Health Management Information Systems (HMIS) in the ICTPH Health Systems Model – A Technical Note

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The Health Management Information System (HMIS) that is in use by ICTPH was developed in partnership with Swasth India with the goal of implementing an IT solution that integrates all aspects and dimensions of a health-care delivery system.

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Introduction

IKP Centre for Technologies in Public Health (ICTPH) is piloting a nurse-managed, physician-supervised, technology-enabled, comprehensive primary health care delivery model in rural Thanjavur in Tamil Nadu (Johar, 2010). Technology is pivotal to the success of this model which is being implemented by ICTPH's partner, Sughavazhvu. This technical note explores the various facets of technology employed in our pilots with a detailed focus on the IT system, the ICTPH Health Management Information System (HMIS).

To understand the context in which technology is employed it is important to first discuss the ICTPH primary health care delivery model which consists of a hub-and-spoke organization of health kiosks. Figure 1 shows the hierarchy of nodes in the model, consisting of the district level administrative "hub", shared diagnostic facilities and the Rural Micro Health Clinic (RMHC).

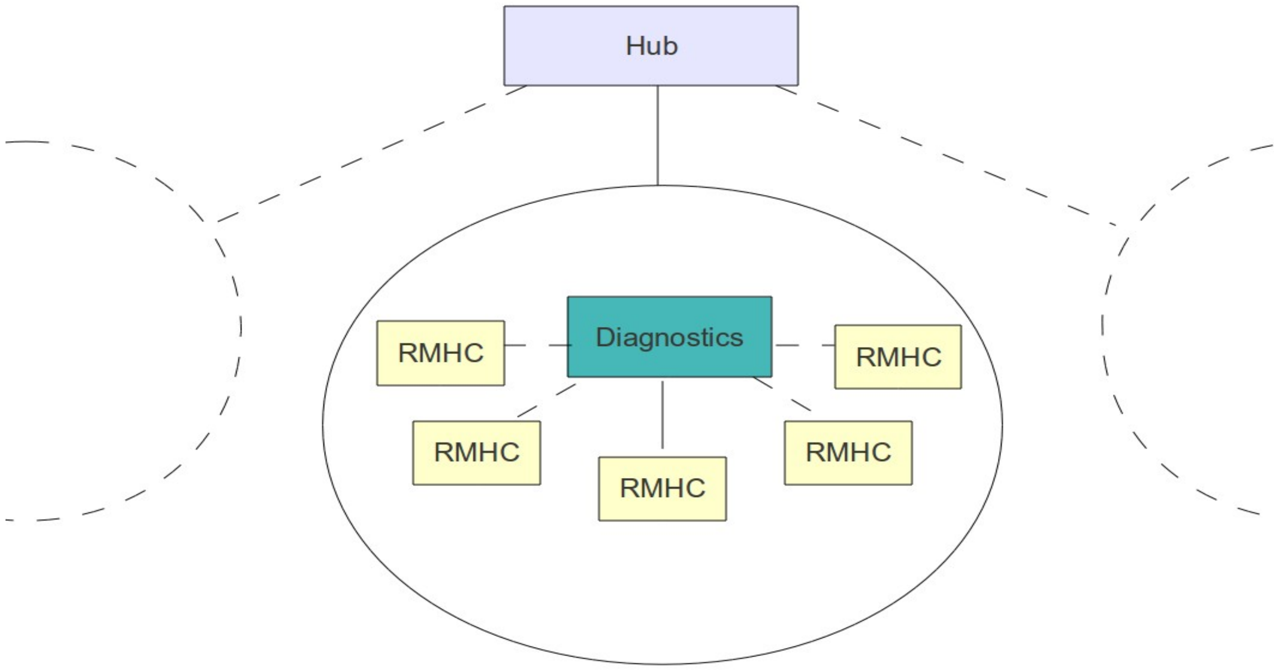


Figure 1: In the ICTPH Health Systems model the "Hub" is represented by a district-level administrative center that also serves as the distribution node for drugs and inventory. A group of Rural Micro Health Centers (RMHCs) managed by the hub cater to the primary health care delivery of populations of about 10,000 people each. A set of RMHCs are serviced by a geo-optimally located diagnostic center

Role of Technology in the ICTPH Model

The technology needs of this model are captured broadly under the following categories:

- **Electronic Medical Records (EMR):** The EMR is a tool to document history of disease and care on a per-person basis. Chronicling health care history has a direct impact on the quality of healthcare. At a population level, this data provides invaluable insights into the epidemiological statistics of the population being served, which is crucial for a preventive-promotive approach to healthcare. This data can be used as feedback to refine the model, to improve efficiency, and at a higher level, to influence health policy too. Carefully designed visit documentation templates facilitate process control and the resulting comprehensive documentation of healthcare visits facilitates adherence to protocol.
- **Supply chain and inventory management**: For the operational success of the model, there is a need for a mature Management Information System (MIS) to manage the procurement and distribution of drugs, consumables and material. The data captured in the MIS can be used to tune the efficiency
- **Diagnostics**: An important aspect of technology in the clinics is the diagnostics infrastructure relevant to primary care, and how it integrates with the rest of the information management systems. Carefully selected Diagnostics can bring down the cost of primary health care.
- **Technology assistance for Health Extension Workers (HEW)**: In the ICTPH health system model, the primary health care providers, i.e. the nurse practitioners, are supported by a group of health extension workers, called ICTPH Guides. An important focus of technology is to assist the guides in being more effective in their outreach into the community.
- **Managed Care delivery and Cash Management**: Another role of technology in the primary health care setting is to provision and maintain back-end insurance towards managed health care. When a non-managed member uses the services of a Sughavazhvu RMHC, the cash management is done by a local rural financial services partner. The IT system at the RMHC tracks the cash management in that case.
- **Monitoring and Evaluation**: Technology is crucial in ensuring that the healthcare delivery system undergoes continuous, realtime evaluation so that the model can be incrementally improved. To this end, a sophisticated Monitoring and Evaluation infrastructure helps to spot and quickly correct inefficiencies in the system.
- **Member Enrolment and Identification**: Tracking the care history of a patient requires a robust identification mechanism. The technological setup handles printing of id cards for all users of the system. This is likely to be replaced in future by a standard unique ID based method such as the Aadhaar project from the Unique Identification Authority of India which employs biometric identification.

Technology Use Cases

Figure 2 describes how the technology use cases apply to the various physical nodes in the model, and how they relate to the personnel to which they apply. The Nodes and Personnel mentioned here are logical roles and sometimes can overlap; for eg the Nurse and the Lab Technician could be roles played by the same person, just as the Diagnostics and RMHC could be combined in one physical entity.

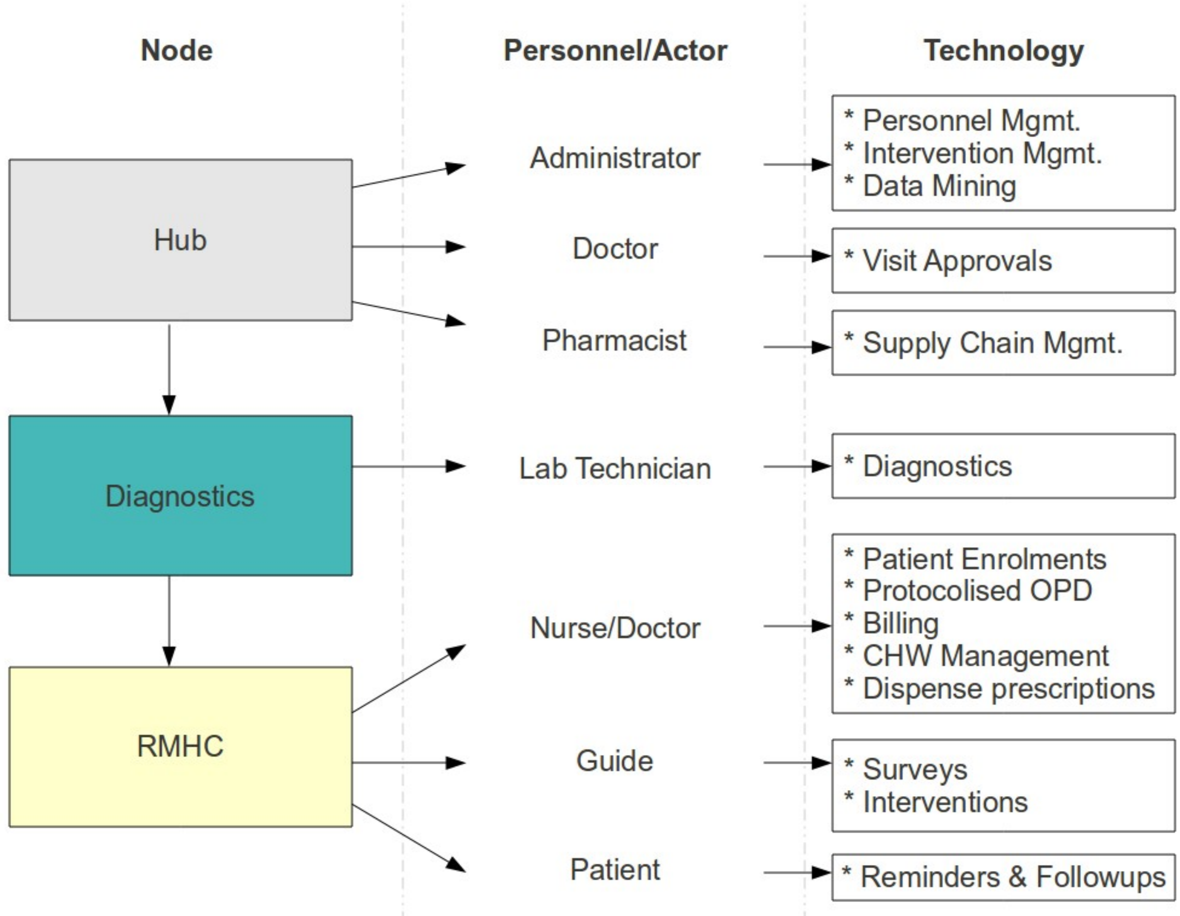


Figure 2: Various actors interact with the HMIS under different contexts. This figure gives a actor-level breakdown of the technology use cases.

Having introduced the technology use cases and their respective contexts, this paper will, in subsequent sections discuss how these are addressed by the Health Management Information System currently being used by ICTPH's implementation partner, Sughavazhvu.

Health Management Information System (HMIS)

With an aim to address the technological needs of the model detailed in the above sections, Swasth India in partnership with ICTPH developed a custom MIS, called the ICTPH Health Management Information System (HMIS), that integrates management of all health system components. With its rich feature set HMIS has native support for most of the relevant use cases described above while also affording easy integration with other information systems and technologies.

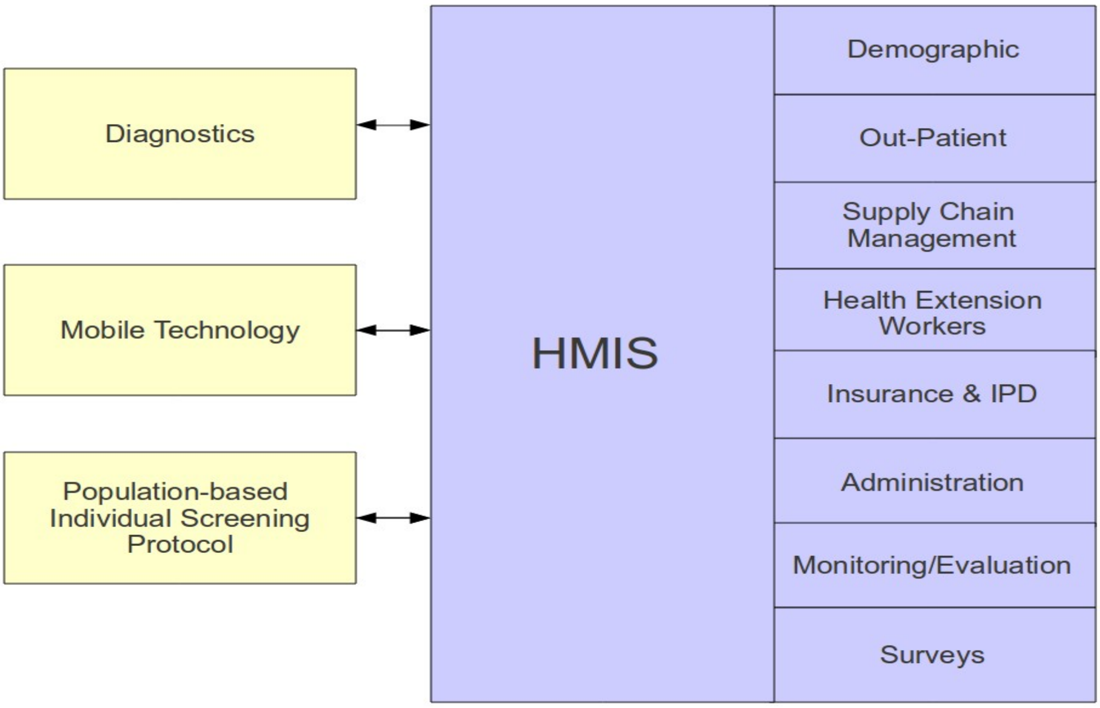


Figure 3: The HMIS has native support for most of the primary health-related functionality. It also interworks with external sources of information such as the Diagnostic results, PISP statistics and information collected on hand-held devices.

The three main sources of data from external systems are

- **Diagnostics**: At a primary care setting, diagnostics include devices dedicated to Haemotological analyses such as CBC or Complete Blood Count, Biochemical Analyses, strip tests (for eg., for Malaria) and Opthalmology. The diagnostic requirements in the ICTPH health systems is described in detail in a separate paper (Johar, Financing Health Systems, 2010).
- **Mobile Technology**: All surveys carried out using hand-held mobile devices, by the community health workers or Guides, are integrated into the HMIS. To quote an example, an infant-nutrition intervention currently piloted in Thanjavur. This project targets infants

between the ages of 2 and 24 months and hopes to address childhood anaemia through the use of nutritional supplements. This intervention employs baseline surveys conducted on the caregivers which are administered by the Health Extension Workers through their mobile phones.

- **Results of Surveys**: The Population-based Individual Screening Protocol (Johar, 2011), or PISP, is an effort to gather locally-relevant statistics about the individuals in the RMHC's catchment area. It deploys the ICTPH Guides to collect risk-related statistics from the community through the use of non-invasive tests (such as measurement of BP, BMI, etc) and the use of carefully designed questionnaires. The PISP is currently being captured on Optical Mark Recognition, or OMR, forms which are scanned by specialised equipment that convert the data into tabular form(Das, 2010), and finally ingested into the HMIS backend where statistics are collated and reports printed. The OMR sheets will, in due course, be replaced by hand-held devices.

Features of the HMIS

The features of the HMIS fall into one of the following six buckets. Here is a summary of these features.

1. Demographic

The Demographic section allows the management of information about recipients of the health care model. Along with individuals and their respective households, this system also stores information about the geographical context in which the health care model is set. There is a hierarchical organization of these geographical entities starting from states all the way through to villages and then to area, clusters and GPS-coded households. The information about the population in the catchment ares of the RMHC either grows organically as individuals visit the clinics or can be seeded by information obtained from external sources.

2. Out-Patient

The out patient module is perhaps the most used sub-system in the primary health care setting. This module provides interfaces to provision health care providers, assign providers to locations, create and moderate Demographic information.

The OPD module of the HMIS has the following features

- For a nurse documenting a visit by a patient, the HMIS supports an interface that closely mimics the SOAP protocol (see Appendix 1) for documenting a visit. SOAP is an acronym comprising of the four stages involved; Subjective which captures a patient's conditions in her own words, Objective consisting of notes made from measurements, physical examination and tests, Assessment consisting of a summary and differential diagnosis and finally Plan which is the care-provider's recommended course of action that includes prescriptions and referrals. As part of the plan, the care provider also recommends, if she deems necessary, a followup to be done by the Health Extension Worker.
- Every visit documented by the nurse goes through an approval by a doctor.
- For every patient, the health care provider can access the history of visits.

Figure 4 shows the sequence of events in the OPD workflow.

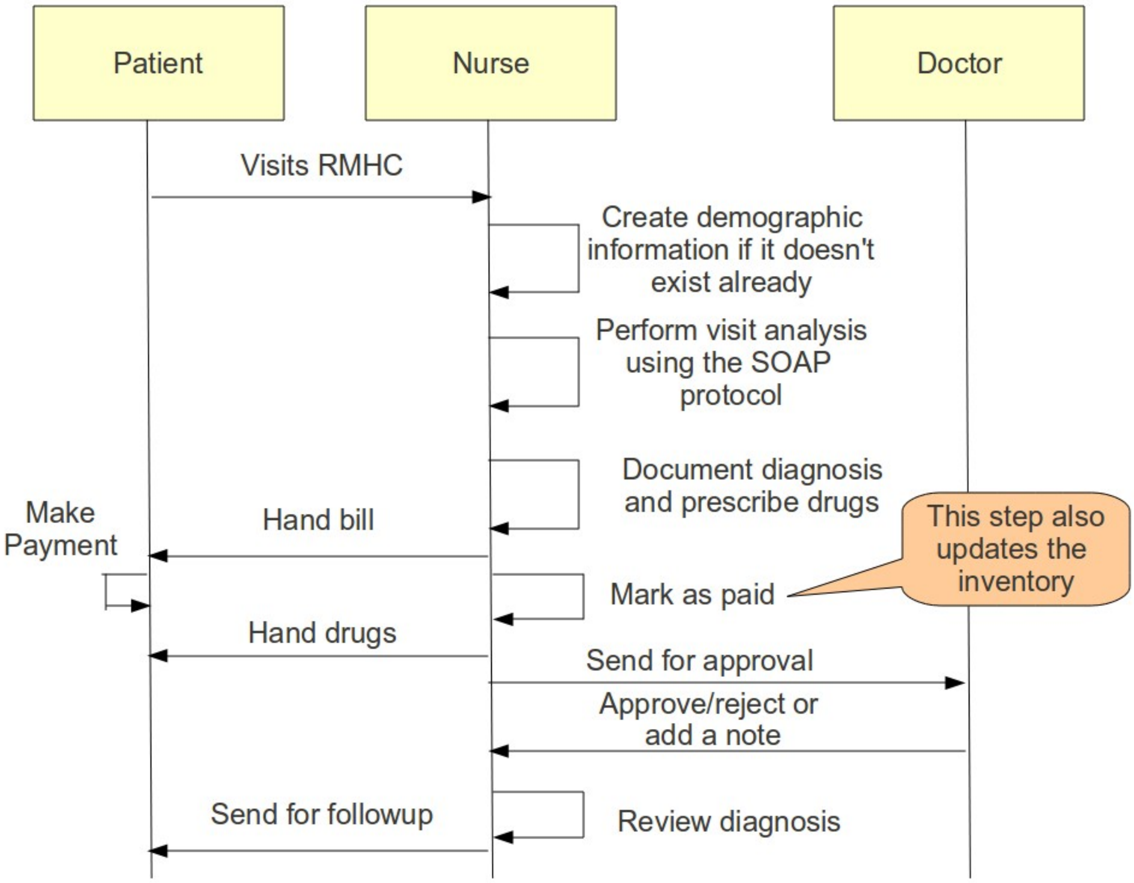


Figure 4: The OPD module in the HMIS is designed to facilitate the nurse-patient-doctor interaction. The care provider identifies the patient, or adds her as a new member, before conducting examinations and prescribing drugs. Every visit is comrehensively documented and approved by a doctor. When the patient pays for consultation (if applicable) and drugs, the nurse/doctor marks the bill as paid at which point the inventory is updated to reflect the recent change.

3. Supply Chain Management (SCM)

The ICTPH HMIS also supports the management of inventory in and supply chains between the various nodes in the model. The users of this module, typically are

- Pharmacists, who receive supplies (drugs and consumables) from external suppliers and then dispatches them to the clinics and diagnostic centers.
- Nurse-practitioners and diagnostic technicians, who manage the inventory at the clinics.

The sequence diagram below explains the information flow between the various actors in the system. While the Pharmacist and the Nurse are both internal to the system, the Supplier could be an external entity, for eg., a local pharmaceutical distributor. In the scenario described below a nurse requests supplies for her RMHC, and is serviced by the pharmacist in the drug distribution center. All the actions described below are performed from their respective views in the HMIS.

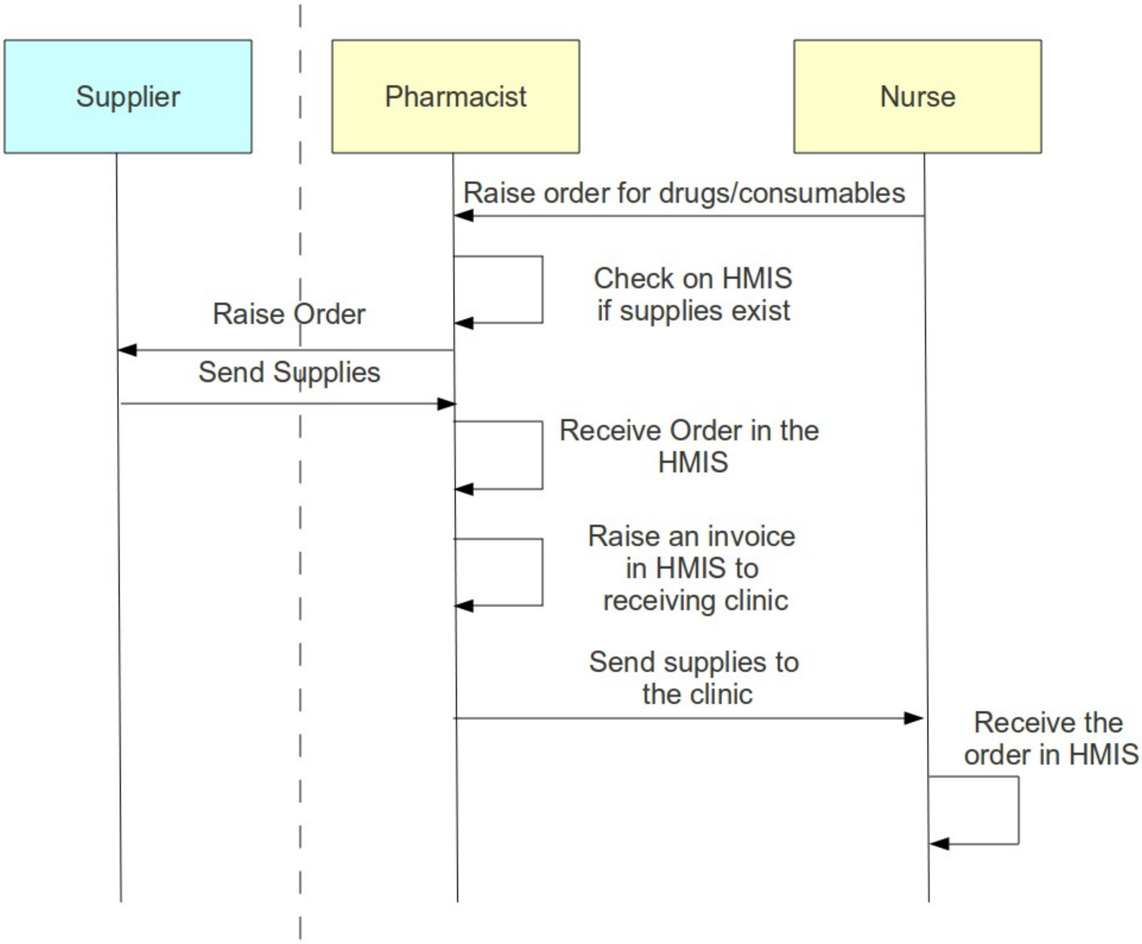


Figure 5: The Supply Chain Management (SCM) module in the HMIS is the module used to keep track of inventory and procurement. This figure shows a typical use case where a nurse manages the inventory at the RMHC.

Appendix 2 shows screenshots of the SCM module in the HMIS. It shows the interfaces for

- Creating drugs to be added to the inventory list. This interface also allows the manager to fix the price of the drugs and consumables.
- Raising an order from the hub to the external supplier.

Apart from the explicit actions of ordering supplies and receiving them, the SCM module also tightly integrates with the OPD actions. For eg, when the care-provider dispenses drugs they are automatically reflected in the inventory counts.

4. IPD Module

The IPD module is instrumental in documenting members' continuum of care even at the secondary and tertiary levels thus affording a richer view into patient history. In many of the cases where a patient seeks care at a higher level, the RMHC will still be involved in followups and regular care, for eg. In chronic disease management. Maintaining records of patients' care-seeking episodes beyond the primary level enables the provider at the RMHC to make more informed decisions. The IPD module allows hospitals to be added into the system and will be crucial to employ a managed care model.

5. Health Extension Worker Module

In the ICTPH health systems model every RMHC is associated with a group of Health Extension Workers, called ICTPH Guides, for every 1000 individuals in the catchment area of an RMHC. The ICTPH Guide provides basic screening services, including administering PISP questionnaires, communicates messages of preventive and promotive health care at the individual, family and community levels, and performs regular follow-ups increasing the efficacy of care dispensed by the RMHC. The ICTPH Guides are managed by the care provider at the respective RMHC. To enable efficient program-management of the ICTPH Guides, the HMIS provides a modue to coordinate all actions related to the Health Extension Workers (HEW) or ICTPH Guides. Interfaces in this module allow the HEW supervisor to

- Organize the HEWs into groups
- Assign training modules to the HEWs
- Allocate material to the HEW to be disseminated into the community
- Create projects and assign tasks to the HEWs

6. Monitoring and Evaluation

The HMIS allows the creation of reports and surveys through a module named Monitoring and Evaluation or M&E. The M&E module is designed to be a highly configurable data-mining tool allowing insights into the statistics. An example of a survey managed by the HMIS is ICTPH's Population-based Individual Screening Protocol (PISP) described in detail in another paper (Johar, 2011). The PISP is an individual screening protocol that includes non-invasive measurements such as BP, BMI and Waist Circumference, as well as questionnaires, that is done for the entire population served by an RMHC. From the resulting data, high-risk individuals are identified for follow-ups. Figure 6 shows an example of the PISP risk-factor prevalence in one such catchment area.

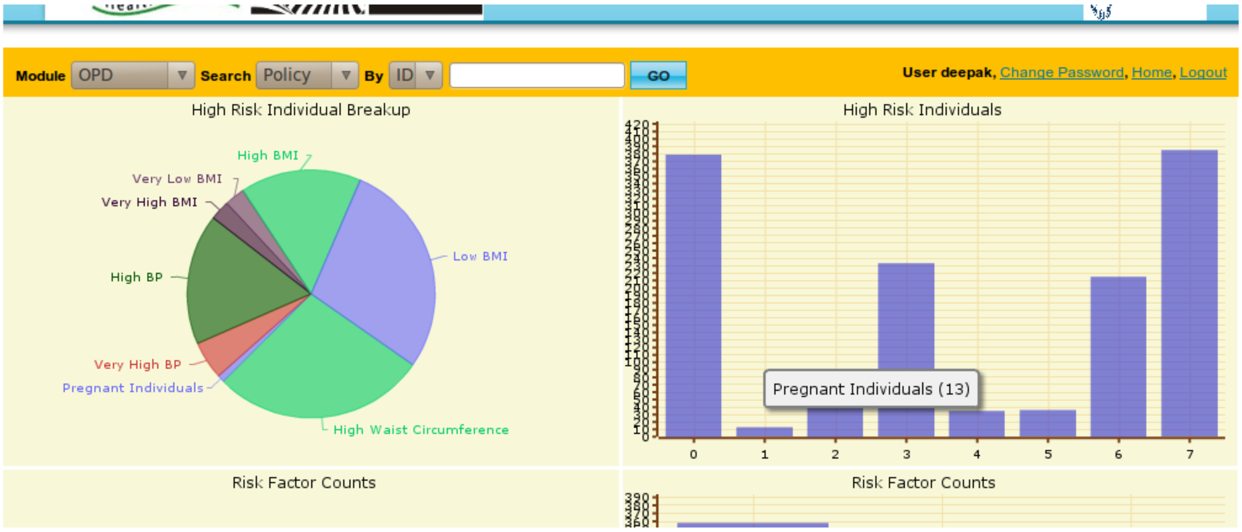


Figure 6: The Monitoring and Evaluation module provides capabilities for visual representation of data. These graphs visually illustrate the prevalence of risk factors as identified in the PISP.

7. Administration

The HMIS, as illustrated in the previous sections of this document, have varying responsibilities and require different views into the database. For eg, a Nurse or a Doctor require access to the OPD module while the Supply Chain or Inventory Manager needs to be able to raise and receive orders through the SCM module. Such role allocation and user administration is done through the Administration module. Some of the other typical roles in the health system as envisaged by ICTPH and Swasth are HEW Manager, Claim Processor, Accountant etc. The system is designed to be felixible enough so that additional roles can be added and modules assigned according to the needs of the health delivery organization using the HMIS.

8. Surveys

The HMIS also supports a survey module that supports a wizard enabling non-technical users to design surveys that link to the HMIS. The responses for these surveys are linked to the records of the members in the health system providing an integrated view into the patients history that includes survey responses as well. The aggregated results of the survey module are available to the MnE section for analysis and reporting.

Some examples of the HMIS usage in the context of ICTPH

- Determining consultation fee: The data from several months was used to analyze patient traffic patterns. The statistics yielded insights into fixing the right price for diagnostics, consultation and prescriptions.
- Drug Inventories: The historical data from the SCM module is used to estimate drug and consumable usage and in determining accurately order volumes.
- Quality assessment by doctor: With comprehensive documentation of every visit to the clinic, doctors were able to review prescriptions and validate overall adherence to protocols.

Technical Details

This section of the document describes the implementation and deployment details of the HMIS.

Design goals

The ICTPH HMIS system is designed with the following goals in mind.

- Modular and extensible: The ICTPH HMIS is designed to be easily extensible, both in terms of adding core features and to customize the installation depending on the specific scenario of the organization using the system.
- Security and Access Control: Since there is a need to support users of different kinds, the HMIS allows users to access only relevant parts of the system.
- High availability - offline solution: Since some of the deployment sites are not always connected to the internet, the HMIS also supports an online-offline model in which the changes are made to a local database and regularly synchronized with the master DB.
- Protocolized Care: The HMIS is built with the intention of facilitating the delivery of protocolized care. In the visit documentation tool a detailed Review of Systems page and a Physical Examination page steers the care provider towards capturing information along established guidelines. The HMIS is also designed to incorporate Disease Protocols relevant to primary health care further standardizing the dispensed care.

Architecture

The ICTPH HMIS is a web-based application that is accessed by the user through a browser. At the backend, the system is built on the LAMP platform, which uses Linux as the operating system, Apache as the webserver, MySQL as the database and PHP as the server-side programming language, all of them Open-Source platforms. The code organization uses the MVC (Model-View-Controller) pattern facilitated by an open-source framework called CodeIgniter.

Deployment

For every health care company wanting to use the HMIS a new instance can be created by maintaining separate copies of the database and code within the same cloud or in different hosting environments. For example, the instances of the HMIS used by Swasth India and ICTPH are deployed on AWS, or Amazon Webservices, which is a hosted cloud.

Within the same instance of the HMIS, the clients are of two types: a thin client which is just a browser accessing the server directly and an online-offline client. The latter type of client is deployed in areas with poor internet connection. In this type of installation all local operations are documented in the local database and regularly shared with the master. The thin client can work on lower-end hardware while the latter has to be deployed on higher-performance hardware (because the full server environment is created on the online-offline client).

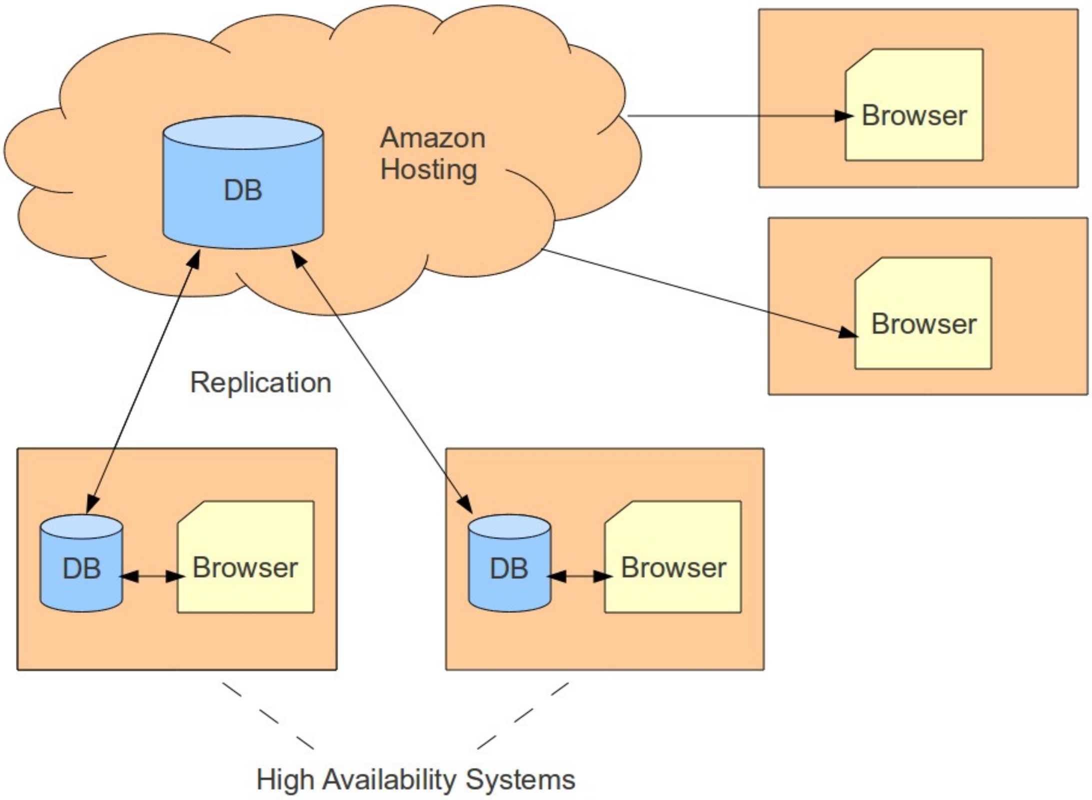


Figure 7: The deployment diagram show the two types of clients; thin clients on the right which use browser based access to the cloud services, and the offline-online clients at the bottom which store their own snapshot of the master database.

Evolution

In the foresee-able future for the HMIS, we envison the following features

- Standards compliance: The HMIS will store the medical records in standard formats such that it is possible to interwork with other EMR systems. This back-and-forth exchange of data with third-party systems and along referral channels will also increase the focus on security to prevent abuse of sensitive information.
- Different form factors: Currently the frontend is a browser-based application. In future we will support the HMIS on other factors, such as tablets and other handhelds.
- Decision-support system: In future, the HMIS system will contain more comprehensively codified protocols which will enable the provider to make use of decision support systems to ensure higher adherence to standard protocols and lower diagnosis errors.
- Usage by PHCs: We aim for the HMIS to be made available to the government PHC network in order to enforce uniform standards of care.
- Geograhical tracking: One of the goals of the HMIS is also to connect the accumulated data to geographies, such that dashboards of high-risk areas for chronic diseases, mapping of epidemics etc. can be done real-time.

- Multi-tenancy: In future it is likely that several implementation partners will share the hosting space, with inter-workable data such that electronic health records of patients can be made available across provider organizations.
- The roadmap for the HMIS also contains more sophisticated analytical engines so that reports can be auto-generated and made available to health administrators reducing the latency period for action.

Appendix

Appendix 1: Visit documentation in the HMIS

The following screenshots illustrate the visit documentation. The document is split into 5 parts

1. Subjective Evaluation

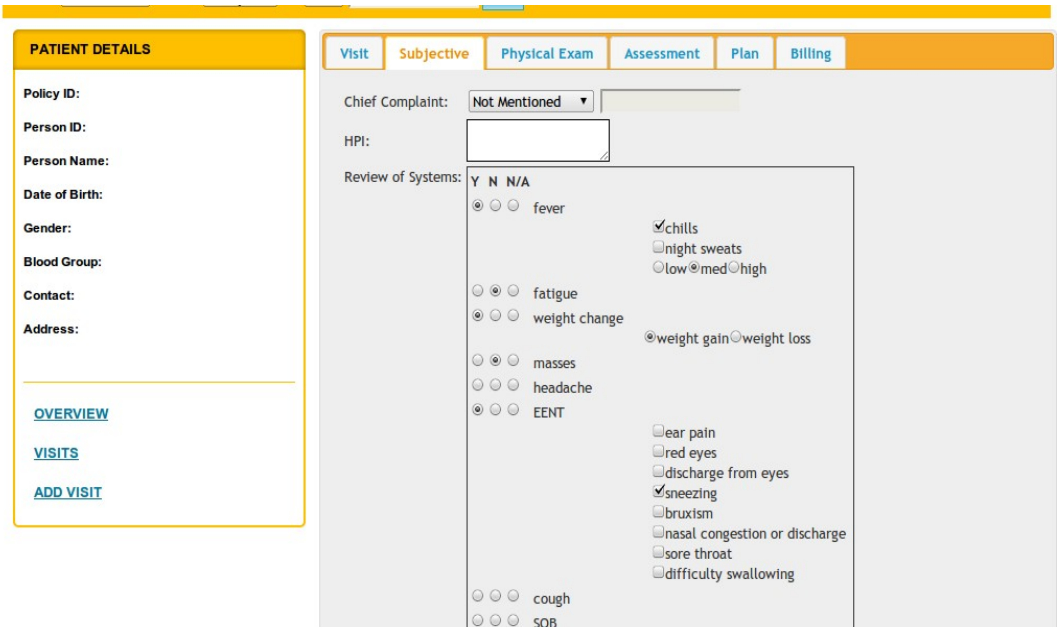


Figure 8: The "Subjective" portion of the visit documentation is designed to capture the user complaints

2. Physical Examination (Objective)

Figure 9: The "Physical Exam" captures objective data such as vital statistics and results of diagnostics and physical examination.

3. Assessment

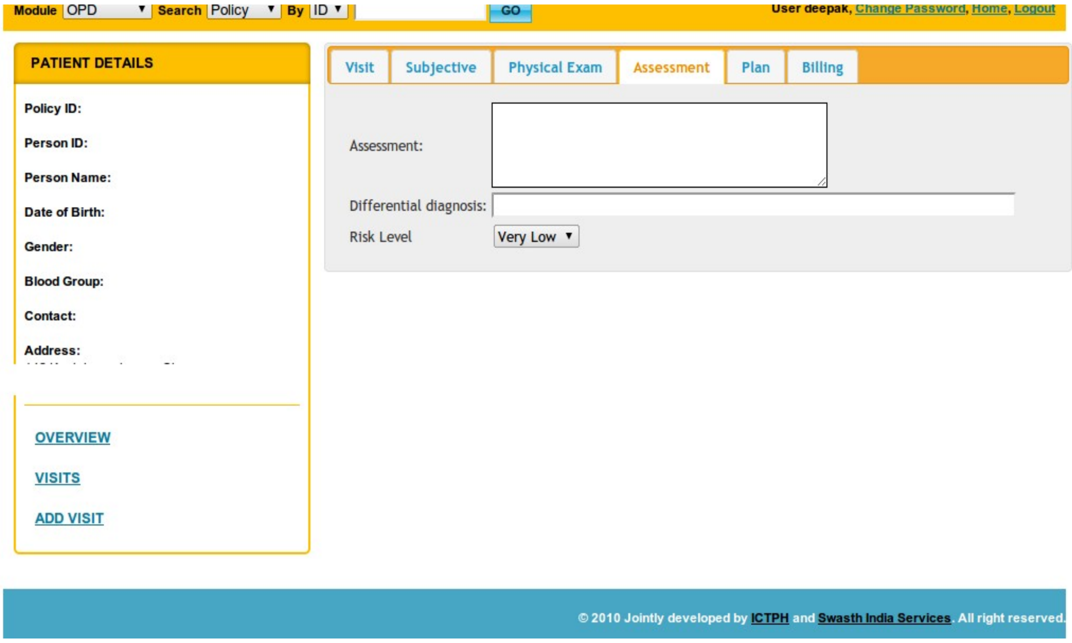
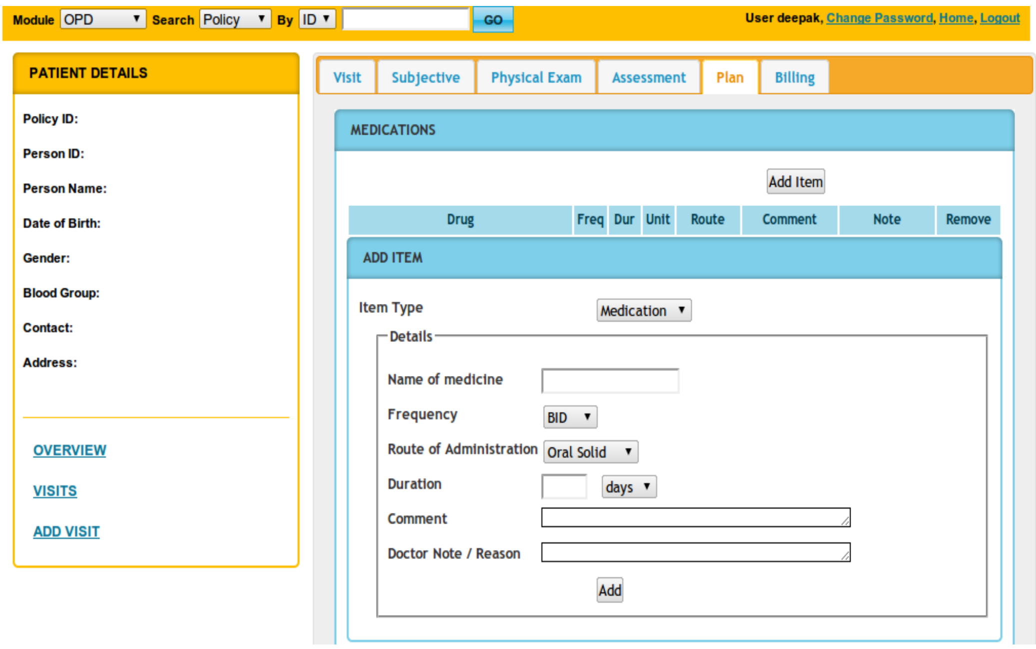


Figure 10: The "Assessment" page allows the care provider to document the differential diagnosis.

4. Plan



5. Billing information

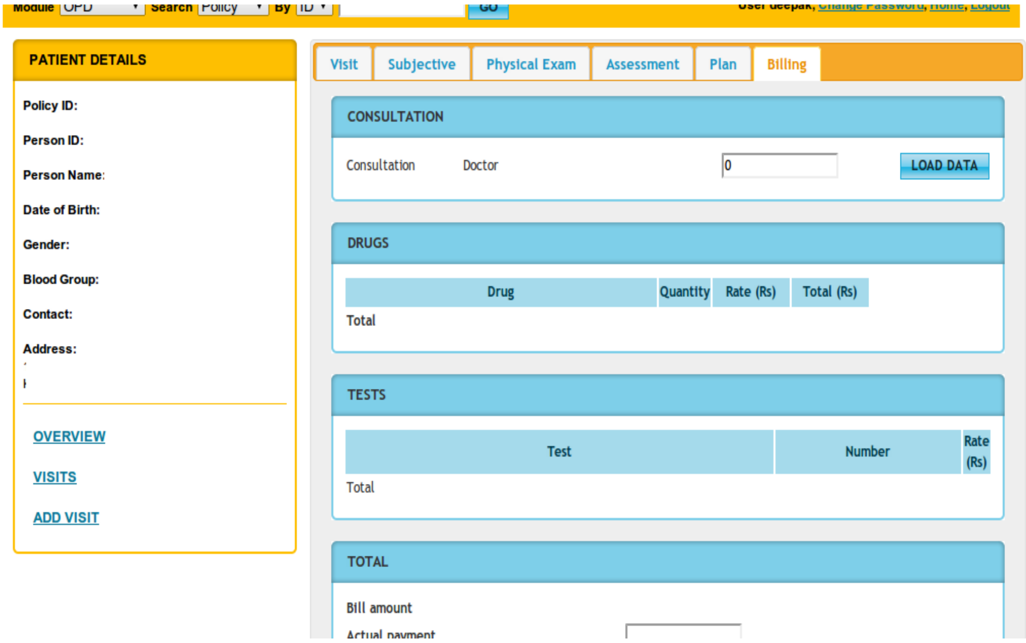


Figure 11: The final part of the visit documentation consists of the "Billing" section.

Appendix 2: Supply Chain Management in the HMIS

1. Creating Items in the inventory

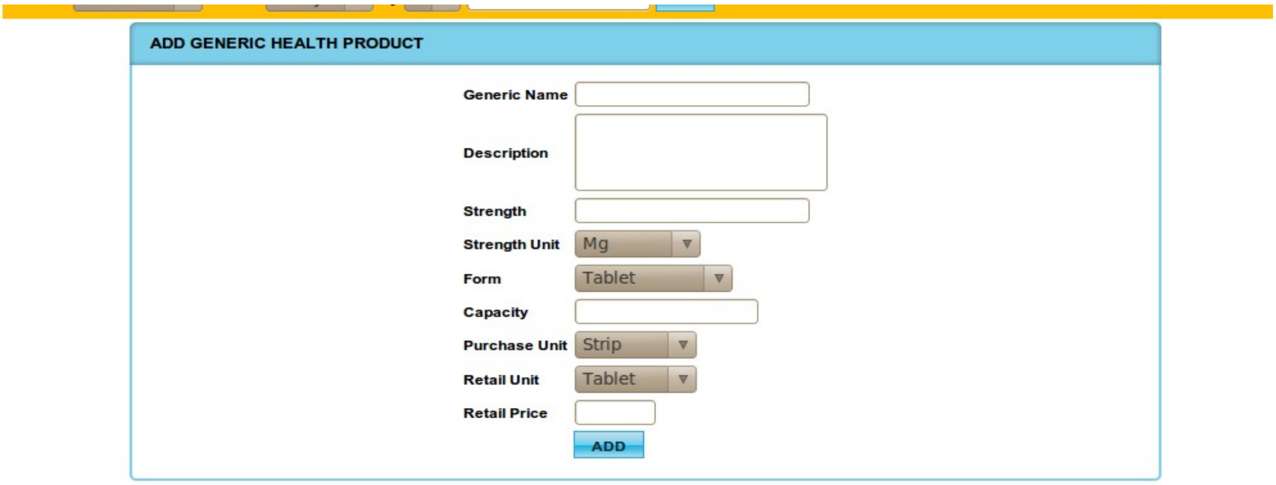


Figure 12: Interface for the creation of a new generic drug in the database.

2. Raising an order

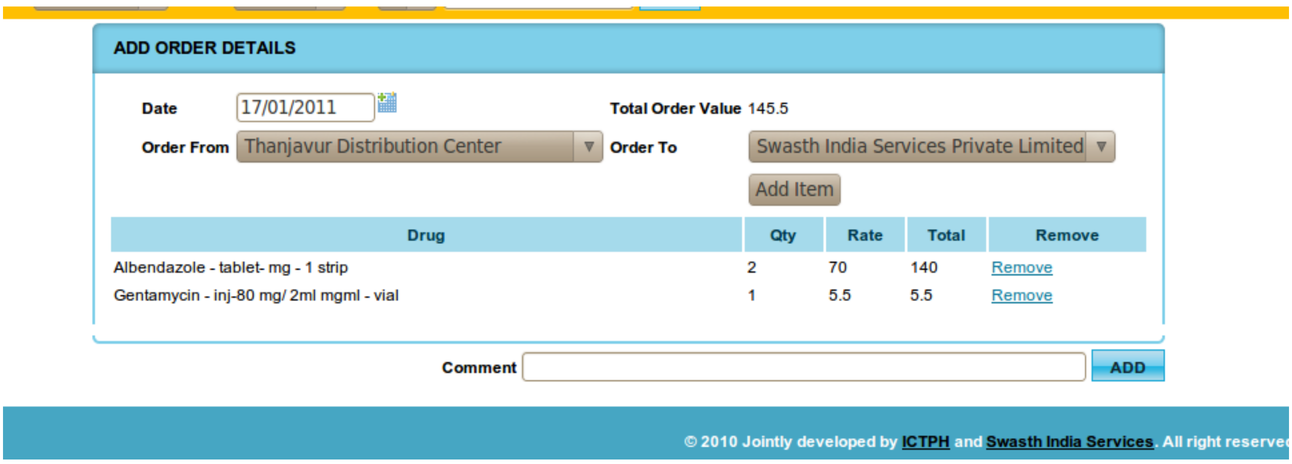


Figure 13: The Nurse or the Pharmacist uses the "Order" module to procure drugs and consumables.

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