

The Hope of Mobile Phones in Indian Rural Healthcare

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Abstract. This research paper evaluated the use of mobile phones by rural community healthcare workers under India's National Rural Health Mission scheme, in particular Accredited Social Health Activists (ASHAs), primarily women whose main role is to aid pregnant women in childbirth. In-depth interviews with ASHAs (13), other rural healthcare workers (14), patients (11) and doctors (18) were conducted using the information and communication technologies for healthcare development model (Chib, 2010; Chib, Lwin, Ang, Lin, & Santoso, 2008). The study revealed that four main benefits of using mobile phones—opportunity production, capabilities enhancement, social enabling and knowledge generation—as well as obstacles to usage, which include economic, technological, socio-cultural and infrastructural barriers, were applicable in the Indian rural healthcare context. The paper provides policy recommendations for developing-country government investment in rural healthcare towards supporting the organic diffusion of mobile phones versus the current Internet focus.

Keywords. mHealth; mobiles; maternal health; ICT; network; India; ASHA.

Introduction

Having a child remains a serious health risk for many of the world's women, with 400 maternal deaths for every 100,000 live births, with 99 percent of deaths occurring in developing countries (WHO, 2008; Mathai, 2005). Consequently, the lifetime risk of death for a woman during pregnancy and delivery in a least-developed country is more than 300 times greater than for a woman living in an industrialized country. Most pregnancy-related deaths and conditions are, however, preventable. According to the United Nations Children's Fund (UNICEF, 2009), approximately four-fifths of maternal deaths could be averted if women had access to essential health-care services. Providing basic medical services, community-based healthcare workers (CHWs) play a critical role in reducing the maternal mortality ratio (Analen, 2007; WHO, 1996). This study focuses on investigating the impact of rural community healthcare workers under India's National Rural Health Mission, known as Accredited Social Health Activists (ASHAs). ASHAs are primarily women, whose main role is to aid pregnant women during childbirth, situated in rural and remote areas where healthcare facilities are often inaccessible, and which even when available, tend to be inadequate.

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1. mHealth

Modern information and communication technologies (ICTs) have the ability to bridge distances and improve access to healthcare information and medical services for people residing in rural areas of developing countries. ICTs, particularly mobile phones, can help patients and healthcare workers overcome institutional barriers by reducing the time spent on travelling to consult medical specialists (Barry, Bower, Norrie, and Reid, 2005; Grigsby, 2008), thereby effectively expanding the pool of available health personnel with relevant expertise (Acharya, Andrews, S. Basu, Khoshnood and Maru, n.d.). ICTs can also aid in earlier diagnosis, and hasten intervention, thus acting as a preventive health tool (Boles et al., 2001). In Indonesia, for instance, mobile phones transmitted vital data of suspected cases from avian flu outbreak in various districts to health officials, which enabled a swift response mechanism from the central medical authorities.

The latest advances in medical information and regular training updates can be delivered to remote rural healthcare workers via ICTs (Chib, 2010; Chib, Lwin, Ang, Hsu and Santoso, 2008; Geissbuhler, Ly, Lovis, and L'Haire, 2003; Ojo, 2006), thereby allowing them to upgrade skills, and mitigating to an extent the issue of the paucity of trained doctors (Chen, Chen, Chen, Guo and Kuo, 2001). Experts, such as urban-based doctors located at a distance, can thus deliver training from afar (Basu, Bhattacharya, Bhowmick, Chakraborty & Sarkar, 2007), instead of incurring the high costs of developing and maintaining learning facilities in distant rural provinces (Barry, Bower, Norrie, and Reid, 2005). Hence, to overcome the problem of scarce medical expertise in rural areas, policy makers are increasingly adopting low-cost ICTs such as mobile phones, often available in even the remotest of regions (Kimaro and Sahay, 2007).

Amongst ICTs, recent reviews have found that the rapidly disseminating technology of mobile phones (MPs) play a critical role in improving rural maternal healthcare and other essential services in developing countries (Noordam, Kuepper, Stekelenburg, and Milen, 2011; Tamrat and Kachnowski, 2011). MPs allow CHWs to access reliable health information, and to contact expert medical personnel, thus allowing for remote diagnosis and training in medical infrastructures with major resource constraints (Chib, 2010). Consequently, there has been a recent surge in the deployment of mHealth initiatives, especially in developing countries (Blaya, Fraser, and Holt, 2010; Olla and Tan, 2008). This paper utilizes a case-study approach to examine the ways in which mobile phones can empower and enable rural health care workers to deliver better healthcare services. However, we aim to counter the techno-optimism encountered in much of the literature by examining the barriers to effectiveness of mHealth projects in addition to the benefits.

2. Conceptual framework

In order to understand the factors influencing the adoption of technology in healthcare, we utilized the ICT for healthcare development (ICT4H) model (refer Figure 1) to illustrate the key benefits, and related barriers, of mobile phones as a healthcare tool (Chib, et al., 2008). This model illustrates four key benefits of ICTs, which can bring about an increase in knowledge and subsequently, healthcare outcomes.

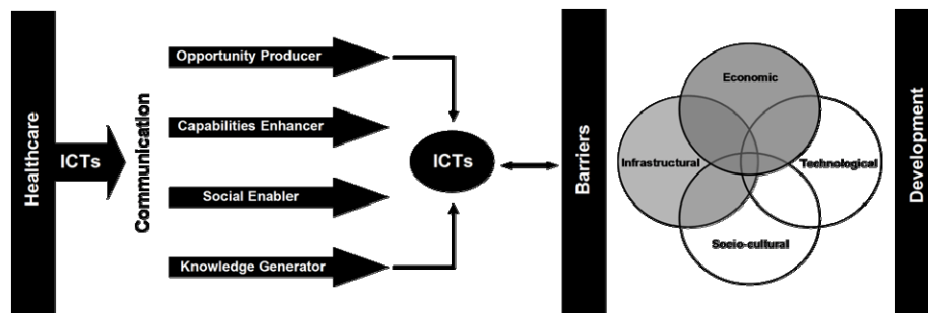


Figure 1. ICT for healthcare development model

2.1 *Opportunity Producer*

Mobile phones improve time efficiency by bridging distance barriers both in improving health service delivery and as a prevention tool, providing earlier diagnosis and intervention (ITU, 2010; Olla and Tan, 2008). Benefits such as increased income and greater time efficiency can result through the creation of opportunities.

2.2 *Capabilities Enhancer*

MPs improve task handling efficiencies, making work more convenient, organized and easily completed. CHWs equipped with MPs were found to be more effective at providing medical data and monitoring trends, leading to improved programme performance (Chib, 2010).

2.3 *Social Enabler*

With ICTs, relationships within the healthcare system are enhanced as better communication expands and enriches exchanges within the social network. MPs facilitate the sharing of information, and importantly, experiences between healthcare workers, doctors and patients (Lee, Chib, and Kim, 2011; Mechael et al, 2010). MPs enable CHWs to easily communicate with their peer group and with the health infrastructure, developing relationships that could be activated in times of need. In addition, MPs, due to their participatory and interactive nature, enhance connection with communities (Mechael, 2005; Kaplan, 2009). Further, healthcare workers are able to obtain better medical information and can pass on the knowledge to the community.

2.4 *Knowledge Generator*

MPs provide CHWs with updated medical information and grant access to professional advice and information, therefore solving issues of inadequate skills as well as the acute shortage of doctors (Pattichis et al, 2006).

In addition to identifying key benefits, the ICT4H model further proposes four types of barriers to the usage of MPs, namely infrastructural, social, technological and economic barriers. Infrastructural problems in many developing countries include power shortages, inadequate cellular coverage, low bandwidth and interoperability standards issues. Lack of adequate human resources in the form of trained personnel has resulted in under-utilized facilities and technophobia (Bagchi, 2009; Hsieh et al, 2001). Socio-cultural barriers such as gender relations, culture, caste and religious issues, inhibit the progress possible due to MP usage (Chib and Chen, 2011; Hafkin and Huyer, 2007; Parmar, Keyson, and deBont, 2007). Technological-informational barriers include low familiarity with advanced technological systems (Chetley, 2006). Economic costs form a barrier to using MPs, including the fixed costs of buying hardware and variable costs in the form of monthly usage fees (Kenny, 2001). This study investigates the effectiveness of mobile phone usage for rural areas of developing countries in terms of the four benefits and the four barriers outlined in the ICT4H model.

3. Methodology

3.1 Research Location

The Indian government is committed towards improving healthcare in rural areas through the nationwide National Rural Health Mission (NRHM), targeted specifically at the poor. However, providing satisfactory health services in rural areas remains a major challenge (DHFW, 2005; NHP, 2003). According to the United Nations (2007), 21% of children across the globe who died below 5 years of age were Indian. The Indian health sector is plagued by a woefully inadequate number of healthcare professionals, the majority of whom are concentrated in urban areas. Critics claim that the existing rural public health system is unreliable and undependable, particularly in emergencies, and is afflicted with poor provider incentives, coupled with low accountability (Bardhan, 2008; Mavalankar, Raman, and Shankar, 2008).

Healthcare initiatives in India allow government officials at the state level to develop local strategies for improvement. While the NRHM covers the entire country, 18 states have been identified as high focus states and receive funding for key components of the mission from the government of India. The infant mortality rate of Uttarakhand state, the study site and a focus state, was 42 per 1,000 births compared to the 2010 National Population Policy goal of 30 (WHO, 2000). “At Agriculture is the primary occupation of the populace of Uttarakhand, with average monthly household income Indian Rupees 2,115 (US\$42)”. A single medical consultation would constitute approximately 3% of a farmer’s monthly income (Bjork, 2005; Sharma, 2006). Delhi, the national capital, the closest location for hospitals with modern facilities, lies 240 kilometres away. Access to medical facilities in the state is hindered by small and scattered habitation, difficult terrain, poor roads and extreme weather conditions. Health services in Uttarakhand are provided through 11 district hospitals, 232 primary health centers (PHCs) and 322 government hospitals.

Given these challenging conditions, village-based CHWs known as Accredited Social Health Activists (ASHAs), translated as “beacons of hope” in Hindi,

form an important link between the community and the public health system (Singh, n.d.). ASHAs, mostly women, are the first port of call for the health-related demands of deprived sections of the population, especially women, children, the elderly, the sick and the disabled (Medical Health and Welfare Department, n.d.). The main responsibilities of ASHAs include “promoting utilization of antenatal and postpartum services, facilitating institutional deliveries, mobilizing children for routine immunization, distributing condoms and oral pills, and promoting healthy behaviour in the communities” (USAID India, 2008).

ASHAs counsel village women on birth preparedness, immunization and contraception, and mobilize the community to access health services (MHWD, n.d.; USAID, 2008). ASHAs are honorary volunteers with a provision for performance-based compensation but work closely with more-qualified CHWs, such as auxiliary nurse midwives (ANMs) and *anganwadi* (courtyard shelter) workers (AWWs) (Lahariya, Khandekar, Prasuna, & Meenakshi, 2007).

3.2 Sampling Design

Qualitative in-depth interviews were conducted, administered in conjunction with consent forms, from 2008-2009. Field observations in the form of short interviews and audio-visual recordings were used as secondary methods to provide supporting evidence for triangulation purposes. A qualitative approach was selected to allow for an in-depth exploration in a rural healthcare setting, particularly since the research team was investigating the dynamic, organic and grounds-up adoption of ICTs.

A mix of convenience sampling and snowball sampling methods were employed due to the absence of a central listing of available hospitals and PHCs. Initial contact and recruitment with ASHAs was made at a public health center (PHC), proximate to the collaborating university, G. B. Pant University of Agriculture and Technology. The geographical combination of cities like Rudrapur and Haldwani and rural farming communities in the district of Udham Singh Nagar aimed to reduce sampling bias. The primary participants were rural CHWs. Out of the 27 CHWs interviewed, 13 were ASHAs. In addition, 18 doctors (DOC), and 11 patients (PAT) were interviewed.

3.3 Data Collection

Our translators, communication students at G. B. Pant University, developed a list of contacts within the Udham Singh Nagar region. Hindi questionnaires were administered by local interviewers from the collaborating university. A separate set of questionnaires was created for each of the three categories of respondents. Each questionnaire consisted of two sections; the first section with generic ICT consumption pattern questions, and the second with questions on their usage of MPs in specific situations encountered at work. The transcripts were analyzed thematically based on codes developed from the benefits and barriers identified before-hand from the ICT4H model. Thus specific quotations were classified into the benefits of opportunity production, capabilities enhancement, social enabling, and knowledge generation, and economic, technological, socio-cultural, and infrastructural barriers. Quotations from

interviewees were included in the report with attribution codes to maintain anonymity of the respondents.

4. Findings

We found evidence that mobile phones provided benefits according to the ICT4H model, yet there were barriers to optimal usage. While ASHAs acknowledged the impact of mobile phone access, motivation to usage was diminished due to significant economic and socio-structural issues.

4.1 Opportunity Producer

Mobile phone usage resulted in greater time efficiency and savings, as opposed to generating income, for CHWs. ASHAs consulted higher medical authorities directly, eliminating the need for them, or their patients, to go to hospitals for minor problems. MPs made multi-tasking possible by enabling the ASHAs to attend to multiple patients while monitoring the existing patient's condition. Productivity improved as a consequence.

We can directly contact the doctors... If we need any information on delivery, vaccinations or injections, we directly talk to ANM on the phone, which saves time and money because we do not need to go to the hospital (CHW15).

Time efficiency resulted from phoning to check on the availability of doctors at PHCs before sending a patient over, as maternity specialists were not available at all times. An ANM stationed at the hospital would provide the doctor's schedule, thus minimizing waiting time and maximizing consultation efficiency.

[ASHAs] come from faraway places. If they don't find doctors at the center, then their whole journey will be a waste (CHW24).

If I have the number of doctors there [PHC], I make a call in advance so that we will find the doctor ready when we reach there (CHW23).

4.2 Capabilities Enhancer

Mobile phones greatly improved communication flows within the healthcare infrastructure, especially during emergencies. While ASHAs were not formally trained to handle pregnancy complications, these interactions helped, especially when the patient was in a critical condition at a remote location.

Sometimes when I face difficulties and problems at work or when I need to request for vaccinations in my medical kit, I contact the ANM... When there is an emergency, we will call the hospital number (CHW19).

The newly-introduced 108 emergency van connected remote ASHAs to advanced medical services with just a call, as CHW19 remarked, “This ambulance service is like a godsend for us.” The usage of MPs among rural patients helped transcend geographic boundaries, as both parties experienced ease of consultation, instant connectivity and on-the-spot feedback and advice, allowing closer monitoring of patients’ health.

If a patient is far away, she can easily contact me at any time, it is easy for them to assist me at night. If somebody wanted to ask about any problems related to medical issues that he is facing, they can ask us directly on the phone. We need not...go to them personally (CHW09).

The use of mobile phones allowed ASHAs to enhance the services offered to the general public, beyond offering advice, to reinforce the health messages and practices in a timely manner.

If we encouraged any family to go for family planning, it is convenient to tell him/her and reinforce that on this particular day, I am coming to you and you should be ready for everything. I also let them know about timings and when to reach (CHW24).

4.3 Social Enabler

The mobile phone acted as the primary communication tool for ASHAs in broadening their social and professional circles. From a professional perspective, one commented on the usefulness of day-to-day planning, claiming that, “My supervisor calls me on my mobile phone and keeps me updated on all information.” Beyond peer communication, the mobile phone also allowed all healthcare workers to direct inquiries up the medical hierarchy, a task they may not have been able to accomplish given their remote locations, and low status within the health infrastructure. A CHW noted that, “It [mobile phone] helps us to connect with ASHAs, ANMs, doctors and patients” (CHW24).

ASHAs were regarded as a valued and trusted source of medical information by patients, with one (PAT 6) noting, “During the whole pregnancy period, I went with the ASHA worker... [She] helps and takes care of us.” Patients from far-flung villages often had to travel several kilometers over difficult terrain to reach the nearest health center. Instead, MPs made ASHAs readily available, and their regular presence in each patient’s pregnancy led to a high level of respect and empowerment.

I would ask the ASHA worker if I face any problem with my pregnancy but not directly to the doctor. I believe the ASHA worker and the information she provides (PAT08).

4.4 Knowledge Generator

Rural healthcare workers rapidly and easily accessed healthcare information via MPs as the phones allowed vertical and horizontal information exchange among healthcare professionals. Health information often flowed upstream within the healthcare system, as CHW 14 noted, “I use the phone to contact my medical seniors and the doctors to get more information... It allows me to solve problems at work.” MPs also enabled the horizontal distribution of information amongst peers. Updates on medical advances were passed through an informal social network, ultimately benefiting patients, as described by a CHW, “If (there are) some new medicines or certain kinds of distributions have to be made... I will utilize this mobile phone (CHW 24).”

In general, MPs provided a channel for an improved flow of information within the healthcare system, generating benefits as theorized. However, all parties needed to access the communication infrastructure and possess relevant know-how in order to reap the benefits.

ICTs [are] just like blood vessels... continuously flowing from heart to toe. If (there is any) breakage, there is no need for ICTs... If I'm using ICTs and he is not[...] then this is not very good. It needs[...] continuous interaction[...and a] proper network (DOC13).

4.5 Challenges

Beyond basic access issues, infrastructural, social, technological and economic barriers to mobile phone adoption existed.

- *Economic Issues*

Most of the CHWs owned mobile phones, although only a handful of these phones were provided by the government. Advanced technologies such as the Internet and healthcare information systems, were, in general, inaccessible to this respondent group of healthcare workers. Consequently, adoption of these technologies was low, with a CHW commenting that, “I did not try to learn [to use the computer and internet] as I do not have these things at my house (CHW23).”

Most CHWs were unwilling to give their numbers to patients, due to the lack of mobile phone subsidies from the government, either for the hardware or for the monthly credit top-ups. Due to the commission-based remuneration system, ASHAs received payment only after referring patients to government hospitals, resulting in an inability to afford expenditure on communication.

Most of the time mine [phone credit] is zero. If someone is earning, then he can afford to spend something. As I am not earning anything, how can I afford to spend [on mobile phone credit]? (CHW06)

- *Infrastructural Issues*

We found evidence contrary to the extant literature that mobile connectivity would be an issue with widespread coverage in rural Uttarakhand. However, Internet accessibility was considered a luxury, as not a single CHW reported usage of either the mobile Internet or public telecenters.

If we have more technological and medical facilities, we are willing to learn. I would like to learn how to use the Internet to help my patient, but right now there isn't such a service (CHW07).

- *Socio-cultural Issues*

Socio-cultural issues comprised both social problems, such as gender inequalities, as well as institutional hierarchies. Firstly, the role of gender was complex; acting as a supporting as well as a hindering factor for mobile usage. ASHAs preferred mobile phone ownership, because the nature of the job required them to be easily located, and their families thought it necessary for their personal safety. CHW 05 commented, "My husband got a mobile phone six months ago; even my kids have mobiles. When I became an ASHA worker, I thought I should have one."

In contrast, there were several factors which challenged the professional activities of female ASHAs. Some family groups could not comprehend why they devoted time in caring for strangers, sacrificing time that could have been invested at home in traditionally-prescribed gender roles. The problem was exacerbated when families found out that the ASHAs paid for the usage of mobile phones personally, despite their unstable incomes. Thus, most ASHAs avoided, or reduced, the use of mobile phones unless absolutely necessary.

If we spend [time] outside the house the whole day, and then in the evening we return with nothing, what would our husbands say? They ask us, if you are not getting anything [income], then why you are going [to work]? (CHW11)

Clearly, the traditional gender roles prescribed within society inhibited women from completely fulfilling their duties as ASHAs. As males migrated to mechanized industries in the region due to rapid industrialization of hitherto rural areas, the predominantly male environment was seen as unsafe for women at certain times and places, particular when combined with existing patriarchal attitudes. Women were seldom seen publicly after nightfall unless accompanied by a male companion. This hindered work efficiency, since medical emergencies could hardly be engineered to occur only during daylight hours. CHW12 said, "Sometimes [my] husband says, 'don't go outside, there're a lot of rape cases.'[...] Basically, there are problems with night shifts [and] dealing with male patients (CHW12)."

Secondly, in addition to gender issues, social barriers in terms of a strict hierarchy existed at the organizational level. As a consequence, ASHAs preferred contacting peers or nursing supervisors rather than doctors for advice. As a CHW (19) claimed, “I contact the ANMs but not the doctors because they do not give us their [phone] numbers.” Working at the margins of the healthcare system, the un-skilled and minimally-trained ASHAs were sometimes seen as outsiders from those within the healthcare institutions, such as doctors. Medical professionals then resorted to questioning the nature and scope of work accomplished by ASHAs.

Medical professionals such as the nurses and doctors do not treat us seriously because they only see us as people who bring patients in for the commission. We just want to be respected (CHW03).

The doctors feel that we are creating trouble here, but it is not our fault as we do not even have the basic knowledge of when a labor is due (CHW08).

It seems that lack of training was a cause of the gaps in CHWs health knowledge and ability to deal with essential medical issues. It should be noted that the doctors and nurses at the hospitals were overwhelmed by the demand for healthcare services, and were a scarce resource themselves. As a consequence, there was little time for this group, or for other resources to be mobilized, to devote towards training ASHAs extensively.

The trainings are not very in-depth. The doctors at the monthly meeting with the CMO will also give us some medical information in a kit. Using whatever information we have at hand, we will have to try to solve the problem/emergency or deliver the baby. This is a no-choice situation (CHW07).

- *Technological Issues*

Most ASHAs experienced initial difficulties when learning to use the mobile phone, including forgetting how to dial the numbers and an inability to differentiate the myriad functions of the phone. Most problems were, however, resolved after frequent usage.

At the beginning, I did not really know how to use the functions of the phone. I did not know how to lock the phone and I ended up calling a lot of people unknowingly and I wasted a lot of money on that. My son taught me how to use the functions and now I know how to operate it (CHW07).

5. Discussion

This study found that adopting a theoretical model, the ICT4H model, had value in determining key enabling and limiting factors in the Indian rural healthcare context. This is particularly important as there is a paucity of theoretically grounded case studies within the discipline. Further, given the increasing salience of the area of mHealth, this study provides an early insight into potential benefits and drawbacks that might be encountered when developing country governments or non-governmental organizations plan for extensive roll-out of ICT programs in the healthcare sector.

From an Indian perspective, the policy framework under the NRHM sought to overcome limited public healthcare facilities by enlisting the support of ASHAs, acting at the margins of the formal healthcare system in far-flung villages. However, critical technological support for ASHAs has primarily come in the form of internet-based initiatives, as part of a community service center (CSC) plan. These centers were an integral component of the 2006-07 National e-Governance Plan (NeGP), wherein the government proposed the setting up of nearly 100,000 CSCs in rural areas nation-wide.

It is evident that penetration of a parallel technology, viz., mobile phones, has far exceeded the public internet access the Indian government had planned for. The relevance of such highly-funded directed ICT interventions (such as public telecenters) in the face of the organic growth and adoption of a user-friendly technology (such as MPs) is a cause for concern. Instead, this study argues in favour of a shift in government investment on ICT for rural health programs from CSC-based services to mobile phone-based services.

The benefits of mobile phone connectivity, as framed by the ICT4H model, are evident, even when extended to remote rural regions. The potential of MPs to deliver effective medical services could be greatly enhanced, beyond basic communication support and education to CHWs, by using advanced applications for monitoring diseases, gathering medical data, and accessing medical databases. Further, the use of MPs would not be limited to diagnostic and prescriptive care, but can extend to preventive methods as well. Further, the intersection of mHealth and mFinance offers a multiplicity of points for improving healthcare management (mHealth Alliance & WEF, 2011).

The practices of mobile phone usage by ASHAs clearly expanded the geographic limitations of health service delivery, formerly a hospital-based practice. Connectivity provided CHWs with access to medical specialists for critical medical advice, allowed them to develop their knowledge-gathering abilities through peer support, and bridged organizational gaps both with immediate supervisors and amongst themselves.

Instant communication access made information and expertise available around-the-clock to CHWs. Patients used their mobile phones for the same purpose; viz. to seek advice from ASHAs and CHWs instead of making a trip to the public health centers. While MP usage did not directly translate into economic benefits for ASHAs, the shifting of time-space boundaries made their work more efficient, translating into economic savings.

It must be noted, however, that the existence of communication between CHWs and doctors, as well as their willingness to communicate, was crucial for effectiveness. Taking a socio-cultural perspective on the ICT4H model suggests that the inherent constraints of the hierarchical medical system and the social environment act as deterrents to effective health outcomes arising from MP adoption. It is important to note that in this case mobile diffusion occurred organically, largely independent of any external intervention. However, the institutional hierarchy, in the form of superior medical professionals, and social norms, for example, controlling families, were observed to limit the possible agency garnered by ASHAs using MPs. Public health officials should take into account socio-cultural and management factors to optimize the potential of mobile communication in healthcare. The emphasis of this study was the implementation core of the healthcare infrastructure, as defined by front-line community healthcare workers. Further research should include government officials, as the decision-making power of these policymakers and funding agencies inordinately influences program implementation.

To counter other barriers found, economic viability can be achieved via hardware handouts or subsidized rates for monthly subscriptions. User friendly and content-relevant innovations such as medical hotlines, dial-in databases, SMS-based monitoring, and health information systems should be considered. While this study focuses on health process outcomes in terms of the usefulness of technology and its everyday use in the job context (such as the effect of MP usage by frontline CHWs on referrals), patient health impact measures (for example, infant health indicators) should be considered in future studies.

Based on such insights, this study argues for greater examination of mobile phone based support for CHWs as part of rural healthcare service delivery. Further, we offer a glimpse into theoretically framed evidence that hopes to inform policy decisions about investments in the use of mobile phones in healthcare of developing countries.

Notes

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References

- [1] B. Acharya, J. Andrews, S. Basu, K. Khoshnood, & D.S. Maru, *Alma Ata in the digital era: Telemedicine for community health workers* (n.d.). Retrieved March 19, 2009, from http://www.nyayahealth.org/Library/AlmaAta_DigitalEra.pdf.
- [2] C.N. Adeya, Mobile telephony and development in Africa: A user's perspective. Paper presented at Wireless Communication and Development: A Global Perspective. University of Southern California, U.S.A. October 2005.
- [3] L.V. Aerschot & N. Rodousakis, The link between socio-economic background and Internet use: Barriers faced by low socio-economic status groups and possible solutions. *The European Journal of Social Science Research* **21**(4) (2005), 317-351.

- [4] C. Analen, Saving mother's lives in rural Indonesia. *Bulletin of the World Health Organisation* **85** (2007), 740-741. Retrieved January 9, 2009, from <http://www.scielosp.org/>.
- [5] R. Anta, S. El-Wahab, & A. Giuffrida, *Mobile health: The potential of mobile telephony to bring health care to the majority*. Innovation Note. New York: Inter-American Development Bank. 2009.
- [6] S. Bagchi, Telemedicine in rural India. *PLoS Medicine* **3(3)** (2006), 297-299.
- [7] P. Bardhan, The state of health services in China and India: A larger context. *Health Affairs* **27** (2008), 933-936.
- [8] N. Barry, D.J. Bower, J. Norrie, & M. Reid, Designing and implementing E-health applications in the UK's National Health Service. *Journal of Health Communications* **10(8)** (2005), 733-750.
- [9] A. Basu, T. Bhattacharya, P.K. Bhowmick, S. Chakraborty, & S. Sarkar, *Shikshak: An intelligent tutoring system authoring tool for rural education*. Paper presented at 2nd IEEE/ACM International Conference on Information and Communication Technologies and Development, Bangalore, India. December, 2007.
- [10] S. Bjork, *The economic burden of diabetes in India: Results from a national survey*. Paper presented at Forum 9, Mumbai, India, 2005.
- [11] H. Blake, Innovation in practice: Mobile phone technology in patient care. *British Journal of Community Nursing* **13(4)** (2008), 160 – 165.
- [12] J.A. Blaya, H.S.F. Fraser, & B. Holt, E-Health technologies show promise in developing countries. *Health Affairs* **29(2)** (2010): 244-51.
- [13] K. Boles, L.L. Hicks, S.T. Hudson, B. Kling, R.W. Madsen, & J.A. Mitchell, et al., Using telemedicine to avoid transfer of rural emergency department patients. *Journal of Rural Health* **17(3)** (2001), 220-228.
- [14] Bridges.org. The SATELLIFE PDA Project. 2003.
- [15] R. Chagares, The health care profile: A health information tracking tool. *Home Health Care Management & Practice* **17(2)** (2005), 88-92.
- [16] C.Y. Chen, H.S. Chen, J.H. Chen, F.R. Guo, & T.S. Kuo, Review of telemedicine projects in Taiwan. *International Journal of Medical Informatics* **61(2)** (2001), 117-129.
- [17] A. Chetley, (Ed.). *Improving health, connecting people: The role of ICTs in healthcare sector of developing countries*. 2006. InfoDev Grant No. 1254, 40. Retrieved from http://www.healthlink.org.uk/PDFs/infodev_frame.pdf.
- [18] A. Chib, The Aceh Besar midwives with mobile phones project: Design and evaluation perspectives using the information and communication technologies for healthcare development model. *Journal of Computer-Mediated Communication* **15(3)** (2010), 500-525.
- [19] A. Chib, & V.H.H. Chen, Midwives with mobiles: A dialectical perspective on gender arising from technology introduction in rural Indonesia *New Media & Society* **12(3)** (2011), 486-501.
- [20] A. Chib, M.O. Lwin, J. Ang, H. Lin, & F. Santoso, Mobiles and midwives: Improving healthcare communications via mobile phones in Aceh Besar, Indonesia. *Asian Journal of Communication* **18(4)** (2008), 348-364.
- [21] A. Chib, M.O. Lwin, & Y. Jung, Adoption of mobile phones to enhance health care: A technology acceptance study of maternal care workers in Indonesia. *Media Asia* **36(4)** (2009), 216-222.
- [22] A. Chib, & A.L.E. Komathi, *Extending the Technology-Community-Management Model to Disaster Recovery in Asia*. In Proceedings of IEEE international conference on Information and Communication Technologies and Development, 2009.
- [23] Department of Health and Family Welfare. *NRHM preamble*, 2005. Retrieved February 1, 2009, from <http://gov.ua.nic.in/health/nrhmpreamble.html>.
- [24] Department of Health and Family Welfare. *Fact Sheet Uttaranchal (Provisional Data)*. 2005-2006 National Family Health Survey (NFHS-3), 2006.

- [25] First Mile First Inch. *Innovation succeeds in delivering improved health care to rural poor*, 2008.
- [26] A. Geissbuhler, O. Ly, C. Lovis, & J. L'Haire, *Telemedicine in Western Africa: Lessons learned from a pilot project in Mali, perspectives and recommendations*. *American Medical Informatics Association Annual Symposium Proceedings*. (2007), 249-253.
- [27] J. Goodman, *Linking mobile phone ownership and use to social capital in rural South Africa and Tanzania*. *The Vodafone Policy Paper Series 2* (2005), 53-65.
- [28] W.J. Grigsby, Telehealth: An assessment of growth and distribution. *Journal of Rural Health* **18** (2002), 348-358.
- [29] N. Hafkin, & S. Huyer, Women and gender in ICT statistics and indicators for development. *The MIT Press* **4(2)** (2007), 25-41.
- [30] R.K.C. Hsieh, N.M. Hjelm, J.C.K. Lee, & J.W. Aldis, Telemedicine in China. *International Journal of Medical Informatics* **61** (2001), 139-146.
- [31] S. Huyer, & S. Mitter, ICTs, globalisation and poverty reduction: gender dimensions of the knowledge society. Part I. Poverty reduction, gender equality and the knowledge society: digital exclusion or digital opportunity? *Gender Advisory Board, UN Commission on Science and Technology for Development (UNCSTD)*, 2003.
- [32] B. Idowu, E. Ogunbodede, & B. Idowu, Information and communication technology in Nigeria: The health sector experience. *Journal of Information Technology Impact* **3(2)** (2003), 69-76.
- [33] A. Iluyemi, C. Fitch, D. Parry, & J. Briggs, *Health information systems for community based health workers: A case for mobile and wireless technologies*. In Cunningham, P. & Cunningham, M. (Eds.) *IST-Africa 2007 Conference Proceedings*. IIMC International Information Management Corporation, 2007.
- [34] International Development Research Centre, *Telemedicine in Nepal: A pilot project*, 2008.
- [35] International Telecommunication Union, *Mobile e-health solutions for developing countries*. 2010. Retrieved December 5, 2010, from www.itu.int/publications.
- [36] Internet World Stats, *India Internet usage stats and telecommunications market report*, .2007.
- [37] R. John, *India nearly doubles mobile phone use in 2006*, 2007. W.A. Kaplan, *Can the ubiquitous power of mobile phones be used to improve health outcomes in developing countries?* *Globalization and Health* **2** (2006), 9.
- [38] C. Kenny, Information and communication technologies and poverty. *TechKnowLogia* **3(4)** (2006).
- [39] H.C. Kimaro, & S. Sahay, An Institutional perspective on the process of decentralization of health information systems: A case study from Tanzania. *Information Technology for Development* **13(4)** (2007), 363-390.
- [40] R. Kuriyan, & K. Toyama, *Review of research on rural PC kiosks*. 2007.
- [41] C. Lahariya, H. Khandekar, J.G. Prasuna, & P.S.K Meenakshi, A critical review of National Rural Health Mission in India. *The Internet Journal of Health* **6(1)** (2007).
- [42] S. Lee, A. Chib, & J.N. Kim, Midwives' Mobile Phone Use and Health Knowledge in Rural Communities. *Journal of Health Communication* **16(9)** (2011), 1006-1023.
- [43] N. Li, & G. Kirkup, Gender and cultural differences in the Internet use: A study of China and the UK. *Computers and Education* **48** (2007), 301-317.
- [44] S. Madon, S. Sahay, & R. Sudan, E-Government policy and health information systems implementation in Andhra Pradesh, India: Need for articulation of linkages between the macro and the micro. *The Information Society* **23(5)** (2007), 327-344.
- [45] K. Malhotra, S. Gardner, & D. Rees, *Evaluation of GPRS enabled secure remote patient monitoring system*. Paper presented at 12th International Conference ASMTA 2005, Wales, U.K.
- [46] M. Mathai, Reviewing maternal deaths and complications to make pregnancy and childbirth safer. *WHO Regional Health Forum* **9(1)** (2005), 27-29.

- [47] K. Matthee, G. Mweemba, A. Pais, M. Rijken, & G. Van Stam, *Bringing Internet connectivity to rural Zambia using a collaborative approach*. Paper presented at 2nd IEEE/ACM International Conference on Information and Communication Technologies and Development, Bangalore, India. December, 2007.
- [48] D. Mavalankar, P. Raman, & M. Shankar, *Achieving Millennium Development Goal 5: is India serious?* Bulletin of the World Health Organization, 2008. Retrieved March 20, 2009, from <http://www.who.int/bulletin/volumes/86/4/07-048454.pdf>.
- [49] P. Mechael, H. Batavia, & N. Kaonga, et al., *Barriers and gaps affecting mhealth in low and middle income countries: Policy white paper*. Center for Global Health and Economic Development Earth Institute, Columbia University, New York. 2010.
- [50] P. Mechael, *Case study for Egypt: Mobile phones for mother and child care*. 2005. Retrieved July 21, 2008, from <http://www.i4donline.net/articles/current-article.asp?articleid=344&typ=Features>.
- [51] Medical Health and Welfare Department *Concepts of NRHM*. (n.d.)
- [52] mHealth Alliance and World Economic Forum. *Amplifying the Impact: Examining the intersection of Mobile Health and Mobile Finance* (2011).
- [53] F. Mirza, & T. Norris, *Opportunities and barriers for mobile health in New Zealand*. *Studies of health technologies and informatics*, **129(1)** (2007), 102-106.
- [54] Mobile and fighting the avian flu in Indonesia. 2007. National Health Programme. 2003. Retrieved February 9, 2009, from <http://www.nihfw.org/ndc-nihfw/html/NationalRuralHealthMission.htm>.
- [55] A.C. Noordam, B.M. Kuepper, J. Stekelenburg & A. Milen, Improvement of maternal health services through the use of mobile phones. *Tropical Medicine and International Health* **16(5)** (2011), 622-6.
- [56] L. Obijiofor, S. Inayatullah, & T. Stevenson, Impact of new information and communication technologies (ICTs) on socioeconomic and educational development of Africa and the Asia-Pacific. *Journal of Futures Studies* **4(2)** (2000), 21-66.
- [57] T. Ojo, Communication Networking: ICTs and health information in Africa. *Information Development* **2(2)** (2006), 94-101.
- [58] P. Olla, & J. Tan, *Designing a m-health framework for conceptualizing mobile health systems*. 2008.
- [59] V. Parmar, D.V. Keyson, & C. deBont, Shaping social beliefs: A community sensitive health information system for rural India. In A. Venkatesh, T. Gonsalves, A. Monk, & K. Buckner. (Eds.), *Home Informatics and Telematics: ICT for the Next Billion* (pp. 133-143). IFIP International Federation for Information Processing, Volume 241. Boston: Springer. 2007.
- [60] C.S. Pattichis, E. Kyriacou, M.S. Pattichis, A. Panayides, & A. Pitsillides, *A review of m-health e-emergency systems*. In Proceedings of the International Special Topic Conference on Information Technology in Biomedicine (ITAB '06), Ioannina, Greece. 2006.
- [61] Reuters. India to be world's No. 3 in mobile phone users. *Express.India.com*. January 21, 2006. Retrieved November 20, 2008 from <http://www.expressindia.com/news/fullstory.php?newsid=61762>
- [62] Z. Sardar, & J.R. Ravetz, *Cyberfutures: Culture and Politics on the Information Superhighway*. London: Pluto Press. 1996.
- [63] D. Sharma, *Farm incomes and costs: Returns from farming*. 2006. Retrieved February 3, 2009, from <http://www.foodpolicy.in/html/incomes/incomes.htm>.
- [64] D. Singh *ASHA: A unit of hope*. (n.d) Retrieved February 9, 2009, from <http://pibhyd.ap.nic.in/ef16070801.pdf>.
- [65] T. Tamrat, & S. Kachnowski, Special delivery: An analysis of mhealth in maternal and newborn health programs and their outcomes around the World. *Maternal and Child Health Journal*, 1-10. 2011.
- [66] United Nations, *The millennium development goals report*. 2007. Retrieved January 9, 2009, from http://www.unicef.org/policyanalysis/files/UNSD_MDG_Report_2007_r10.pdf.

- [67] United Nations Children's Fund, *Where we stand: Maternal and newborn health*. The State of the World's Children, 9–11. 2009.
- [68] USAID India, *Accredited social health activist plus scheme*. 2008. Retrieved January 9, 2009, from http://www.usaid.gov/in/our_work/activities/Health/health_plus.htm.
- [69] E. Wheeler, & P. Winstead-Fry, Rural women's health. In S. Loue, & B. E. Quill. (Eds.), *Handbook of Rural Health* (pp. 135-156). New York: Springer. 2001.
- [70] World Health Organization, Why the mother-baby package. *Mother-baby Package: Implementing Safe Motherhood in Countries*. 1996, 1-14. Retrieved January 9, 2009, from http://www.who.int/making_pregnancy_safer/documents/who_dhe_msm_9411/en/index.html.
- [71] World Health Organization, *National population policy*. 2000. Retrieved November 20, 2008, from http://www.whoindia.org/LinkFiles/Policy_Population-Policy.pdf.
- [72] World Health Organization, *Progress towards MDG 5: Maternal mortality*. World Health Statistics. 2008.
- [73] I. Zorn, Virtual community building for networking among women. In C. Ng, & S. Mitter. (Eds.), *Gender and the digital economy: Perspectives from the developing world*. New Delhi: Sage. 2005. 186-208).