

## **Providing healthcare services in rural India: Innovative application of mobile technology**

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### **Abstract**

*Mobile technology stands out as more robust and sustainable option as compared to PC based telemedicine in remote rural villages in India, with the increasing penetration and rising transmission capabilities of mobile networks. However, the technology becomes a powerful transformational tool if it is applied as an enabler of a synergistic system. This paper describes a healthcare delivery model based on mobile technology as an information transmission tool between rural patients and centrally located providers, using trained intermediaries as local facilitators, entrepreneurs and health activists. A customised handheld device that carries added features like biometric identification of all users, thermal printer, smartcard reader and writer and USB ports for connecting external diagnostic devices, was configured to collect healthcare information. A clinical decision support tool was designed to complement VHCs cognitive abilities to collect comprehensive clinical information and assist local decision making. An efficient use of bandwidth allowed the data to be populated on a web based EMR that could be remotely accessed and served by the doctors. A printer allowed printing of authorised prescriptions, collection receipts and referral notes at the device level. Linking with financial services allowed collection of payments and deliver an innovative micro-insurance scheme. The solution attempted to solve problems of access, affordability and quality of healthcare delivery using system design and technology synergistically. It not only enables symptomatic care but also complements delivery of preventive health services making it extremely useful for contextualised population health interventions with global relevance.*

### **1. Introduction**

Healthcare applications of mobile phones are steadily gaining popularity over last few years [1, 2]. With the increasing penetration of mobile networks in remote rural villages in India, mobile phones are becoming an important tool for enhancing doctor-patient communication [3]. The mobile technology is increasingly enhancing functionalities of handheld devices, smart phones and PDAs, which are potentially replacing the use of PC based alternatives while supporting mobility needs of patients and medical practitioners [4, 5]. With these advantages it is increasingly becoming possible to create innovative applications for developing countries that can shift the paradigm of delivering services and resolve problems plaguing the healthcare systems [6].

With these considerations, this paper presents a novel mobile based handheld device and service architecture for a pilot project implemented in Yavatmal district of central India.

### **2. Background**

In past few decades there has been an increasing recognition of limitations of public healthcare system in India and possible role of private sector in overcoming these limitations to create more equitable and efficient healthcare system that fits within limited public resources [7]. Private sector has already been predominant healthcare provider, especially in rural India covering more than 75% share of services provided in some areas. Extensive analysis of health care financing and delivery in India, has prompted greater role of private sector in achieving national healthcare objectives [8]. However, the concentration of private sector in larger town and cities and its reluctance to penetrate deeper has

been an area for concern [9]. In order to overcome geographical disparities, The Government of India has proactively been promoting telemedicine and use of ICT [10].

In last few years many models of healthcare delivery using tele-medicine kiosks and mobile vans supported by satellite connectivity have evolved, where public private partnership plays a dominant role. Some pilot projects have successfully demonstrated that ICT can facilitate basic healthcare services in remote rural areas [11]. But, there have been a large number of challenges with PC based delivery models.

### **3. Problems with PC based telecare**

The problems of “PC in a kiosk” based telecare is fraught with infrastructure problems like lack of electricity, maintenance issues in heat and dust of tropical climate, moral and ethical issues in providing quality care, knowledge gaps of users, supply of medicines and other healthcare products to the last mile and unproven clinical efficacy [12]. The models driven by private service providers (either independently or in public-private partnership) have been limited in their impact by overarching issues of acceptability, affordability and financial feasibility [13]. The predominant focus so far has been on symptomatic reactive care whereas ignoring the need of preventive care in resource poor settings. Moreover, there is little support for cognitive limitations of users at grassroots level, who operate in variable local healthcare infrastructure and are limited in abilities for local data management [14]. Lack of definitive user identification and transparency of business transactions especially in “fee for service” models make it difficult to run a sustainable program that could build trust and make communities self-reliant. Despite success of small pilot projects, linguistic, cultural and geographical spread of diverse population has made scaling up difficult.

Furthermore, in a country where 42% of the population lives below poverty line [15], it is not sufficient just to make services available for a cost, but also needs to invoke active community participation to reduce the burden of preventable problems. The implementation of such projects also needs to be infused with sense of service and incentives to work with marginalized groups. Empowerment of grassroots intermediaries to involve their communities has been identified as the key factor that fosters local ownership in the backdrop of availability of culturally appropriate content and services that respond to needs of the poor [16].

### **4. M-health applications**

To address some of the challenges addressed above, a wide variety of applications based on mobile phone technology have been developed and implemented. The rapid growth in mobile industry has fuelled innovations in m-health, equally for the developing world. India is one of the fastest growing markets where more than 100,000 new connections are being sold every day, moreover, Govt. of India has made compulsory for connectivity providers to setup towers in rural areas.

The advantages of mobile phone in this context are that it can not only perform almost all basic functions of a PC, in addition it is rugged, easy to charge (e.g. 3 hours of charging lasts for day which is useful in limited power supply conditions) and it circumvents requirements of broadband connectivity as GPRS has become ubiquitous. Surprisingly, literacy does not seem to be a barrier in use of mobile phones. Even semiliterate people in villages are now becoming expert mobile users and innovations have diffused into m-commerce, m-health, m-learning and m-governance projects across the developing world [17]. Kaplan in his review of literature observes that user friendliness and low start up cost make m-health an interesting option in developing world if we can customize the application to fit into the complexities of local healthcare delivery networks and work out appropriate financial models [18].

### **5. Proposed solution**

To address the above mentioned issues, a simple to use yet comprehensive solution architecture based on mobile phone technology was developed by the author on behalf of a private hospital network, as a part of its corporate social responsibility. The intention was to apply a systems approach and not just offer a new gadget. The objectives were to address the healthcare issues in integrated fashion. Appropriate system design was desirable in order to integrate or retrofit with ongoing public and private initiatives, making it financially feasible, locally affordable and sustainable. To be effective the system had to be easily usable by a semi literate person, enable 2-way, comprehensive clinical information transfer which was valid and useful for clinical decision making. At the same time it should accrue minimal data usage – to keep the speed of communication high and the cost low.

To address these objectives a 4 pillar intervention model was designed namely:

1. Developing local human resource: Shortage of doctors, nurses and other qualified staff in India and their reluctance to work in remote locations makes it difficult to operate a delivery system based on presence of qualified staff on ground. Therefore, a suitable local candidate was selected (on the basis of predefined criteria) to become the local anchor point and liaison between rural patient and city based providers. This person was called a Village Health Champion, who was willing to invest into technology as a local entrepreneur and develop it as her source of livelihood with the support of larger healthcare delivery network. We consciously deviated from salaried multipurpose health worker model as it has been observed to be ineffective in sustaining the motivation and quality of services in the past [19].
2. Develop supply chain to the last mile: Merely a remote consultation would not be enough if the logistics of performing diagnostic tests, supply of medication and conducting indicated procedures within local resources was not possible. We had to align multiple partnerships with local healthcare providers (accrediting them according to the quality) and rural business agencies (for FMCG and agricultural goods) that could enable transfer of consumables and drugs along with other products already reaching the last mile. The intention was to leverage existing systems instead of creating new ones.
3. Create a community based micro-insurance model: Affordability being major impediment to access, we wanted to create a financial model that could offer basic primary healthcare services either cashless or with minimal co-payment [20]. Sustainability would be determined by low premium, high volume of enrolment, using informed VHC as a gatekeeper, focussing on prevention and local management of minor ailments by use of traditional alternative medicines and pre-negotiated fee with local private providers.
4. Technology model was then designed to enable the above three modules leveraging on existing mobile phone network. The model attempts to address a wider approach to technology application within a strong theoretical framework to support design and usage of information technology as suggested by Venkatesh et.al. [21].

Some of the important features of the model are discussed in the following sections.

### **5.1. Mediated interaction between remote doctor and patient**

We chose intermediary to mediate healthcare delivery as opposed to direct mobile connectivity between providers and consumers (as in other m-health models) given the contextual determinants in rural Indian scenario. Not only would the consumers face wide knowledge and language disparity in remote consultations but also the doctor has no method to cross validate his/her assumptions while dealing with challenged communication. The acceptability of an unseen provider is difficult to establish in rural mindset. An intermediary could not only be trained to use next level of technological competency and harness its full power, but also facilitate (and translate) interaction between provider and patient. Also VHC remains as a trusted physical point of reference in case any difficulty or connectivity issue is experienced. She can validate, test, dispense, collect payments, follow up and comply with other instructions of the doctor at local level. In other words a well trained VHC becomes hand and eyes of remote doctor at grassroots level, in a supervised apprenticeship model.

VHCs performance mapping (MIS), training need assessment, incentive calculation and other human resource development tools are centrally monitored for optimizing their performance in the long run.

### **5.2. Web based EMR and optimizing doctor's time**

The mobile clinicians are usually busy in multiple tasks and hence difficult to make them stationary at telemedicine centre at hub level. The web based nature of system uploads data from handheld device into a web based EMR, which can be accessed by the doctor anytime, anywhere based on his/her convenience. Therefore multiple providers can allocate their time in staggered manner and securely log in to start serving posted cases using their computers/PDAs and mobile phones. Theoretically they could be anywhere in the world. At the same time peer to peer referrals and access to common records becomes possible. At the time of referral, the admitting physician can log in to see the entire history and previous notes to arrive at faster conclusions.

The access to previous test reports and images further reduces the investigation duplication cost (and time). In future evidence based guidelines suited to local contexts could be linked in order to enhance quality of services and adherence to best practices.



**Figure 1 – Handheld M-health device**

### 5.3. Customised handheld device

A commercially available handheld device which is concurrently used for micro-finance applications in rural India was chosen as it fitted most closely with the system design requirements. The device was then custom programmed for healthcare applications. The touch screen display enabled semi-literate users to use it in local languages and also enabled graphical displays instead of a standard alphanumeric mobile keypad. The biometric device helped in establishing patient ID and GPS verified the location from where the transmission was made. These two features were essential to control privacy, prevent fraud and ensured reliability of field data.

The thermal printer could print prescriptions, cash receipts and referral slips. USB ports enabled interfacing digital camera for including lesion photos in addition to an integrated vital signs measuring device as shown in figure 1. The device can measure ECG, temperature, BP, SPO<sub>2</sub>, and has a digital stethoscope enabling remote auscultations.

The smart card would be carried by the health champion that has relevant health information, thumb impressions, photos and other clinical data coded for its enrolled customer base. Distributing smart cards to the entire population base was considered both expensive as well as wastage because they are not used to carrying cards in traditional attire without pockets.

The speakerphone and audio interface allowed the remote physician and the patient (facilitated by health champion) to simultaneously engage in information exchange, as and when a remote consultation was in progress, giving it a feeling of being live and establishing doctor patient bonding. This was also considered important to make health champion feel a part of the team because it would minimize the likelihood of her resigning from the system and establish herself as an independent practitioner once trained well. In current public sector scenario in India, many multipurpose health workers have established independent rural practices as quacks.

### 5.4. Clinical Decision Support System

Acknowledging limited cognitive abilities of Village Health Champions (VHC) and relatively difficult technical nature of healthcare information collection, a decision support system was designed to assist the VHC. On registering and entering main presenting complaint, the device prompts healthcare worker in simple sentences in local language to ask next question/s and enter the answers using key pads. The branching tree logic prompts a series of questions that end in one of the 3 executable actions for the VHC. She is prompted to either dispense one of the over-the-counter medicines, that she carries in her first aid kit (or take a picture of lesion or do a simple procedure like BP measurement or pregnancy testing etc.) or transfers immediately if person is seriously ill (or if one of the flagged signs is registered) or is prompted to call the doctor for a tele-consult. This triaging prevents unnecessary burden of seasonal locally manageable conditions being referred to the doctor or over referrals to the hospital. At the same time it keeps a sentinel

watch on the criticality of conditions that can be flagged for immediate ambulance call. It can be upgraded to enable reporting and monitoring of epidemics and notifiable conditions in future.

### **5.5. Minimising use of bandwidth:**

The volume of data generated by the images and clinical descriptions could be large enough to take longer than expected time to transmit information and receive appropriate feedback from remote end. This could be especially problematic if the signal strength was weak. Therefore some of strategies adopted were:

1. Transmitting ID confirmation instead of thumb impressions – the user’s identity would be compared by comparing thumb impression image presenting on biometric device and ID linked image stored on the smart card of the VHC. Not only one-to-one confirmation is fast (as compared to one-to-many) but the information transmitted over GPRS would just be “ID confirmed” and not the actual bulky image.
2. Local triaging - for routine ailments (e.g. flu, headaches etc.) and emergency decisions (e.g. chest pain) the decision is made locally at the device level itself, so that emergencies are not held up waiting for remote end to respond. CDSS enabled this feature where a flagged entry would prompt VHC. Only relatively cold and complex problems are posted for clinician’s tele-consult, optimizing their skill utilization.
3. Transmitting coded data – the codes generated by CDSS as a particular branching pattern is followed (cough-> blood in sputum-> low grade fever and so on so forth) are transmitted over GPRS and reconstructed into clinical terminologies at the remote end EHR. Similarly raw signals from peripherals (e.g. ECG, SPO2) are transmitted to be analysed at remote end and reproduced for the clinician in desired output format.

### **5.6. Linking it with m-finance**

The VHC maintains a running account with central administration hub. Every time she collects money and issues receipt, the transaction is logged and her account is debited. The payee and payer both have to log their identities. This makes possible to collect fee for service, sale of healthcare items/drugs, insurance premium payments etc. Direct links to m-banking in future could enable EFTPOS like services for rural consumer. This feature becomes especially important in private healthcare delivery system whose feasibility and sustainability would depend upon low volume high frequency transactions across multiple geographical service points in absence of distributed banking system.

### **5.7. Enabling preventive healthcare**

The VHC has two streams of work flow assigned to her. One is “demand based services” which are described above, where a person comes to her with some complaints and she helps them receive best possible evidence based care. On the other hand she has another set of “protocol based services” where after finishing her OPD hours she has to make house calls (to families enrolled in the scheme) in order to carry out listed tasks, that are automatically generated for her on a daily basis. These tasks may include antenatal and neonatal health checks, weekly/monthly monitoring and drug distribution for chronic cases, post hospitalization follow ups, motivational counselling for tobacco users, reporting of domestic violence to community leaders, basic mental health services, targeted reminders for policy renewals, camps and immunization services scheduled on particular days, and so on. For each of these tasks she has to collect user ID, fill in the designated questionnaire and complete the tasks as prompted. The data would automatically populate web based EMR.

## **6. Future works**

The automation of the system guides the VHC into gradually more and more complex and demanding tasks as per her capacity without creating cognitive overburden, facilitates skill enhancement and team spirit. The constant learning, feedback from doctors and refinement of various field activities prompts revisions on an ongoing basis. As the technology develops, and VHCs acquire skills, in future it would be possible to link other POC (point of care) testing devices through USB port which may include USG imaging and lab on chip technology to integrate with service offerings.

In future the micro-insurance and financial services could overlap with other m-banking solutions and enabling complex services like health savings account. The government of India in launching insurance services that offer high-end

tertiary care cover for poor patients. This scheme is intended to seamlessly overlap primary care coverage onto the secondary and tertiary care coverage at no added cost or administrative inconvenience to the user.

The system could also enable public health research and data collection by automating surveys and preventive screening programs. Some basic hygiene measures like water testing kit integration could be made possible that could report to a central quality monitoring agency. Currently there is huge paucity of reliable primary health data in the developing world. This model could become more granular to generate direct evidence and further inform appropriate interventions. Some of the fields could form a regional data repository with surveillance systems to pick up epidemiologically significant data and process automating alerts that could be escalated to appropriate authority.

Technology could be advanced to handle supply chain management of larger quantities of healthcare products, bring transparency into mass distribution of items like bed-nets, vaccines, nutritional supplements and so on so forth. Where each recipient could be identified and entries logged for reporting to funding agencies. The corruption in a blind system can be addressed only by bringing some form of validation tool at grassroots level.

Finally the data from field, hospitals and insurance payouts could be collated to track or contribute to estimation of per capita cost of care and inform policy makers for informed decision making.

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