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The Emergence of Mobile-Supported National Health Information Systems in Developing Countries

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Abstract

A major challenge for national health information systems in developing countries is their scalability and sustainability at the lowest levels where primary health care is delivered. This paper contributes to the discourse on how national health information systems can scale to the lower levels and how mobile technology is supporting the collection, handling and dissemination of data. But can mHealth go beyond the 'hype' and visions it has come to be associated with? Using an action research methodology in a long-term action research project, the usability and then scalability of mobile solutions for large scale national health information systems are studied. In this paper, initial successes and challenges with using m-Health for national public health information systems is reported and discussed.

Keywords:

Mobile, Health, Information system, Nigeria, India

Introduction

Health information systems (HIS) are having a major and ongoing impact on the lives of people in both low and high resource settings. A robust health information system is a basic foundation of public health [1]. The achievement of the health-related Millennium Development Goals (MDGs) will depend upon the effectiveness and efficiency of health systems. HIS remains the backbone for providing information to track progress for improving and strengthening the different health system components and monitoring the MDG goals. On the ground, however, HIS development in developing countries has proven to be difficult due to organizational complexity, fragmentation, lack of coordinated organizational structures (that maintain disparate information systems), unrealistic ambitions, and more generally due to the problem of sustainability. Poor availability and quality of data and a resultant poor knowledge and "culture" of use of information for planning and decision-making characterize HIS in many countries. Importantly, poor physical infrastructure has remained a serious obstacle in ensuring an efficient health information infrastructure in many developing countries.

The world over, both within the domains of research and practice, there is an increasing recognition of the role mobile technology and mobile phones can play in supporting public health systems. There is an emerging field and research domain for the application of mobile technology for health, mHealth. Mobile phones have a particular status across all developing countries. There are 2.2 billion mobile phones in the developing world, compared to 305 million computers and only 11 million hospital beds [2]. Between the end of 2007 and the end of 2008, mobile phone subscriptions increased by approximately 1 billion [3]. Mobile technology comes with the unique potential that it has already become a routine part of most peoples' everyday lives. It is becoming increasingly affordable and accessible, and has the required infrastructure (for example, the network coverage) even in villages to support its easy use and maintenance.

There are over 4 billion mobile phones, 64% of which is in the developing world [4]. The majority of the mobile subscribers are now outside the major cities and wealthiest states. For example in India there are 65 times more mobile connections than Internet connections [4]. This creates opportunities to use mobile phones to capture data at the source, thus removing significant sources of data quality problems usually associated with manual transfer of data between paper reports. In addition the aim is to use mobile phones as a channel for feedback to the community health workers. We explore to what extent this technology can be used for effective data exchange and communication in public health; how mobile phones in general can secure routine health data as well as stimulate better health provision by better communication and training. A major concern is how mobile phones can be coupled to and leverage district health information systems.

In this paper we discuss the emergence of mobile-supported national health information systems in developing countries by describing two ongoing mobile health projects in Nigeria and India. The mobile solution will also be described and discussed.

mHealth Applications

There are numerous mHealth projects in developing settings: the alliance of UN, Rockefeller & Vodafone in Feb 2009 formed after e-Health ideas exchanged in Rockefeller's Bellaio Conference (UN Foundation, m-Health Alliance) [5]; Using Mobile Phones and RapidSMS to Improve Child Nutrition Surveillance in Malawi (UNICEF, Govt. of Malawi and Mo-

bile Development Solutions) [6]; SIMPill – embedded mobile phone chip in medicine bottle to remind patients in South Africa (2007). 90% took TB medicine while earlier only 22%-60% took it; mHealth for Development paper, 2009) [7]; Text-to-Change – Sends HIV awareness messages in Uganda [8]; Cell-Preven. Health workers use mobile phones to send SMS messages with real-time data on symptoms experienced by clinical trial participants, enabling immediate response to adverse symptoms [9]; Frontline-SMS – a bulk SMS solution [10]; OpenRosa [11].

Generally, m-Health projects can be broadly discussed according to: technology, domain area of application, the hierarchical level in the data flow; and data handling processes it is used for.

By technology, m-Health applications can involve SMS (Short Message Service) or 'texting', voice services and other packet data services such as WAP, GPRS, etc. These can be simple typed SMS from any phone; coded SMS texts (following some predefined logic (which gets interpreted at a central server); or SMS-based data transfer from applications (J2ME, Android, etc) installed on the phone. WAP and GPRS have been little used in the settings we are concerned with in this paper for the reason of unreliability (at this time).

By domain, m-Health has been applied to various health areas including maternal and child health, community health volunteering support, immunization, general emergencies, monitoring of patients with illnesses such as HIV/AIDS, supporting the control of diseases such as malaria, etc.

In this study, the focus is on mobile systems feeding routine data from the lowest levels where they are produced such as communities and health facilities, through different levels up to the national trunk. In this scenario, facility/community level datasets are transmitted to upper levels through the state to the country warehouse, with health information defining a whole range of data elements spanning from utilization data, maternal and child health data, mortalities, nutrition and disease surveillance data. In developing countries, the collection of such data has historically proven to be intractable.

Most mHealth applications are in the piloting phase. A community of practice for mHealth is still being developed and mHealth standards are yet to be developed. This paper thus reports on a significant phenomenon, the emergence and early institutionalization of mobile systems for routine data collection, with data flowing from the lowest levels to the national level.

Materials and Methods

Our research approach is action-oriented and interpretative and characterized as a 'network of action' methodology. The network of action approach is based on the principle of creating learning and innovation through multiple sites of action and use, and sharing these experiences vertically and horizontally in the network [12, 13]. It is premised on collective action where connected research units are able to share experiences and learning. The cases presented here are derived from units (or nodes) within the Health Information System Programme (HISP) network of action. The authors are actively engaged in these units (HISP-Nigeria and HISP-India) which are, with their respective partners, the principal development partners for this system in their respective countries. The pilot in India started in February 2009 and is ongoing. While that in Nigeria started in July 2009 and is ongoing. However, these pilots are converting into full-blown deployments and installations as the rate of adoption has been tremendous. Data sources for this study have been primary and secondary. Primary sources have included notes from participant observations, performing training, and formal interviews with health workers at different levels as well as administrative and technical personnel. The authors have also been involved in the iterative development of the solution. Secondary sources included formal reports from the projects highlighted.

Cases

Here two cases are presented which are significant by virtue of being based in the national system of two very populous and complex countries in Africa and Asia – Nigeria and India respectively.

The Nigerian Case

With a population of over 148 million people [14], Nigeria is the largest country in Africa and accounts for about half of West Africa's population [15]. Health service delivery is largely a government function and as in all countries, the establishment of a robust national information system is a priority. Though the HMIS framework was articulated (in 1992) and implementation commenced (in 1997) in a number of states, the HMIS is only recently (2003) beginning to be institutionalized [16]. This recent strengthening efforts (mainly donor-led) can be attributed to increased demand to show progress towards attaining the MDGs. Since 2003, a free and open source data warehouse solution, the District Health Information System (DHIS) [17] has been implemented at the national and state levels. However, a recent situational analysis has revealed the very low base from which the HMIS is being developed. Computer equipment is usually either in short supply or poorly maintained where it exists. Power supply is very poor; and transportation through long distances and from hard-to-reach areas is difficult. Data use is almost non-existent at all levels of the system. Reports are submitted late and data quality is poor in the HMIS.

It is in this premise and following from the observation that the mobile networks have greatly improved that this study is set. The application of mobile technology has a huge potential for circumventing the aforementioned challenges and improving data reporting. At the time of independence in 1960, Nigeria had a population of about 45 million people with 18,724 functioning fixed telephone lines - a tele-density ratio of 0.04 telephones per 100 people [18]. At the commencement of mobile telephony in 2001, there were only a few thousand lines available from the operators and services were too expensive for the average Nigerian. By 2002, the number of mobile subscribers stood at 1.5 million and prices fell [19]. By the end of 2004, the GSM operators had recorded well over seven mil-

lion subscribers, which was a real explosion when compared with about half a million working lines from NITEL in 2001 and is now reaching 60% penetration [20]. This shows that Nigerian telecommunication industries experienced rapid growth in terms of usage and subscription. By 2007, there were 34 million telephone lines with 1,670,767 fixed lines and 32,265,827 mobile phones in Nigeria [21].

This study thus set out to explore the possibilities with using mobile phones for communication of data from health facilities as well as at the local government area (LGA) level. A simple form-like data collection tool on mobile phones was developed for transmission of data securely and timely. The pilot was tested in 2 states, Katsina and Yobe in Northern Nigeria. This region is characterized by extremely low levels of health service utilisation, the existence of polio and measles outbreaks, low staffing levels and low skill levels of existing staff, absence of significant technology other than mobile coverage. It involved health workers in 26 busy facilities and 34 local government area Monitoring & Evaluation office thus covering the whole state of the Katsina and parts of Yobe.

Findings

A major finding was that the application was well received. As one of the state resource persons said, "let us not call this a pilot because it is bringing very useful results and is now part of the system". With this rapid adoption at facility, LGA and state levels, came specific interests in the sustainability of the system. Facility workers were concerned that they did not understand the data elements properly. The data elements used in the system were from the national standard for facility but they had not been properly trained on it. The implementers therefore had to do training on the data collection and what the elements mean. The LGA officers were particularly interested in an increase in the datasets collected particularly the addition of the full complement of disease surveillance reports. The state level officers were more concerned about the ability of the tool to strengthen the LGAs. As one expressed, "I am sure you have tested it elsewhere. Let us think of how to improve it and include other relevant data elements that the LGAs also need very much". Thus, the rapid adoption and acceptance of the mobile system led to an early discussion by stakeholders at different levels to improve it. These improvements have occurred at a rapid pace when compared to the DHIS computer-based installations. This is attributed to the fact that the mobile application is seen by many users (network effect) and its ease of use has allowed the health workers to be more engaged in data capture.

The Indian Case

India has more diversity within its border than any other country and its population of 1.1 billon people lives and work in very different circumstances and geographies. The mobile penetration is 30% and is the fastest growing market in the world.

The Society for Health Information System (HISP India) [22] which has more than 10 years experience of working with health information systems in India, and are developing and implementing the District Health Information System (DHIS) software for health management that is currently being deployed in almost all states in India to support sub district data registration and analysis activities, and is integrated with the national database through the Ministry of Health web portal. The DHIS deals with aggregated (non-patient) data collection and analysis in an integrated manner across health programs, including important monitoring of MDG 4 and 5 indicators.

Implementing software solutions at the lower levels of the Indian health system is a huge undertaking due to its enormous scale in terms of the vast number of installations, system maintenance and training activities. A mobile solution to strengthen the work of community health workers need to be coordinated and supported by backbone systems e.g. to produce the mobile collection forms, to store, process and report the data collected by mobile phones, and generate work schedules and feedback reports back to the mobile clients. The strategy was to install such a backbone system at the Block PHC level as lower levels is hard to computerize, and link the transmission of data from the mobile (such as through a SMS) to this backbone.

A pilot project was initiated by National Health System Resource Centre in India in collaboration with HISP India. Health workers in facilities at the lowest level were provided with a tool to report routine data to the district and state level through the DHIS. The mobile application for sub-centre reporting was piloted in 5 states: Kerala, Rajasthan, Gujarat, Himachal Pradesh and Nagaland. 189 health workers were given mobiles for reporting.

Findings

After 6 months the results are very promising. Data is reported and 100% said they prefer this way of reporting as it saves time – they do not need to travel to report – and it is more efficient. The role of social networks has a appeared in several ways as one users supports the other. Introducing mobile phones among health workers have changed the communication patterns and seems to go beyond what used to be hierarchical borders. For instance, an HMIS manager now could contact directly the health worker and vice versa. Earlier he/she had to send a written request to the PHC to get them to contact the health worker, for instance, to invite for a meeting. The work related communication increased and 88% said they had called other health officers for help and 85 % said they had contacted doctors for medical help in case of emergency. Introducing mobiles into public health is not only about introducing a tool for data capturing but it seems have the potential of changing the way of working and communicating which can have great effect on health provisioning.

The Application

In Nigeria and India, an open source Java-based mobile platform was built on the already existing DHIS-based national health information infrastructure. The solution consisted of a native Java mobile application installed on a mobile phone and a server gateway that plugged into the DHIS data warehouse (See Figure 1 below). In Nigeria, the mobile application was developed based on the existing national HMIS facility forms and implemented at the facility and district levels. In India, it

was based on the national HIS form for (ANM) coordinated by the National Rural Health Mission.

The application was designed to support the health workers in the filling and sending of the reports through the mobile phone. It is based on free and open software development facilitated by a commons-based production network established between developers in the HISP network.

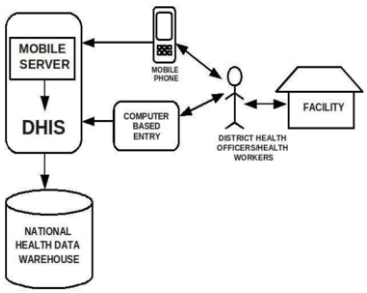

Figure 1 - An illustration of the mobile-supported health information infrastructure

The application allows for data entry based on period (e.g. by month) and by (sub-centre or health facility). Data elements collected are those for **antenatal care and pregnancy outcome, mortalities and births, family planning, immunization, nutrition and growth monitoring, community outreach services and facility utilization**. In designing the application, mobile network coverage fluctuations typical of such settings were considered. Data is stored on the phone using basic Record Management Store (RMS) functionality. This allows data to be stored on the phone and forwarded when reception of the mobile network returns. It thus allows for the retrieval of previously filled reports. Technically, it is a J2ME application utilizing only the basic Java functionality (MIDP 2.0 and CLDC 1.1) functionalities and it can be installed on very low end phones.

Discussions

The emergence of mHealth applications and projects is a significant phenomenon – not only because of a fast rate of adoption but also the ability to achieve instant results with data handling. This can be attributed to the relatively small means with which the important issue of the lack of quality data can be addressed. In short, mobile technology provides a fundamental leverage that had been lacking in these settings – a network infrastructure for electronic data transmission. This, combined with the ease of use of mobiles compared to computers, has allowed many applications of mobile technology to emerge. It is important to note that; as this is a relatively new phenomenon, it may be too early to discuss with precision the possible success rates. But it is an important question to ask if these will translate to institutionalized systems for large-scale national systems. We have found that this is the case - mobile phones have been adopted for the day-to-day work of data handling in cases of Nigeria and India.

In leveraging the mobile technology and infrastructure, there are inter-related challenges that have been encountered. We discuss these as use-oriented, technical and sociopolitical.

The introduction of mobile phones among health workers has changed their communication patterns and has led to a challenge of the hierarchical borders and bureaucratic protocols often associated with public work routines. Health workers can be contacted directly by the state bypassing levels in the data flow but allowing for rapid exchange of information.

In addition, mobile health solutions for national health data systems suffer from being coupled to an underlying installed base. This can have consequences if such underlying base is problematic and poorly functioning. It was seen that the introduction of the mobile solution made existing problems with the underlying system more transparent and addressed. This happened in the Nigerian case where the national reports were not well known due to lack of forms and the lack of competence to use them. The phone thus provided a 'window' into the operation of the system and allowed quick corrections to be made. In both countries, the mobile application was found to be an effective tool for training the health workers on the meaning of the data elements.

Planning and involving stakeholders – expectations are difficult to define as requirements were desperately varied. By growing the system gradually, we have found that stakeholders could be involved gradually and more easily. Cost of SMS has been an issue in Nigeria since the prices are much higher in Nigeria than India which has among the lowest prices in the world.

The phones are costly and the question of who shall own the phones arose. The challenge that people could lose them or sell them is there. In India we saw that the phones were very well taken care of and seen as very valuable for them individually. In a case where a phone was stolen, the health worker was able to negotiate the phone back with help from the community by paying 500 rupees (5 USD).

The fear of deleting the application as happened in India could be solved by installing the application in mobile chip memory, but we have seen that there are be frequent changes to application so flexibility is more important. As such, an over-the-air (OTA) approach is advised. We observed that only low-level phones are purchased for personal use and it is difficult to leverage robust applications on such. For example, in Nigeria in one of the states piloted, only two of the district health information officer surveyed had a Java-enabled phone. The phones found were mainly cheap Chinese-made phones. This implies that funds are needed to fully utilize the user friendliness of mobile application.

By adopting the 'the low-end phones' approach, the risk of phones being stolen is reduced, more phones could be purchased and scalability thus more easily achieved, especially when compared to deploying relatively expensive personal digital assistants (PDAs) and smart phones. In situations where only few data elements will be collected, where there are low funds or where the number of users is staggering (e.g. in the thousands), pure (typed) SMS solutions such as Frontline-SMS

may be advisable. Such systems may not be advised for forms with many data elements to ensure high levels of data quality. The cost of the phones therefore has been a concern when planning for scaling. There are ongoing negotiations with manufacturers in this regard.

Conclusion

m-Health support for public health systems is being institutionalized in developing countries. The rapid adoption and gradual institutionalization is partly due to the individual acceptance and familiarity with the mobile application as a standard tool for data collection and dissemination. However, beyond the mobile phone as a standalone device there is a systems perspective observing the other components and kinds of infrastructure – such as the paper registers at the facilities, the computers at the district levels, the networks and the servers at the state level, and also the basic infrastructure required to support the mobile phone use (charging facilities, support, network coverage etc). Mobile applications can be sensitively designed and introduced, so as to support the development of an 'integrated mobile supported health information infrastructure' in developing countries.

Future work would explore the incorporation of improved technologies (GPRS and X-forms) as well the role of social networking in supporting mobile-supported networks.

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