisions. These two systems are funded under the national rural health mission. Furthermore, these information systems use different technologies and standards. While MCTS was adapted from the e-mamta system of Gujarat state which was developed by the state unit of national informatics center, a government agency, HMIS portal is built on a proprietary software application. Moreover, these two systems are meant to serve different information needs even though the data captured and reported is almost similar. These two systems rely on thousands of health workers for data collection, and hundreds of data entry operators for capturing data online. However, one of the major difference is that MCTS collects at the health sub-center level but the HMIS portal collects data from all the health facilities in the district. Additionally, MCTS focuses on the services provided by the frontline health workers of the health sub-center and it includes home visit. On the other hand, the HMIS portal reports data on healthcare services offered at the health facilities.

The above description of the two national HISs provides an insight into fragmented and weak HISs in India. The new national health policy underlines the importance of creating a HIS that can serve the diverse health information needs of various stakeholders of the health system be it providers, payers, patients, public health professionals, policy and program administrators, and health information technology users. Additionally, India has other “siloh” information systems for monitoring health programs such as HIV/AIDS, malaria, tuberculosis, leprosy, blindness control, integrated disease surveillance system, and other disease specific information systems (Ministry of Health and Family Welfare, Government of India, 2010). These independent systems, developed and maintained by both public and private information technology agencies, have contributed to
fragmentation and locking of health data in different systems. Fragmented HIS design has made it difficult for government departments within and outside the health ministry to extraction, analyze and use health data from multiple systems. It has become not only resource intensive but can also lead to faulty decision making due to inadequacy, and poor data quality.

The proposed new health policy and the concept note for the National e-Health Authority (NeHA) of India (Ministry of Health and Family Welfare, Government of India, 2015) has summarized the HIS related issues-policy, regulations, standards, institutional capacity- that the country is confronted with and also proposed an approach to address these issues.

With growing emphasis on expanding universal health coverage, data collection and analysis will become even more meaningful in the future. Unsurprisingly, increase in volume, variety and speed of electronic data flow will pose serious challenges to the Public Health Agencies (PHA) with respect to their strategies to collect, store, analyze, and use data to improve public health programs and policies (HLN Consulting, LLC., 2013). In order to effectively meet diverse data needs of various stakeholders, accurate and timely information exchange among information systems is essential. This fact is clearly stated in the national data sharing and access policy of the government of India (The Gazette of India, 2012). The policy highlights the issue of lack of open data sharing within the government departments and proposes to build a data warehouse, and data archive with online analytic processing capacity. However, this database is meant for data collected through large scale periodic surveys and is not limited to the health sector only. The centralized system will serve an important purpose but is inadequate to facilitate continuous monitoring and dynamic policy decision making in public health.
A research study (National Health Systems Resource Center, 2011) on public health information technologies in India assessed the usability of key national and state level HISs and highlighted the issues of standards and interoperability, and recommended creation of an IHIA. Since the national health system is comprised of state and district health sub-systems, health information needs are interlinked and represent an integrated but decentralized information system.

An architecture is essential to ensure effective functioning of different HISs of a health system. Given the fact that HIS landscape India is not only fragmented but also involve internal and external stakeholders who, often, have diverse goals, an architecture can help meet the diverse health information needs of stakeholders and organizations. A good architecture produces a system that is scalable, supportable, cost effective, flexible for innovations, available for use, has acceptable performance, and functional processes for testing and change (Payne & Beckton, 2014).

What is an Integrated Health Information Architecture?

The proposed national health policy has outlined the key principles for creating an IHIA in India. However, there is no operational definition. In the absence of a common understanding of what IHIA means, identifying the key stakeholders and key systems, defining their scope, planning and implementation, monitoring and assessment will become a herculean task. Therefore, for the purpose of this paper, the definition of the Joint Public Health Informatics Task Force (JPHIT) report is used. This task force was created in 2008 in the United States as a collaboration of public health associations who were committed to use health informatics for improved population health. According to the JPHIT task force report, “An information architecture is a blueprint for how PHAs at all levels of government invest in information technology (IT), facilitate improved system interoperability, reduce duplication of development, and help ensure the greatest return/value on
investigation” (HLN Consulting, LLC., 2013). This definition implies that an IHIA enables data sharing among various specialized HISs like electronic medical records, logistic information system, laboratory information systems, pharmacy information systems, human resources information systems, and health management information systems under an overarching framework of ‘systems of systems’ (Sahay and Braa 2012).

An IHIA will facilitate dynamic use of data for development, implementation, and assessment of health policy and programs besides delivery of individualized patient care and facilitating clinical and public health research. An important and unique feature of such an architecture is that it can provide standardization with flexibility for decentralized health system innovations. Moreover, the architecture design will allow contextual development and implementation of health IT initiatives while ensuring flow of information across providers systems and public health decision support systems. Another important advantage is that it will improve effectiveness and efficiency of decision support system by reducing duplication of resources (financial, human resource, infrastructure, information) and efforts as discussed in the HIS landscape section.

According to the proposed national health policy (2015) a national IHIA is expected to become operational in the next few years and a new national institution, called the National e-Health Authority (NeHA) will lead this process. The government has initiated the process to establish the NeHA which will guide the creation of IHIA over a period of 4-5 years (Ministry of Health and Family Welfare, 2015). The NeHA concept note underlines the diverse healthcare needs of the state and the fact that by constitution subject of health is under state’s jurisdiction. Furthermore, it proposes to create regional Health Information Exchanges (HIEs) that will comprise state level
HIEs. In this context, this study is not only timely but will offer a concrete example of IHIA in one of the Indian states that can become a learning site for other states in the country.

**Research Objectives**

Therefore, the overall goal of this research study was to develop an IHIA at the state level, as a case study, that can facilitate data-based decision making in the state and will offer both vertical and horizontal scalability. A related but critical challenge is balancing the needs of different stakeholders that cover both private and public sector organizations. This research study develops the underlying rationale, provides a clear context of stakeholders, proposes an IHIA to meet the needs of program administrators at different levels, describes the key implementation and sustainability related challenges, and discusses few key next steps. An important point to note here is that even though this paper has briefly talked about data governance in different sections, and fully acknowledges its importance, but this subject was not within the scope of the study. For the purpose of this research study Bihar state was selected for the following reasons:

- Third most populated state in India.
- One of the high focus states under the national health mission due to poor health indicators.
- High focus state for international donors
- Site for entrepreneurial, and government and donor funded HIS innovations to overcome last mile access challenge, and to expand access to health care services. Bihar is one of the first states that implemented state-wide mhealth interventions (mobile kunji) which is now scaled up nation-wide. Bihar was one of the first states to implement a pilot project called *eSwasthya* (e-health) in the *Madhubani* district as early as 2002-03 (Bihar Institute of Economic Studies, 2004).
- Researcher’s prior work experience in Bihar.
Research Methods

This research study employed two principal research techniques namely secondary literature review and primary data collection. The literature search was conducted using PubMed and Web of Science. Initially, the project conducted analysis of secondary literature on IHIA experiences in both developed and developing countries. The key search terms used for the literature search and the related outputs are mentioned in Annexure I. The literature reviewed showed that national level HIE initiatives were mostly a developed country phenomenon though developing countries like China were also implementing health information exchange to facilitate better patient care and population health outcomes (Vest, 2012). Relevant gray literature was also analyzed to understand and describe the HIS landscape of India and the health systems overview of Bihar. For this purpose, the websites of the ministry of health and family welfare, census of India, national health systems resource center, national institute of health and family welfare, public health foundation of India, Society for Health Information Systems Program, and the South-East Asia Regional Office of the World Health Organization were searched. This literature search was focused on published policy and program documents, monitoring and review reports, periodical surveys and census data.

Secondary research was followed by eleven key informant interviews (Annexure II) that included health administrators, public health practitioners, physicians, and e-health professionals at the state level. A key informant interview guide (Annexure III) was used to collect data on health policy and programs, clinical health information systems, data management systems, data analysis and use, type of providers, financing of HIS, scale and sustainability). Since this study did not involve collecting
Health System of Bihar-A Brief Overview

The state public health system in Bihar is complex and involves multiple stakeholders (Annexure IV). Bihar is the third most populous states of India with a total population of more than 104 million (Office of the Registrar General, and Census Commissioner, Government of India, 2011). Population is unevenly distributed across the state as shown in the state population map (Figure 1). In this section, the administrative structure, public health agencies, population health status, and the state HIS overview is described.

**Figure 1: Population Size by district in Bihar**

Source: Census of India, 2011.

**Administrative Structure**

The public administration structure of Bihar is divided into divisions (comprised of several districts), districts (comprised of many blocks and sub-division), sub-divisions, and blocks (comprised of several villages). Bihar has nine divisions, 38 districts, 101 sub-divisions, and 533 blocks ("Health
Profile of Bihar, 2013). Figure 2 below is an illustration of the administrative structure and connection among different levels. This administrative structure is responsible for delivery, monitoring and review of public services including healthcare.

**Figure 2**: Administrate Structure of Bihar.

**Public Health Agencies**

The primary responsibility for implementation of NHM programs is with the State Health Society (SHS). The SHS is an autonomous organization that was created under the NRHM to lead the implementation of NRHM programs. However, SHSs decisions are strongly influenced by the state health department which oversees all the health programs in the state including those funded by the national government. Other state-based public health institutions like the state health systems resource center, and the state institute of health and family welfare provide technical assistance to the SHS and department of health. However, they are supervised by their national level counterparts. Besides, institutions like the Public Health Foundation of India also provides need based technical assistance. In terms of health Information Technology (IT) support, SHS has an in-
house team of three people, as mentioned by one of the key informants. Each health facility at the primary health center level and above has a data center to support data entry activities. The SHS has outsourced customization, hosting, and maintenance services of state HMIS, that uses District Health Information System 2.0 (DHIS2). The technology support for national HIS initiatives implemented in the state is provided by the national informatics center, a national government IT agency, and its state counterparts in addition to the in-house team of SHS. Private technology companies like Tata Consultancy services, and non-government organizations like the Society for Health Information Systems Program also offer technology support and maintenance services for specific products. A number of national and international non-government public health organizations also work with the government and provided technical and financial support.

**Public Health Infrastructure**

Under the national rural health mission since 2005, Bihar has expanded its health infrastructure that has resulted in increased access to health care services and hence improved population health systems. However, given the population size, socio-economic inequality, and geographical spread, availability of functional public health infrastructure is many parts of the state is still a challenge. The table (1) shows the availability of and gap in public health infrastructure at different levels of the health system in the state. The data in the tables shows that there is significant gap in health facilities (CHC) that provide basic and comprehensive emergency obstetric care and serve as a referral hospital. Due to gap in referral capacity, access to clinical services is severely limited for rural population and increases cost of health care services. Another major lacunae is at the tertiary care level which there is lack of adequate capacity.
### Table 1: Public Health Facilities in Bihar.

<table>
<thead>
<tr>
<th>Public Health Facility</th>
<th>Required *</th>
<th>Current Status</th>
<th>Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sanction</td>
<td>Functional</td>
</tr>
<tr>
<td>HSC: Health Sub Centre</td>
<td>20760</td>
<td>16623</td>
<td>9696</td>
</tr>
<tr>
<td>APHC: Additional Primary Health Centre</td>
<td>3460</td>
<td>2787</td>
<td>1330</td>
</tr>
<tr>
<td>PHC: Primary Health Centre</td>
<td>.....</td>
<td>534</td>
<td>.....</td>
</tr>
<tr>
<td>RH or CHC: Referral Hospital or Community Health Centre</td>
<td>865</td>
<td>466</td>
<td>67</td>
</tr>
<tr>
<td>SDH: Sub-Divisional Hospital</td>
<td>63</td>
<td>55</td>
<td>38</td>
</tr>
<tr>
<td>DH: District/Sadar Hospital</td>
<td>38</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>Medical College &amp; Hospital</td>
<td>21</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[Govt-10, Private-3]</td>
<td>[Govt-7, Private-3]</td>
</tr>
</tbody>
</table>

**Note:** *. Requirement is based on 2011 Population (10, 38, 04,638).

**Source:** [http://www.statehealthsocietybihar.org/healthinfra.html](http://www.statehealthsocietybihar.org/healthinfra.html)

### Population Health Status

Improved public health infrastructure has contributed to improved population health status though a lot is yet to be done. The state has high decadal population growth (25.07%) and total fertility rate (3.5) as compared to that of the national average (Table 2). Furthermore, maternal mortality (219/100,000 live births), and infant mortality (44/1000 live births) together with lack of availability,
and access to healthcare services in socially and geographically excluded regions, continue to pose challenge, and the health system is struggling due to provide an effective response due to lack of financial, and technical resources, infrastructure, leadership, and governance (Annual Report to the People on Health, 2011).

Table 2: Demographic and Health profile of Bihar State as compared to India figures.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Bihar</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total population (million) (Census 2011)</td>
<td>103.8</td>
<td>1210.1</td>
</tr>
<tr>
<td>Decadal Growth (%) (Census 2011)</td>
<td>25.07</td>
<td>17.64</td>
</tr>
<tr>
<td>Infant Mortality Rate (SRS 2013)</td>
<td>42</td>
<td>40</td>
</tr>
<tr>
<td>Maternal Mortality Rate (SRS 2010-12)</td>
<td>219</td>
<td>178</td>
</tr>
<tr>
<td>Total Fertility Rate (SRS 2012)</td>
<td>3.5</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Source: www.mohfw.nic.in

Health Information Systems in Bihar- A Brief Overview

Bihar has a number of HIS that use web, mobile phones, or a combination of information and communication tools. However, only a few of these systems are operational in the entire state; those that are operational include two of the national systems namely HMIS portal and the MCTS. The state specific systems include Human Resources Information System (HRIS) for Health, the DHIS 2, and Sanjivani (a web enabled ambulatory care information system). These three state HISs are funded by both national and state governments in additional to the financial and technical assistance from the development partners in the state. While HRIS is meant to strengthen the human resources for health efforts in the state, the DHIS2 software is the backbone of the state HMIS portal. This portal is different from the national HMIS portal in the sense that it is managed by the state team though it collects and reports all the data elements required by the national HMIS portal. But it also collects data on state specific health programs. DHIS2 system is under pressure from the national government as it is a duplication of resources. But from the SHSs perspective DHIS2 is important.
as it allows customization to capture additional data for an existing programs or help monitor a new state level program.

*Sanjivani* system is, perhaps, the only information system designed for capturing individual clinical data. Clinical data use is at the heart of the clinical care offered by various providers. According to the key informants, in the public health system, data pertaining to pathological tests, radiology diagnosis, medication, patient Admission, Discharge and Transfer (ADT), are collected primarily on paper. The key informants explained that for ambulatory care services, data is again captured in paper but also online through a web-enabled information system called *Sanjivani* (Box 1). This system is implemented across the state but captures patient registration, and drug distribution data. One of the key informants explained that it is a locally developed system but is dependent on the federal funding and is most likely to be replaced by a more comprehensive system developed by the Center for Development of Advance Computing, a national IT agency. The approved state annual health program implementation plan (2014-15) of Bihar highlights conditional budget approval for continuation of *Sanjivani* which means that the national government is willing to fund clinical information system which is developed in consultation with the CDAC and is in compliant with the Electronic Health Record standards of the government. The key informants told that state health society’s financial demand for operating *Sanjivani* system was denied (Bihar State PIP 2014-15, page 106). This implies that *Sanjivani* will close out and a new system will take its place. The key informants mentioned that new system will import existing patient data from *Sanjivani* before phasing it out.

The situation in private hospitals is similar to the government health facilities as far as use of electronic systems for data capture was concerned. Even in the private hospitals, there is lack of a
system that captures ambulatory and in-patient data over the life cycle of the patient. In one of the large private hospitals, Picture Archiving and Communications System (PACS) system is used. One of the key informants said, “PACS allows us to easily access clinical information for in-patients using a medical record number”. Elaborating further, the key informant said, “If a patient, after discharged from the hospital, uses the outpatient services, the data from those clinical encounters are not entered into the PACS system”.

<table>
<thead>
<tr>
<th>Box 1</th>
<th>Sanjeevani : Key Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Primary purpose- record number of out-patient visits (and drug distribution)</td>
<td></td>
</tr>
<tr>
<td>• Patient registration data entry done by data entry operators employed by the government</td>
<td></td>
</tr>
<tr>
<td>• Drug distribution data and disease name entered by pharmacist</td>
<td></td>
</tr>
<tr>
<td>• Physician/clinician do not access or enter any data</td>
<td></td>
</tr>
<tr>
<td>• Lab test data available in paper form and sometimes entered in remark section of the application</td>
<td></td>
</tr>
<tr>
<td>• Lab test data entry module under development</td>
<td></td>
</tr>
<tr>
<td>• Web-enabled but also allows offline data entry for later synchronization</td>
<td></td>
</tr>
<tr>
<td>• Currently hosted on cloud server; a new vendor identified for in-state hosting</td>
<td></td>
</tr>
<tr>
<td>• Software build on dot net platform</td>
<td></td>
</tr>
<tr>
<td>• Developed by state-based developers</td>
<td></td>
</tr>
<tr>
<td>• State Program Implementation Plan (2014-15) provides conditional approval by Government of India until the nationally approved software application (Java-based) is put in place and data migrated to the new application.</td>
<td></td>
</tr>
</tbody>
</table>

Not surprisingly, in the absence of national or state level health IT policies, regulations, and standards each system uses technology of its choice and is managed by a particular department or program. As a result there is little or no-coordination among these departments in design, development, deployment of HISs. Surprisingly, individual patient data is collected and reported across the state but there is no policy or regulation to protect and secure patient data.

In the above context, the state health systems must aim at intervening in a manner that maximizes its return on investment by expanding access to health care to maximum number of people.
including those living in remote and underserved areas. This aim can be accomplished through strong monitoring, assessment, and evaluation system that can track the progress but also enable corrective action at the right time. It is in this context that building an IHIA is a timely and much needed intervention.

**Key Stakeholders for Integrated Health Information Architecture**

A critical challenge in creating an IHIA is to balance the needs of different stakeholders that cover both private and public sector organizations. In this section of the paper, the key stakeholders—healthcare consumers, healthcare providers, and policy and political leaders are briefly described. Even though payors are an important stakeholder, for the purpose of this study, payors are not described as a separate stakeholder because public health system is the focus of this study where free services are offered or a nominal amount of money is charged. Furthermore, 72% of 212.6 million health insurance policies in the country were sponsored by the government (Insurance Regulatory and Development Authority of India, 2013-14). The health insurance coverage is highly skewed as 62% of the health insurance premium comes from Delhi, Tamil Nadu, Maharashtra, and Karnataka. This means insurance coverage in states like Bihar is quite low. High out of pocket health expenditure is also an indication of the low coverage of health insurance.

**Healthcare consumers**

As mentioned in the proposed new health policy, rural population continues to bear the brunt of inequity in access to health care services. States like Bihar with majority of its population living in rural areas (Ministry of Health and Family Welfare, Government of India, 2014-15) are among the most affected. Despite the fact the NHM has resulted in increased outpatient visits, hospital bed occupation, immunization and antenatal care services, and a large section of the rural population remains outside the reach of the health system. Lack of physical infrastructure, shortage of health
workforce, absence of diagnostic services and drugs, poor of quality of service, and high out of pocket expenditure on transportation and medicines have limited access to health care services (Annual Report to the People on Health, 2011).

The government health facilities have outsourced pathology and radiology services to private sector providers under the public-private partnership mechanism though they are located in the hospital premises. Since there is shortage of specialist doctors, private clinicians are contracted on fee for service basis.

Since Radiology, Pathology and surgical services are, in general, available at the district and state level, diagnostic and surgical procedure data remains with these providers in the digital format. The patient receives the information only in the paper form and radiology films. If a patient visits different providers, repetition of diagnostic tests is a common phenomenon even though the previous test results are available in the paper form. There is a growing perception among general population that physicians deliberately recommend radiology and pathological tests as they earn money from those laboratories based on the number of patients referred.

An IHIA will empower patients in terms of access to their complete personal health records and sharing of these records with providers to prevent unnecessary diagnostics, and treatment.

**Healthcare Providers**

Delivery of healthcare services, primary healthcare services in particular, and health infrastructure has improved though many of the health facilities are still non-functional due to erratic supplies, lack
of qualified human resources and required health technologies. A range of providers both public and private (Figure 3), provide clinical health care services to the people.

In the government health system, clinical services are provided at the primary health center, community health centers or referral hospitals, district and sub-district hospitals, nursing home and hospitals, state medical colleges and hospitals, and federal medical colleges and hospitals. The public health facilities are distributed across the state based on the population norms. The first point of contact to access a physician at the sub-district (block level) is the primary health center. The range of services offered by each of the health facilities is well-defined as per the Indian Public Health Standards (2012) though the actual service delivery widely varies. The health sub-centers are managed by Auxiliary Nurse Midwives who provide immunization services, home visits, interpersonal counselling, and conduct or assist institutional delivery. The private sector clinical providers includes nursing homes, clinics, and hospitals. However, they do not formally share any patient data with the government health facilities or policy makers. Private providers offer another option for the population to access healthcare services. These private providers offer a range of services that includes preventive care and advanced surgical procedures. Most of the private nursing homes and multi-specialty hospitals are based in district headquarters and state capital. Fully equipped pathology and radiology laboratories are only available at the district hospitals, and medical colleges and hospitals.
**Figure 3:** Type of Clinical Service Providers in Bihar.

Despite collecting a wide range of clinical data to facilitate clinical decisions, access to all the data sets across different providers is impossible. The state level health information system landscape is complex and highly fragmented. In a way, states mirror the fragmented national HIS landscape which is comprised of both national and state-specific HIS.

Inability of the public health facilities to exchange patient data among themselves results in duplication of data collection, and loss of valuable data in aggregate reporting. These barriers are due to absence of an IHIA that can facilitate data sharing among various public sector providers, and with policy and program leaders for evidence based clinical and program decision making.

**Policy-makers and Political Leaders**

In the post-MDG era, the sustainable development goals of the United Nations will become the guiding light for country led development. The technical report of the bureau of United Nations Statistical Commission on indicators for monitoring global development suggest creating an integrated architecture for monitoring (UNSD, 2015). This implies that an IHIA will not only allow Bihar to monitor its progress but also contribute to the national efforts toward the sustainable development goals of the United Nations.
The political and policy commitment to provide universal health coverage is the guiding force behind revising the national health policy of India which was more than a decade old. Creating a robust information system to monitor not only the progress but also the performance of the health system is critical for achieving the policy goals outlined in the draft national health policy. Realizing the necessity of a pan-India information network, the policy proposes to create a national IHIA. The draft policy has outlined the key principles (Box 2) and strategies for an integrated health information system combining the power of cloud computing and mobile technology that includes major initiatives such as the EHR standards and the Aadhaar initiative, which is an effort of the national government to provide a unique number to each citizen of the country based on bio-metric data in order to facilitate delivery of public services especially for the poor people.

An IHIA will allow policy-makers and political leaders to access and use integrated data sets to assess influence of policy decisions on population health. Based on the health system scenario of Bihar, discussed above, an IHIA for Bihar will depend on the stakeholder diversity, relationships among stakeholders, data needs of stakeholders, and existing data, processes and systems in the state. Also, it is important to understand the providers involved in each level of architecture.

<table>
<thead>
<tr>
<th>Box 2: National Health Information Architecture: Key Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Adoption of National Electronic Health Record Standards federated architecture to roll-out and link systems at State level and national level;</td>
</tr>
<tr>
<td>(b) Progressive use of “Aadhaar” (Unique ID) for identification (in case UID is not available, then other ID would be created as per the standards notified by the Ministry) and issue of a unique Health Card to every citizen;</td>
</tr>
<tr>
<td>(c) Creation of health information exchange platform and national health information network;</td>
</tr>
<tr>
<td>(d) Use of existing/planned national &amp; state level IT infrastructures such as the National Optical Fiber Network, Meghraj (cloud),</td>
</tr>
<tr>
<td>(e) Smartphones/tablets for capturing real-time data; and</td>
</tr>
<tr>
<td>(f) Setting up of dedicated governance structures.</td>
</tr>
</tbody>
</table>

Source: Draft National Health Policy 2015, India.
Organizational Mapping to Understand Organizational Linkages in Bihar

In the following sections state health system organizational mapping, mapping of state level tertiary healthcare provider organizations, and mapping of health facilities that constitute district health system is discussed. While state level medical colleges and hospitals provide tertiary care, district hospitals offer secondary level healthcare services and support sub-district health facilities through referral support. Understanding these organizational architectures is essential to understand the dependencies and interactions among entities of the architecture.

Organizational Mapping of State Health System

The state health system is interconnected (Figure 4) with various state government departments and also with the national health system. The department of health is comprised of directorate of health services, medical education, directorate of AYUSH (Ayurveda, Unani, Siddha, and Homeopathy), State Health Society (SHS), and district health system. The medical education wing is responsible for management of medical colleges and hospitals in the state. The health department also exchanges information with state planning unit, national health ministry, and other departments like finance, and administration. Besides, the regional program management unit in the division headquarter shares information with both the state health department, and the SHS. The dotted arrows shows functional relationship between those entities. These are the key organizations which exchange information with the state health system.
Figure 4: State Level Organizational Mapping.

Mapping of State Level Tertiary Healthcare Facilities

Given that state level medical colleges and hospitals are directly governed by the state medical education department, any IHIA architecture must take into account the governance structure. The below map (Figure 5) shows how state level medical colleges and hospitals are connected with the state health department. These health facilities include private medical colleges and hospitals as well.
Figure 5: Mapping of State Level Tertiary Healthcare Facilities.

Mapping of District Level Healthcare Facilities

The district government health system is comprised of primary health centers, community health centers or referral hospitals, sub-divisional hospitals and district hospitals. The district health system includes private hospitals, nursing homes and clinics. In the existing health system, private health care facilities do not share data (dotted line relationship) with the government health system. However, a favorable policy, and adequate and appropriate incentive system can motivate and empower private healthcare providers to share a set of patient data with the public health system. In order to facilitate health information exchange between private and public healthcare providers, an enabling architectural design is required (Figure 6).
Proposed Integrated Health Information Architecture

The above organizational mapping at three different levels shows that state health department at the state level manages exchange of health information with different entities of the state health system. In this context, an early requirement analysis for creating an IHIA needs to explain the three key aspect of an IHIA i.e. data elements, data collection and sharing processes, and data collection and sharing systems. These three aspects are discussed in the following sections in relation to a district hospital in order to understand how these three aspects currently work, how it will change after IHIA has been implemented.

Data Elements

Current Situation: The broad categories of data collected and reported (Box 3) into different HIS at the primary health center and a district hospital are almost similar. The data categories include
antenatal care, pregnancy outcomes, post-natal care, disease outcomes, laboratory test results, immunization history, in-patients and out-patients, and surgical procedures including those conducted under vertical disease control programs like blindness control.

**Box 3: Data Collected (for individuals) and Reported as Aggregate.**

<table>
<thead>
<tr>
<th>Demographic data</th>
<th>Reproductive tract infections/sexually transmitted infections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health worker profile</td>
<td>Family planning services</td>
</tr>
<tr>
<td>Antenatal care services</td>
<td>Child immunization</td>
</tr>
<tr>
<td>Deliveries</td>
<td>Number of cases of childhood diseases</td>
</tr>
<tr>
<td>Number of caesarean section performed</td>
<td>Blindness control services</td>
</tr>
<tr>
<td>Pregnancy outcomes and details of newborn</td>
<td>Patient services (ambulatory care and in-patient; mortality)</td>
</tr>
<tr>
<td>Complicated pregnancies</td>
<td>Laboratory test results</td>
</tr>
<tr>
<td>Postnatal care services</td>
<td>Mortality and cause</td>
</tr>
<tr>
<td>Medical termination of pregnancy</td>
<td></td>
</tr>
</tbody>
</table>

The bed capacity of districts hospital can vary from 100-500 (Ministry of Health and Family Welfare, Government of India, 2012). These hospitals have a high volume of patients which not only produce a high volume of data but also a wide variety of data. Government health facilities report facility-wise data on out-patient data, in-patient data, institutional delivery, caesarian section, and major and minor surgeries (Ministry of Health and Family Welfare, Government of India, 2014-15).

*Post IHIA Situation:* The foundation for the proposed IHIA is already laid by the EHR standards document which not only recommends Minimum Data Set (MDS) for an EHR system but also specifies use of semantic standards like Systematized Nomenclature of Medicine--Clinical Terms (SNOMED-CT), and International Classification of Diseases 10 (ICD 10). These standards will enhance data quality and analysis and avoid misinterpretation. The MDS includes demographic information like unique patient id, data of birth, address, etc. The clinical data set includes past health history, clinical encounter details, provider information, clinical summary, diagnosis, and treatment plans (Ministry of Health and Family Welfare, Government of India, 2013). An IHIA will
allow health facilities to collect the above data elements which are partially collected and reported as of now. Additionally, it will enable health facilities to implement components of EHR in a phased manner keeping in mind limited health system capacity. For example, two of the critical modules for improved patient care are Computerized Patient Order Entry (CPOE) and clinical documentation (Figure 7). Adding these modules will allow providers to collect and analyze important data in a coherent way. The data from modular system will constitute on a clinical data repository that will allow providers to query clinical data and then respond to healthcare needs of individual patients. These data sets will also serve the aggregate data needs of program managers and policy makers.

In future data collection and reporting requirements are likely to expand once the state adopts the Indian Public Health Standards. The new system will effectively respond data needs on patient safety, sexual harassment, and patient’s privacy. Achieving these requirements without losing the granular patient data is an important feature of the IHIA.
Structured Data Storage: Clinical Data Warehouse (Relational Database) [State Level]

Policy, Program and Administrator Interface (Operational Use)

TCP/IP over VPN

Structured Data Storage: Clinical Data Repository (Relational Database) [State Level Tertiary Providers and District Level]

Health Human Resource Information System

Provider and Researcher Interface (Query and Answer)

TCP/IP

Internet/Intranet

TCP/IP over VPN

Structured Data Storage: Relational Database Management System

ADT, Pharmacy, Clinical Documentation, Radiology, Lab, CPOE

[System for Data Storage: Relational Database Management System]
Figure 7: Integrated Health Information Architecture.

Data Collection and Reporting Processes

Current Situation: Clinical and administrative data are captured manually in paper form at the health facilities. A register called reproductive and child health register is used to collect data required for monitoring healthcare service delivery using the mother and child tracking system at the health sub-center level. One of the key informants told that this register was recently modified and family planning related services were also added to the existing list of data sets. While the data collection process focuses on individual patients, the process of data sharing varies based on the type of system. For example, individual data is reported into the mother and child tracking system, and the Sanjivani system. On the other hand, aggregate data is reported into the national and state HMIS portals (Figure 8).

The ADT data is made available in paper. But a patient only receives a discharge summary which is also not a standard process in the district hospitals. The ambulatory care system also generates a large amount of data but a limited set of data is reported into the Sanjivani system. The data management issues were reiterated by one of the key informants who said that clinical data collection in paper forms lacks a systematic approach and standardization. Despite the fact that a range of clinical data—medication data, diagnosis test utilization, surgical procedures, and outcomes—is collected at district health facilities, these data sets fail to support quality management practices for improved clinical outcomes both at the individual and population levels. One of the key reasons for this failure is ineffective clinical documentation. In order to support the clinical decisions, it is necessary to capture sufficient information from each clinical encounter and allowing continuity of care through the lifecycle of the patient.
Standard reporting formats (Annexure V & VI) for each type of system is made available and used for reporting data electronically, through spreadsheet, and online into different health information systems. The reporting periodicity also varies across different systems. The aggregate data is reported on a monthly basis at the primary health center but at the district hospital it is reported monthly, quarterly and annually into the HMIS. The process of reporting aggregated health care service data is mostly online though paper-based reports are also shared within the facility and at the district level during review meetings.
**Figure 8:** Data Flow in the Health Management Information System.

*Post IHIA Situation:* Many of the MDS data elements are already collected on paper and also reported online. Therefore, data collection requirements may not increase drastically though standardization of data collection formats is essential and electronic data collection and reporting uptake will take time due to limited capacity of the state health system of Bihar. But over a period of time the IHIA will ensure standardization of data collection and reporting formats besides using standards for data interchange to facilitate meaningful use. Use of data interchange standards Health Level 7 (HL 7), National Association of Drug Court Professionals (NACDCP), and Digital Imaging and Communications in Medicine (DICOM) will facilitate data interchange between modular systems and the clinical data repository which will enable structured data storage. The IHIA will prevent loss of paper data, and promote exchange and use of data among providers and researchers. Provision of evidence-based healthcare services is possible once the IHIA is in place and adequate capacity has been built. Transfer and interchange of data will take place over secure networks to ensure data privacy and confidentiality. The process of extracting, transforming, and aggregating data in the clinical data warehouse will allow analysis and use by the program managers and government public health leaders to monitor and review population health. Besides, it will facilitate evidence-based policy and program development.

**Data Collection and Reporting Systems**

*Current Situation:* The system for data collection and reporting includes both paper based and electronic systems as discussed in earlier sections of this paper. These systems include both national and state specific systems. This section is focused more on post IHIA situation to avoid repetition.
**Post IHIA Situation:** The IHIA will help overcome the challenge posed by standalone use of different HIS in Bihar. The MDS is partially captured through the MCTS and *Sanjivani system*. Since *Sanjivani system* is in the process of being replaced by a new system, IHIA offers a unique opportunity to overcome the burden of fragmented system. The proposed IHIA will use Relational Database Management System to support each of the modular components. This system will allow storage of structured data in clinical data repository which uses a relational database. Use of Transmission Control Protocol/Internet Protocol (TCP/IP) over Virtual Private Network (VPN) will allow secure communication among different information systems in the IHIA.

An important point to remember here is that implementation of the proposed IHIA will require changes in organizational processes, systems, policy and regulations, and governance structures. This implies that implementation design must factor into key factors that can adversely impact implementation and sustainability of this IHIA.

**Implementation and Sustainability Challenges**

The proposed new health policy and NeHA demonstrates political and policy commitment of the ministry of health and family welfare to use health IT for improving access to and quality of care to its masses. The policy and NeHA envisions to strengthen national HIS which is comprised of state level HISs. However, health system research on health information in India is very limited (Rao et al. 2014). In other words, local knowledge base required for effective implementation and sustainability of an IHIA is missing locally. But global knowledge base on implementation of health information systems, offers some useful lessons for HIS interventions in India. Some of these key challenges are discussed below.
Organizational Capacity and Leadership

Evidence shows that organizational issues are one of the key categories of success and failure factors related to HIS implementation in low resource settings (Fritz, Tilahun, & Dugas, 2015; Brender, Ammenwerth, Nykanen, & Talmon, 2014; Feldman, Schooley, & Bhavsar, 2014). Based on the systematic review on success criteria for electronic medical record implementations in low-resource settings, Fritz, Tilahun, & Dugas (2015), report that adequate human resource and project management capabilities are vital for successful HIS implementation. Another related and important issues is data governance and data stewardship which must be integrated with the organizational strategies. While data governance plan is necessary to define the purpose for collecting data, ownership of data, and intended use of data, data stewardship focuses on operationalizing data governance (Fernandes & O’Connor, 2009).

The proposed National e-Health Authority will lead, monitor and support creation of an integrated health information architecture. However, there is no such provision of facilitating creation of a similar institution at the state level which will collaborate with the NeHA for the implementation of policy directives. Until then, the existing agencies and individuals will decide on how to deal with the implementation of EHR or any other standard. Surprisingly, the EHR standard document is not complemented by a capacity building strategy to enable its implementation. The existing health informatics workforce capacity, both in terms of number and competencies, of the state public health agencies in Bihar is very limited as evident from the number of staff managing all the national and state level systems in Bihar. This can become an important bottleneck for IHIA implantation in Bihar (Luna, Almerares, Mayan, Gonzalez, & Otero, 2014). Successful HIS implementation will depend on its alignment with the organizational context, perceived benefits and costs by the users, and also its ability to support workflow processes (Brender, Ammenwerth,
Nykanen, & Talmon, 2006). In other words for HIS interoperability, people co-operability is necessary (Rossi Mori, 2013).

**Policy and Regulatory**

Merely developing EHR standard document and a policy directive for creating an IHIA is not enough. Most importantly, policy guidelines that promote meaningful use of health data are essential to develop a culture of data-based decision making and healthcare delivery. The EHR implementation experience in the United States underlines the importance of focusing on comprehensive regulations, and standards (Warner, 2012). With growing emphasis on patient empowerment in India, awareness about personal health information is likely to increase. This implies that patients will demand a higher level of privacy and confidentiality of their health data. In the absence of a well-defined regulatory framework, like the Health Insurance Portability and Accountability Act of United States implementation of any standard including EHR standards in India can run in deep trouble (Fritz, Tilahun, & Dugas, 2015; Luna, Almerares, Mayan, Gonzalez, & Otero, 2014). In the Indian context, educational and behavior change interventions are also needed to improve clinical documentation, patient care and prevent harassment or maltreatment by the providers. As one of the key informants said, “Our culture is to first treat the patient rather than first focus on documentation”.

Moreover, there is lack of regulatory mechanism and policy incentive for private sector providers to share data among themselves or with the public health providers. Taking a cue from the ‘meaningful use’ policy intervention, a similar intervention can motivate both public and private providers to implement HIS standards and exchange patient data.
Stakeholder Collaboration

Research (Brender, Ammenwerth, Nykanen, & Talmon, 2006) shows that collaboration among various stakeholders is necessary for building an effective national HIS. Such an approach is useful to facilitate discussion among various states and public health agencies that decide to create an information architecture. Besides, engaging private healthcare providers, insurance companies and health IT companies in the consultation process will help to understand purpose, motive, capacity and readiness of various stakeholders. The proposed NeHA has representation of various stakeholders (Ministry of Health and Family Welfare, 2015), however functional modalities remain uncertain. Moreover, it fails to involve powerful professional associations like the Indian Medical Association, and the Indian Nursing Association. Until NeHA comes into effect, its role is performed by ad-hoc committees or health IT staff of SHS or department of health.

Financial

The Health Information Exchange experience in the United States shows that financial sustainability of HIE systems is questionable unless the federal government funding continues. Except for few of the HIEs like that of Indiana, New York, Massachusetts and Colorado, all other HIEs are struggling to remain financial viable. The initial idea was to provide financial incentives to implement HIEs that can later on become self-sustaining. However, the dependence for financial resources is a stark reality. The NeHA will have to design a mechanism that provides government financial incentives for a limited period but is tied with generation of revenues over a period of time. Furthermore, policy framework should ensure that enough business opportunities are created for the HIE by the stakeholder group to keep it financial viable and also perform optimally (Vest & Gamm, 2010).
Technical

Technical issues are another major challenge (Feldman, Schooley, & Bhavsar, 2014) and includes information system development processes, user involvement, use of standards, system architecture, affordable and stable technologies, and technical support and maintenance services (Brender, Ammenwerth, Nykanen, & Talmon, 2006; Luna, Almerares, Mayan, Gonzalez, & Otero, 2014; Fritz, Tilahun, & Dugas, 2015). Reliable and stable IT infrastructure, and power supply, as mentioned by the key informants, is still a gap in Bihar which will hamper implementation capacity (Luna, Almerares, Mayan, Gonzalez, & Otero, 2014; Fritz, Tilahun, & Dugas, 2015). Implementation of IHIA will require changes in communication, clinical documentation, and quality management workflow process of health facilities. Importance of key processes in clinical practices is well acknowledged but implementation and sustainability of changes in clinical workflow processes is complex, resource intensive, and a slow process. In the initial phases, communication workflow process can focus within the organization that includes physicians, nurses, lab technicians, pathologists, pharmacists, and administrative staff. Later on communication with the patients can be added to the system. Effective communication workflow will enable comprehensive and accurate clinical documentation in which will strengthen delivery of quality care to patients and support population health reviews. Overcoming technical issues will require strong organizational capacity, collaboration and adequate financial resources.

Functional

Given the fact that this is the first instance of an IHIA implementation in Bihar and India, the process for generating functional requirements, designing systems, deploying and evaluating the system will pose create hurdles. Functional issues are at the core of success and failure of electronic
medical record systems (Brender, Ammenwerth, Nykanen, & Talmon, 2006; Fritz, Tilahun, & Dugas, 2015). Ensuring alignment of information systems processes with routine organizational practice is key. Importantly, reducing complexity and providing incentives to users is necessary to facilitate increased ownership of the HIS.

**Next Steps and Conclusions**

One of the most important next steps that should precede planning and implementation is related to data governance and data stewardship. The paper briefly touched on this issue due to its limited scope. However, a detailed data governance plan and the details for operationalizing this plan (data stewardship) must be put in place before planning and deploying health information exchange initiative (Fernandes & O’Connor, 2009). Data stewardship will ensure that qualified human resource, appropriate policies, and relevant tools are accessible.

As a next step, the researcher plans to share the findings of this study and initiated discussion with the health policy leaders of the state of Bihar, and other interested Indian states. Additionally, the researcher will follow up with international organizations that work on HIS issues in developing countries and has expressed interest in the output of this research and are keen to explore the possibility of implementing in one of its project sites.

The proposed IHIA in Bihar is a noble and timely effort and has the potential to fill an important gap identified by the proposed new health policy of India. Furthermore, implementation of IHIA will contribute to the development efforts of donor funded programs in Bihar that aims to increase health IT capacity of the state for improved monitoring, review and assessment of the health programs besides facilitating evidence-based policy and program development. Even though this
study is situated in Bihar, the proposed IHIA is relevant for other developing countries that has similar health system context as that of Bihar.
References


Annexure I. Literature Search (last five years).

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Annexure II: List of Key Informants.

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<th>Sl. No.</th>
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<tr>
<td>1</td>
<td>Administrative Officer</td>
<td>State Health Society Bihar</td>
<td>December 17, 2014</td>
</tr>
<tr>
<td>2</td>
<td>Systems Analyst-Cum-State Data Officer</td>
<td>State Health Society Bihar</td>
<td>December 16, 2014</td>
</tr>
<tr>
<td>3</td>
<td>Software Developer-Cum-System Administrator</td>
<td>State Health Society Bihar</td>
<td>January 14, 2015 (phone)</td>
</tr>
<tr>
<td>4</td>
<td>State HMIS Consultant</td>
<td>Bihar- Technical Assistance Support Team, CARE India</td>
<td>December 16, 2014</td>
</tr>
<tr>
<td>5</td>
<td>State HMIS Consultant</td>
<td>Bihar- Technical Assistance Support Team, CARE India</td>
<td>December 16, 2014</td>
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<tr>
<td>7</td>
<td>Project Officer</td>
<td>UNDP Bihar</td>
<td>March 8, 2015 (phone)</td>
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<tr>
<td>8</td>
<td>Team Leader</td>
<td>Hope System-Bihar</td>
<td>December 16, 2014</td>
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<td>9</td>
<td>System Administrator</td>
<td>Bihar Medical Infrastructure</td>
<td>November 17, 2014 (phone)</td>
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<tr>
<td>10</td>
<td>Medical Officer</td>
<td>District Hospital, Jehanabad, Bihar</td>
<td>March 25, 2015 (phone)</td>
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<tr>
<td>11</td>
<td>Consultant-Orthopedic Surgery</td>
<td>Paras Hospital, Bihar</td>
<td>March 25, 2015 (phone)</td>
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</table>
Annexure III: Key Informant Interview Guide.

Key Informant Interview Guide
(Note: The name, job title, and organizational details of the interviewees will not be included in the final research paper unless the interviewees provide their consent for the inclusion of their name in the list of interviewees. Individual comments and inputs will be recorded in the research paper without any reference to the name/job title/organization of the interviewee. Relevant questions from the list below will be used for the interview purposes. All the questions may not be relevant to all the interviewees).

1. Please share about the key health goals of the state.

2. What are the key health policy and program decisions you make on a routine and/or strategic level?

3. What kind of health information do you need the most or are interested the most for strategic and everyday decision making?

4. What kind of information system you envision as useful for the purpose of policy decision making?

5. What do you think about the knowledge and competency of your staff at different levels of the health system as far as use of information technology for data collection, analysis and use for program monitoring and assessment is concerned?

6. Please mention 3-5 key e-health initiatives that are currently implemented in the state.

7. How do current e-health initiatives like Mother and Child Tracking System (MCTS), Mobile Kunji, expand access to health care services?

8. How do different e-health initiatives contribute to the health goals of the state?

9. How are non-government and private agencies contributing to the use e-health initiatives for improved access to health care services?

10. What do you think could encourage and increase community involvement and stake in sharing and seeking healthcare information through e-health initiatives?

11. Is there anything additional that you would like us to consider in our research? Who else do you consider as an important key informant for our study with whom we should talk to?

Close: We appreciate your valuable inputs and thank you for sharing it with us. We expect to complete the data analysis and the paper by April 2015. The paper will be available in the public domain for anyone interested to use it. Thank you again.
Annexure IV: Health System of Bihar—Organizational Interlinkages.

**National Informatics Centre**
- Premier IT agency in India, under the Dept of IT, Ministry of Communication and Information Technology.
- IT agency for implementing MCTS

**Department of Health & Family Welfare**
- (includes Health Management Information System)

**National Health Mission**
- Led by Additional Secretary & Mission Director

**National Institute of Health and Family Welfare (NIHFW)**
- technical institution for education, training, research and evaluation

**State Health Mission-Bihar**
- Implemented by the State Health Society and led by an Executive Director
- State has an annual health plan approved by the MHW, Government of India

**State Health Systems Resource Centre (Bihar)**

**Society for Health Information Systems Program India (HISP India, an NGO)**
- HMIS Former technical partner of NHSRC supporting a number of NRHM states (including Bihar) in the implementation of the District Health Information System- 2 based state HMIS

**National Health Systems Resource Centre (NHSRC)**
- autonomous technical Support institution with the NRHM.
- Led by an Executive Director

**Ministry of Health and Family Welfare (MHFW), Government of India**
- Led by Minister of Health and Family Welfare

**NHSRC Governing Body**
- Chair: Secretary-Health & Family Welfare
- Vice-chair: Additional Secretary & Mission Director-NRHM

**State Institute of Health and Family Welfare (Bihar)**

**Legends**
- ➔ Administrative & Functional Reporting
- ➔ Technical Assistance