



KIMBAHUNE

mHEALTH- PHC: An ICT Tool for Primary Healthcare in India

N. BONDALE, S. KIMBAHUNE, AND A. PANDE

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Access to timely, quality healthcare is one of the important issues concerning communities in rural India, among many others such as education, safe drinking water, transport, approach roads, and electricity. Information and Communications Technology (ICT) has made a significant impact on the functioning of enterprises and urban communities; however, the benefits of ICT are yet to reach rural communities.

Rural communities can benefit from the use of informatics in pro-

viding for their primary healthcare needs. With appropriate user interfaces and tested software usability, a mobile phone can be a valuable and robust device in the hands of a village health worker, enabling them to provide quality healthcare to remote village communities with the help of expert advice [1], [2]. This article describes how an innovative ICT tool called “mHEALTH- Primary Health Care” (mHEALTH-PHC) can be used to meet the primary healthcare requirements of the community. The MHEALTH-PHC tool was developed after studying the needs and the logistic problems related to primary healthcare of the rural tribal population of villages in India.

Primary healthcare is defined as healthcare that is inherently preventive, curative, and rehabilitative, and that also promotes a healthy lifestyle. The concept of primary healthcare, therefore, recognizes that public health is an effective medium for achieving socioeconomic development. Primary healthcare also implies that it is the first contact a villager has with the healthcare system – a healthcare

system that is accessible, acceptable, affordable, and appropriate to all the people in the country. India has adopted a primary healthcare strategy with an emphasis on the integration of curative and preventive medicine at all levels as recommended by the Bhore committee (also known as the “Health Survey & Development Committee”), whose report gave comprehensive recommendations for the remodeling of health services in India [3], [4]. The establishment of Primary Health Centers was one of the recommendations of this committee, and as result all states of India

now have an established Primary Healthcare System.

To improve the availability of and access to quality healthcare for rural communities, especially for the poor, women, and children, the Government of India launched a program called the National Rural Health Mission [5]. The main goal of the Mission is to reduce infant, child, and maternal mortality through promoting newborn care, immunization, antenatal care, institutional delivery, and post-natal care. Therefore, top priority is placed on the Reproductive and Child Health (RCH) program which is implemented through the Primary Healthcare Centers and Sub Primary Health Centers in all the states of India.

Primary Healthcare Centers and the Community

For the community, the Primary Healthcare Center is the focal point for health-related outreach activities. The Centers are responsible for the implementation of national health programs. They are charged with carrying out a health survey of the community,

establishing baseline health status, ensuring safe water and environmental sanitation, promoting health awareness, monitoring disease surveillance, and maintaining health related data along with epidemic investigations, containment, and research. The Indian Public Health Standards help monitor and improve the functioning of the Centers [6].

The four pillars of the public health system implemented through the Centers are: 1) a female volunteer who is an accredited social health activist at village level; 2) a female health worker called an auxiliary nurse midwife, 3) a male health worker called a multi-purpose worker at the Sub-centers, and 4) a Medical Officer at the Center. The interface between a Center and the local community is entrusted to the social health activist. The interaction between the local community and these key persons, as well as the communication and coordination among them, has a great bearing on the effectiveness of the system.

A Center typically covers 25-30 villages and has 6-8 Sub-centers providing basic health services to the villagers. The community population catered to by each Center is around 30 000 in plain areas and 20 000 in tribal and hilly areas. Each Sub-center covers a population of 5000 in plain areas and 3000 in tribal and hilly areas. The average distance between the Center and a Sub-center is about 5-10 kilometers [7]. We are currently conducting mHEALTH-PHC field trials at a Center (hereafter referred to as “Center-K”), in the Thane district of Maharashtra state in India. There are 78 Centers in the Thane district of which 27 are nontribal and 51 tribal [8]. Center-K is a tribal Center and together with its 8 Sub-centers caters for a tribal population of 31 144 covering 29 villages and 58 “Padas” with agriculture and related activities being

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the major occupation of the community. Common prevailing complaints are gastrointestinal, fever, obstetrics and gynecology related, and fall related (musculoskeletal). Center-K services the community through various health programs such as family planning, RCH, immunization, water disinfection, iodine deficiency disorder control, blindness control, tuberculosis control, leprosy elimination, and water-borne and communicable disease control programs.

For mHEALTH-PHC, our focus is on the RCH program, which focuses on preventive, promotional, and curative mother and child health services. The midwife and the social health activist conduct home visits to deliver antenatal and postnatal services to the mothers. They also record the health data of children below the age of five years.

Challenges for Primary Healthcare Centers and the Community

Although government intends to provide the primary healthcare to the rural community through the National Rural Health Mission, the ability to reach the community and deliver end user benefits is restricted due to challenges faced both by the community and the Centers. We list some of them in general and for RCH specifically.

- Lack of transport and approach roads makes it difficult for pregnant women to reach a nearby Center or rural hospital;
- When complications arise, there is no easy way for a midwife to seek advice from Center doctors. Similarly for Center doctors, there is no easy and effective way for them to consult experts at the city hospitals;
- The secondary status of women in the community, preferences for a male child, short birth intervals, inadequate immunization coverage,

socio-cultural practices, and poverty are other compounding factors adversely affecting maternal and child health;

- The health information system in the Sub-center is being operated manually. This situation causes inadvertent delays in transmitting the data recorded by the social health activist and the midwife to the Center, often located 5-10 km away from the Sub-center. As a consequence, there are feedback delays from the Center, and then mothers are deprived of prompt advice and intervention. The manual recording of data is also subject to human error, unfavorably influencing health interventions.
- Capacity building for health workers in terms of data management is lacking and health records are not interpreted epidemiologically. Thus, until feedback is received from the Center, the interventions may not be consistent or even appropriate; and
- For typical Indian rural conditions, there are other challenges such as good approach roads, safe drinking water, uninterrupted power supply, and availability of educational facilities for staff families to stay in villages. As a result, the posts of trained doctors remain vacant in many Centers.

After studying the above challenges, we designed and developed the mHEALTH-PHC solution [9]. For healthcare management and monitoring, there is a need for information flow from a patient at the village level to a doctor at a Center level. These need to be monitored simultaneously at different levels of the management process. In the following section, we describe a mobile phone based informatic tool called mHEALTH-PHC, which facilitates the required information flow. This tool addresses the challenges identified above.

mHEALTH-PHC: Mobile Phone-Based ICT Tool

The ICT tool mHEALTH-PHC was first showcased in the e-Health pavilion at the World Telecom Conference 2009 in Geneva [10]. This tool helps to meet the health-care needs of the community and to overcome the challenges faced at the Center by connecting the rural patient to the Medical Officer through the midwife or the social health activist. By establishing efficient communication between the social health activist, midwife, and Medical Officer, mHEALTH-PHC expands the Center outreach; thus facilitating timely, quality healthcare to the community under consideration. As mentioned above, for the mHEALTH-PHC application, we are currently focused on the RCH program.

mHEALTH-PHC Components

To connect the remote patient to the doctor, mHEALTH-PHC has five major components that together use various technologies including mobile Internet, Interactive Voice Response (IVR), Indian language font rendering, and usability frameworks:

- 1) Client software in the local language on a mobile phone used at the patient's end;
- 2) Servers in the secured data center;
- 3) A doctor's console, which is viewed by a doctor/expert to suggest treatment/tests and prescribe medicines to the patients;
- 4) An IVR application to record the information and observations; and
- 5) A reporting console to view various reports related to rural health in consolidated manner.

The mHEALTH-PHC design is based on the existing government healthcare infrastructure and is influenced by rural community requirements and challenges. The mHEALTH-PHC platform is based on the patented "mKRISHI"

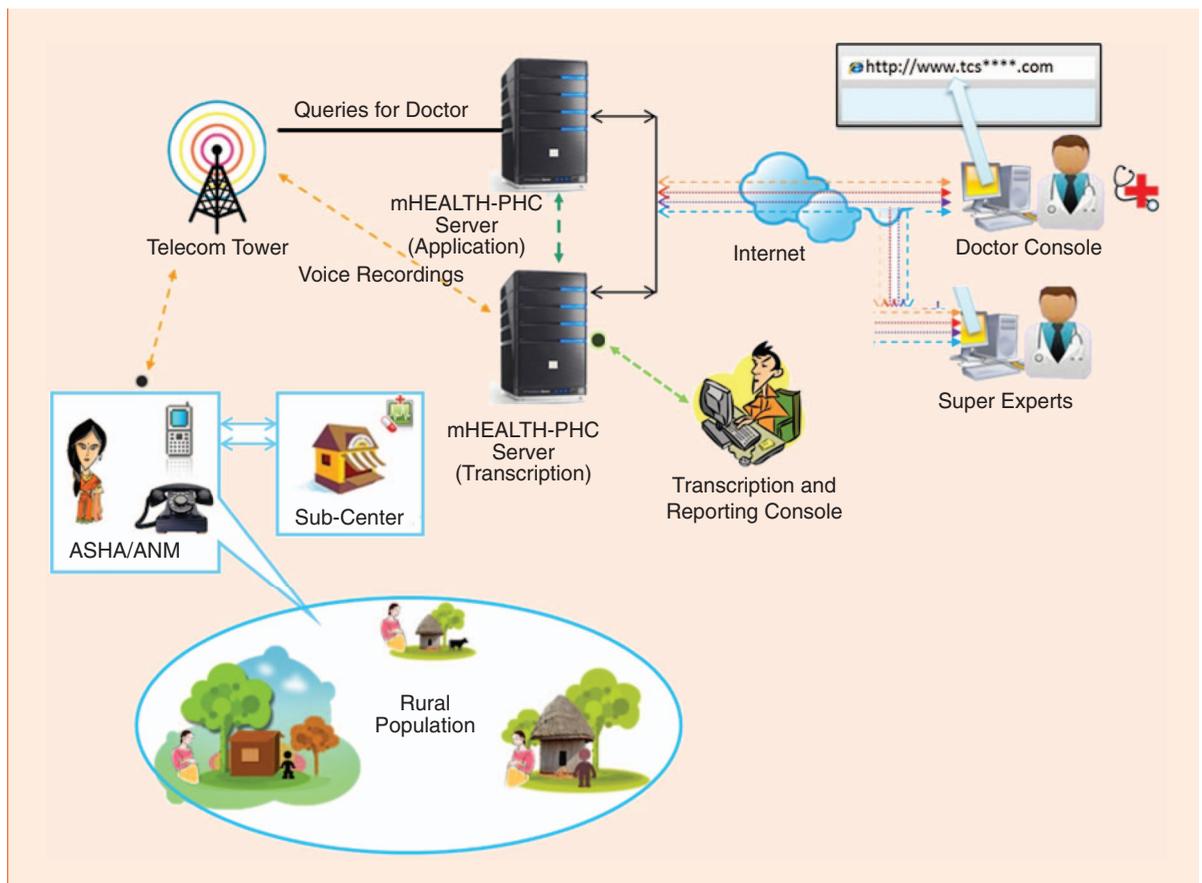


Fig. 1. Components of the *mHEALTH-PHC* platform.

platform developed to provide personalized agro services to farmers [11]. Its architecture (shown in Fig. 1) reflects the processing of healthcare services at different levels in the existing primary healthcare infrastructure. The usability framework was considered while designing the interface.

Our design approach, and how the *mHEALTH-PHC* system supports the delivery of health services, is summarized in the following points:

- To ensure institutional delivery and knowledge of public health of the population in the village, the social health activist should be able to record her observation easily.
- A simple mobile phone and IVR technology was selected to record her observations during her visits. The transcription software was designed to

convert her visit report from voice to text.

- The doctor is equipped with electronic pen (E-pen) to write his/her prescription on regular paper.
- Blood and urine testing is needed for implementation of RCH as well as for diagnosis of other prevalent diseases in the area. This required sophisticated yet inexpensive medical equipment.
- Also, the ICT system was required to work on the 2G cellular network and cope with frequent power issues.

mHEALTH-PHC Interfaces

There is one social health activist per thousand population, and she acts as the “eyes and ears” of primary healthcare as she goes from house to house in a village. Conventionally, the social health activist

maintains a register in paper format, which takes considerable time for processing and analysis. With *mHEALTH-PHC*, the social health activist can now record the details of her visits to families in villages on her IVR-based interface and can be notified of any emergency or task using the same interface. A special template has been designed to cover the details of the social health activist’s home visits, wherein she just selects items from the possible options to make the report. This saves her considerable time, making her job easier and more efficient. These voice records are then transcribed using transcription console and data is available in web based form. Various reports can be generated from the data using the reporting console. Fig. 2 shows the quarterly report generated. This data can provide valuable inputs for policy makers

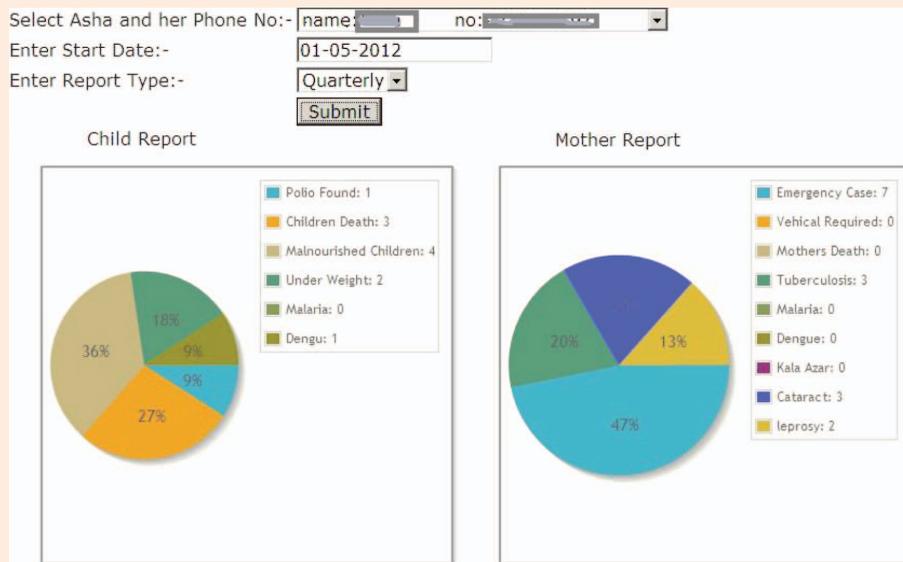


Fig. 2. Sample quarterly report using *mHEALTH-PHC*.

to formulate and fine tune the overall health policy.

The midwife at the Sub-center provides preliminary healthcare to pregnant women and performs normal deliveries of babies. The *mHEALTH-PHC* tool can aid the midwife, as it can be integrated with the portable battery operated medical test devices for blood and urine analysis. This facilitates inclusion of pathology test reports as part of “patient medical history.” The midwife can record a voice query through the interface available to her. Wireless Internet makes it possible to upload a patient’s personal information and medical history to the server. A web console gives an integrated view of patient’s medical history including the midwife’s voice comments about the patient’s illness and symptoms to the Center doctor or Medical Officer.

Through the Doctor’s Console, the Center doctor (or Medical Officer) can see the patient’s details with medical history and listen to the midwife’s recorded voice query. The doctor would then give his/her advice in voice/text or may hand-write a message using an E-pen as shown in Fig. 3. The image of the prescription is captured and

sent over wireless Internet to the midwife’s mobile phone and the midwife can then take action accordingly. If required, a specialist available at the rural hospital or in a city hospital could be contacted over the Internet and the entire case, including patient’s medical history, could be referred through *mHEALTH-PHC* for expert advice.

Thus, *mHEALTH-PHC* connects the social health activist in the village, the midwife at the Sub-center, and doctors and medical officers at the Center, and if required, doctors at a Rural Hospital or city hospital, through wireless, Internet, and web technologies.

mHEALTH-PHC Implementation

The main goal in implementing *mHEALTH-PHC* is to deliver high quality primary healthcare. Hence a mechanism to audit and take corrective actions if required is built in to the system. Considering the low literacy level of village health workers, we have provided the user interface in local languages using multi language text rendering (MLTR) software. Entering large amounts of text is avoided by using

voice input. By using a mobile application, we have avoided power related problems which were some of the main causes of failure of computer-based systems in the villages. Medical devices are equipped with a battery that has a reasonable capacity to work even in the absence of electrical power.

Primary healthcare at an affordable price is another goal. To achieve this, we have adopted a “Software as a Service” (SaaS) architecture. This ensures that all hardware cost and maintenance issues are handled centrally at the data center, and support for the client software can be eventually handled by the multi-purpose worker at the Sub-center, who would be appropriately trained for this service. This training would also be useful to serve the local community as well for other minor software and computer-related issues.

Overcoming the Challenges

Preliminary results from our field trials indicate that the implementation of *mHEALTH-PHC* has contributed significantly to overcoming the challenges faced by Primary Healthcare Centers as well as the community.

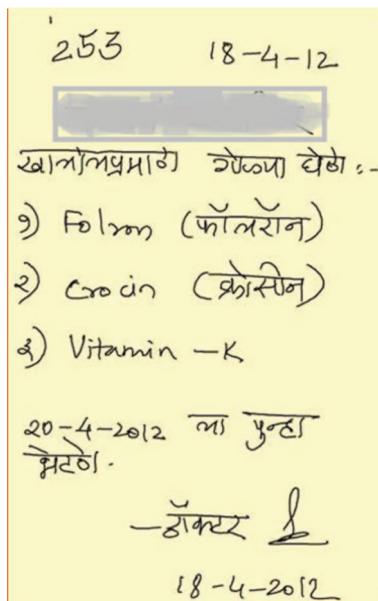


Fig. 3. Doctor's prescription using E-pen in local language (Marathi).

mHEALTH-PHC has established a much needed link between the village social health activist, the sub-center midwife, the Center Medical Officer, and the expert at a rural or city hospital. Data and information in digital form can now be transferred easily across the Sub-center and Center, avoiding the delay caused by manual operations. Health workers are trained to use mHEALTH-PHC which manages the health data. This helps capacity building of health workers. Although few doctors prefer to go in rural areas, mHEALTH-PHC helps rural patients to get the advice from city experts, as the medical history of the patient along with the current query is readily available to the doctor. Availability of contact numbers for private and public vehicles through mHEALTH-PHC, will help to solve transport problems to some extent. As stated earlier, although mobile phones are the most useful device in the hands of village health worker, use of mobile phone and Internet technologies have their own challenges like database design, privacy of data, human computer interface along,

with scalability and computational problems [9].

mHEALTH-PHC for RCH

The mHEALTH-PHC platform primarily digitizes the "Mother and Child Health Card" that is used conventionally in the RCH program. The midwife registers a pregnant woman with the help of client software on a mobile phone. A unique identity number is given to the mother as in the conventional registers called "R-15." The newborn baby, when registered is allocated a unique identity number as is already given in the conventional "R-16" register. The identity numbers of both mother and child are linked in the system for better future reference. The platform, therefore, connects two major users of the health system; the beneficiary (that is, the pregnant woman) and the doctor, via the midwife. Hence, for this application of the mHEALTH-PHC tool there are two major components; a midwife interface and a doctor's interface.

The midwife interface is on the mobile phone using a local language. This application captures the entire pregnancy lifecycle and post-delivery details. Based on the data, it automatically builds the history of the mother beneficiary in the system. This software has the following functionalities: authentication, new patient registration, pre-delivery checkup module, pre-delivery trimester checkup module, post-delivery update, update the history of registered patient, and making a health query. Fig. 4 shows the mobile screen shots in local language.

The doctor's interface, called "Doctor's Console," is accessed on computer as the Center infrastructure includes the facility of personal computer and Internet connection. Fig. 5 shows the screen shot of the Doctor's Console. The beneficiary's personal profile as well as medical history is available to the doctor in the same format as is currently available in the RCH

program. The Doctor's Console has the following functionalities: authentication, "check queries," "give advice," and "send alerts." Using the "give advice" module, the doctor can advise by analyzing the beneficiary's profile, medical history, and test reports. The doctor can use text or voice for advising and use an E-pen for prescribing.

To communicate epidemic alerts or good practice to the larger community, the doctors can broadcast the message or send an alert through the "Alerts" module. A doctor can select a specific area or group to send the alerts, which can be in local languages. Health workers can also listen to various posts done by doctors to get rich information about health related instances in a particular area and plan accordingly.

mHEALTH-PHC: Field Experience

For the patient, the first encounter is with the social health activist. For mHEALTH-PHC also, the first encounter is with the social health activist or midwife. We found both of them willing to use the software and the feedback is encouraging. Using mHEALTH-PHC, the midwife could view the previous data records of the pregnant women. This information helped her to frame accurate questions while talking to a specific pregnant woman on her visit. This made her job more efficient by reducing the interaction time.

Prior to the implementation of mHEALTH-PHC, the midwife could not establish connection to the Center doctor, even in case of emergencies, if the doctor was busy or if the doctor was out of coverage area of the signal. The asynchronous query capability provided by mHEALTH-PHC, and provision of marking the query as "urgent", made the midwife more comfortable and effective. With mHEALTH-PHC, the midwife gets the doctor's response as soon as the doctor is free and attends to her query. During the pilot, Midwifess made more

than 50 queries and the doctors gave advice for all.

As mentioned earlier, IVR based interface for social health activist made her task much simpler. It has reduced the paper work as well as the time spent per visit as she just has to select the items from the master list to make the visit report. With social health activist's suggestions, the interface now provides all comprehensive lists. They also requested that the menu of their interface be modified such that they could record additional relevant information for the patient.

Feedback on Adoption

A couple of weeks after midwives were trained to use mHEALTH-PHC, it was found that midwives were using their application less frequently. The main reasons given were issues relating to the usability of the application:

- a) A midwife would enter the data of the patient, but there was no feature to retrieve and check the data on their mobile phones. This made it difficult for them to check what they have entered.



Fig. 4. Midwife interface with screen in English and local language (Marathi).

- b) To ask the question using voice interface, around 6-7 clicks were needed in the menu to reach "ask question".
- c) There was a mismatch between a small number of terms and acronyms used in the software and that used by a midwife. For example, Sub-centre was termed as Sub Primary Health Center (SPHC) in the software, and so on.

The above adoption issues and challenges were solved through extensive collaboration with midwives. A new call flow to their satisfaction was finalized, where the midwife can access the desired

functionality in less than 3 clicks. For data entry, a drop down list was provided for easy and efficient functioning. With the growing field experience and feedback received, suitable changes and improvements to the applications are being made. It is an evolving process.

Significant Observations for Scalability

Expert researchers in the field recommend that government support is critical for sustainability of m-Health projects [5]. Our observation fully supports this view. The following are significant observations for supporting scalability:

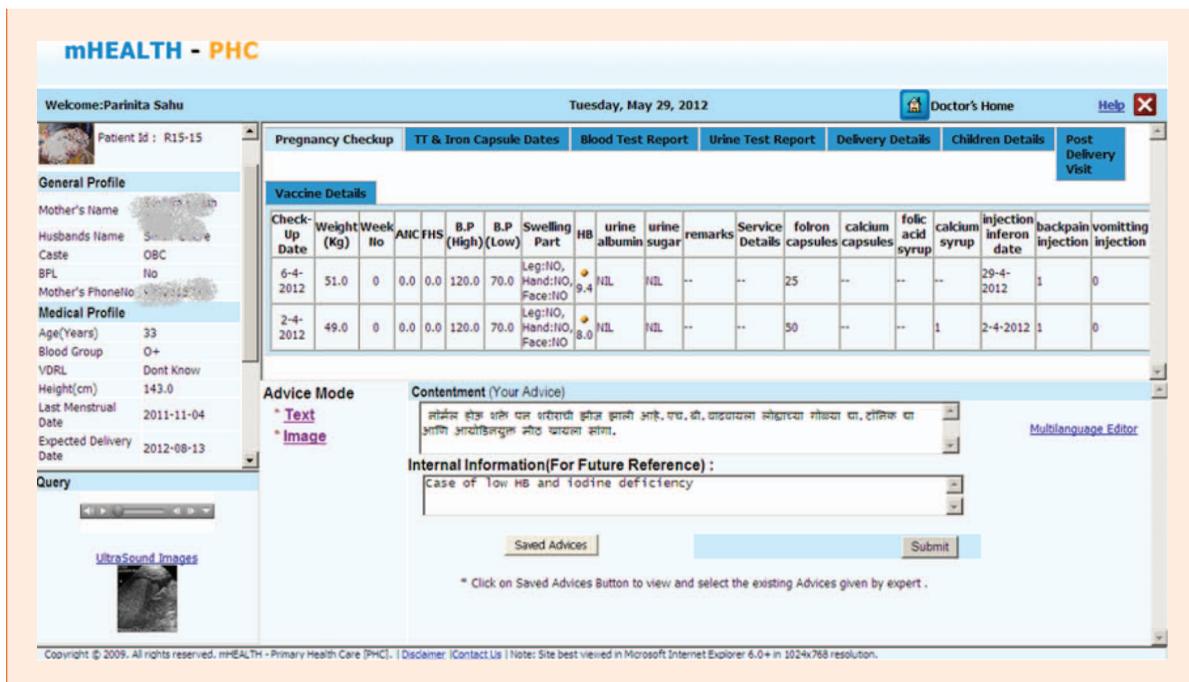


Fig. 5. Screen shot of doctor's console.

- a) The key driver for application usage and adoption by health workers is using incentive-based remuneration in addition to the existing payment structure;
- b) Charges for mobile usage, voice or data is not seen as a barrier compared to the travel expenses;
- c) A health worker will be comfortable using the new technology, only if it does not burden him/her and is easy to handle;
- d) The usability framework for both mobile and web-based applications is suitable for all key persons using mHEALTH-PHC;
- e) Community and private participation is essential along with the government; and
- f) Analysis using the reporting application instantly gives a perspective of the prevailing conditions in the field. This feature of the tool is well appreciated by the planning and a decision making authority, as it holds tremendous potential in preventive healthcare.

mHEALTH-PHC: Vision for the Future

In the future, mHEALTH-PHC will evolve according to the requirements of the community and stakeholder needs. We see a role for advanced technologies to meet those needs. For scaling up of the system and to capture social health activist's voice reports into text, speech recognition technology can be incorporated for automatic conversion from speech into text. Similarly, for converting doctor's handwritten prescription into text, one may need to use handwritten script recognition. It will be useful to design an expert system module which captures experts' diagnostic knowledge from past medical history of tens of thousands of patients.

The Government and National Rural Health Mission will eventually require functionality to assess

the quality of healthcare and performance of primary health centers and sub centers. After the improved quality of primary health care for the community in the current village is demonstrated, the same model would be expanded on a sustainable basis to cover a large number of villages. In doing so, Public Private Partnership arrangements could play an important role.

To achieve sustainability, the beneficiaries could pay and services be compensated according to the value added. The business model would require several functionalities in mHEALTH-PHC, related to procurement, payment, audit, and quality management, which can be provided by connecting the tool with existing hospital management systems. The tool could also be useful to implement the legal and policy framework of the government for primary healthcare in the country, once it is adopted by the government.

Author Information

N. Bondale is with the School of Tech. and Comp. Science, Tata Inst. of Fundamental Research, Mumbai, India; email: nandini@tifr.res.in.

S. Kimbahun IS with TCS Innovation Labs, Tata Consultancy Services, Mumbai, India; email: sanjay.kimbahun@tcs.com.

Arun K. Pande is Director, IT Innovation for Masses. Email: drarunkpande@gmail.com.

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