

**The Aceh Besar Midwives with Mobile Phones Program: Design and  
Evaluation Perspectives using the Information and Communication  
Technologies for Healthcare Model**

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## **Introduction**

One of the greatest challenges in public health in developing countries is the ensuring of adequate maternal and infant health care. Health statistics reveal that Indonesia has a poor record in maternal and infant mortality (Author, Lwin, Ang, Lin, & Santoso, 2008; World Health Organization, 2005). An information communication technology for healthcare (ICT4H) intervention, funded by World Vision, United Nations Children's Fund (UNICEF) and United Nations Population Fund (UNFPA), was initiated in the Aceh Besar region by utilizing mobile communications technology to support midwives (MWs) in close proximity and contact with these rural communities. The introduction of ICTs, in this instance, mobile-phones, to basic community health workers (CHWs) in rural areas was to bridge lacunae in their work environment resulting from under-capacitated resources, constrained access to information and delayed responses to emergencies (Ganapathy & Ravindra, 2008; Kanter, Mechael, Lesh, Dhadialla, & Kramers, 2008). The use of mobile phones has been noted in the area of prevention and monitoring for pregnant women, to reduce infant and maternal mortality through treatment, and provide post-natal follow-up healthcare support (Maniam, Chin, & Chenapiah, 2007).

The discipline of mHealth has been gaining ground as mobile device penetration rates grow rapidly, increasingly prompted by plunging hardware and usage costs, as developing world consumers adopt this accessible communication technology (Donner, 2004; Iluyemi, 2007; Kinkade & Verclas, 2008; McConnell, Chathoth, Pardy, Boostrom, Boostrom, Louw, et al., 2008; Mishra & Singh, 2008; United Nations, 2007). Case studies have been recorded in the instances of using Short Message Service (SMS) for HIV/AIDS prevention and control, and for treatment of tuberculosis in South Africa (Atun, 2005); consultation services and dissemination of critical health information in rural communities in India (Bali & Singh, 2007; Bhavnani, Chiu, Janakiram, & Silarszky, 2008); and using Personal Digital Assistants (PDAs) to collect data and teach medical students in Ghana and Uganda respectively (Chetley, 2006).

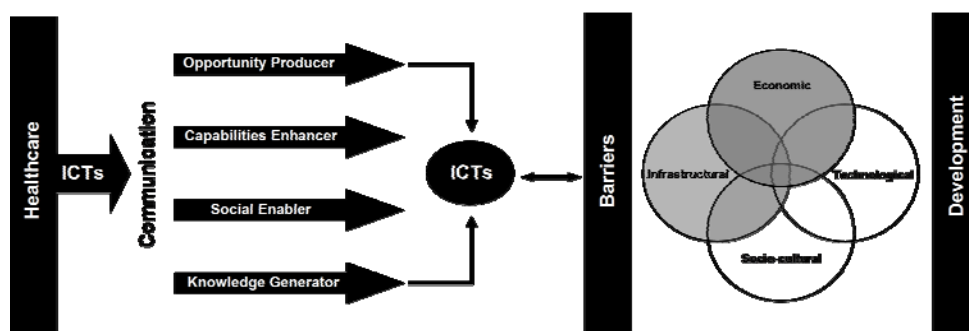
Other benefits recorded of using mobile technologies include access to accurate information in a timely manner (Angelidis, 2008), pre-treatment of primary healthcare problems (Bali & Singh, 2007); improving communication within the complexities of the healthcare system itself (Malkary, 2006), and with the patient community (Harper, 2006); integrating data into a central database in the form of electronic medical records for efficient tracking (Anantraman, Mikkelsen, Khilnani, Kumar, Machiraju, Pentland, et al., 2002; Chetley, 2006); and improving the administrative efficiency of healthcare providers (Baker, 2006).

Despite these benefits, mobile technologies need to be integrated into the broader healthcare and social system, such that they complement existing technologies such as computer- and internet-based technologies, amongst others (Angelidis, 2008; Darby, 2004). In some cases, customized solutions, such

as Java-based applications (Domingo, 2006) and mobile interfaces (Sherwani, Tongia, Rosenfeld, Ali, Memon, Karim, et al., 2007), have been developed to codify specific health information. Indeed, such ground-up innovations have been criticized for failing to incorporate learnings from existing innovations across a scattered community of developers (Alampay, 2006). Training is an important component in adoption, particularly to that segment resistant to adoption and usage, for example, older users such as senior physicians (Fontelo, Liu, Muin, Tolentino, & Ackerman, 2006; Malhotra & Gardner, 2008).

This paper examines the design process of the health communication process within the framework of the ICT-for-healthcare-development model (ICT4HC) (Author, Lwin, Ang, Lin, & Santoso, 2008). I analyze the planned deployment of an ICT4H project that introduced a mobile telephony-based system to a specific group of users, rural midwives, and examine the myriad impacts and constraints that arise. The broad research question I aim to answer pertains to the design and evaluation of mobile phone-based ICT4H projects using a generalizable theoretical frameworks, specifically the ICT4HC model.

Figure 1. ICTs for healthcare development



The ICT4HC model (Author, Lwin, Ang, Lin, & Santoso, 2008), based on the *value-of-ICTs-to-education* model (United Nations Development Programme, 2005), suggests that an ICT, such as mobile phones, can act as a *producer of opportunity*, improving productivity for health professionals; *enhancer of capabilities*, increasing their capacity and potential; *enabler of social ties* by strengthening communication links within the medical hierarchy, and with the patient community, and *generate knowledge* that would allow critical information to be shared and used effectively.

The ICT4HC model addresses the presence of inter-related barriers that could hinder the translation of benefits into sustainable development goals. It suggests that there is no easy one-to-one correspondence of individual benefits to individual barriers, or even amongst themselves. Further, the obstacles of infrastructural, economic, technological, and socio-cultural factors have been repeatedly noted in existing ICT4H studies. For an in-depth examination of the barriers arising in this project, please refer to the study by Author, Lwin, Ang, Lin, and Santoso (2008).

The development paradigm, sometimes characterized as a Western agenda, focuses on economic benefits as a significant component of opportunity made available by ICTs. However, the broader mobile

phone literature suggests that the economic impact in the developing nation has often been negligible; instead the greater opportunity production has come via enabling social ties (Donner, 2008; Richardson, Ramirez, & Haq, 2000).

Henwood (1993) suggests that women need to be producers of technology in addition to becoming adopters, especially since technology production and manipulation have traditionally been appropriated by men (Ling, 1999). Thus, the opportunity to be involved in the bottom-up design of an ICT4D project ensures a level of participation that can also impact the consumption and creation of knowledge (Thas, Ramilo, & Cinco, 2007).

ICT4D projects need to recognize the multiple roles of women, such as family- and community-oriented roles, in addition to their work functions. The social connectedness function of the phone for women, noted by various scholars (Lee & Robbins, 2000; Rakow & Navarro, 1993), should be incorporated into the project design to allow for greater communication within the health infrastructure. Project designers, however, need to be aware that overly emphasizing and reinforcing stereotypical roles such as care-givers may, in fact, be detrimental to realizing a gender-equal society when operating in traditionally patriarchal societies (Alcántara, 2001). The potential of greater mobility offers the ability to pursue opportunities farther afield while maintaining familial relationships from afar (Kopomaa, 2000; Mechael, 2006), but could strengthen the bonds of these responsibilities. Enhancing capabilities in terms of technological familiarity and specialized capacities can also come at the cost of loss of freedom, with the technology being perceived as an “instrument of control” for monitoring and surveillance (Rakow & Navarro, 1993), particularly for women at the lower rungs of social or institutional hierarchies.

Such an analysis needs to be cognizant of constraints within these gender-bound roles in traditional societies, such as the lack of economic decision-making power, and educational opportunities, as well as mobility issues (Ahmed, Islam, Hasan, & Rahman, 2006; Dunn & Dunn, 2006; Hafkin & Taggart, 2001). The economic issues presented by mobile technologies vis-à-vis technologies such as computer access to the internet are less due to the increasingly cost-effective market-driven system. Socio-cultural constraints extend to educational opportunities, and particularly within the realm of technological design, in the lack of technical training provided and lower incidence of English as a spoken language amongst these women (Elnaggar, 2007; Hafkin & Taggart, 2001). Given these barriers, technological design needs to focus, beyond usefulness, on ease of use (Venkatesh & Morris, 2000), and supplemented with training in the use of modern approaches to healthcare (Ganapathy & Ravindran, 2008). The free flow of information has (Mirza & Norris, 2007) raised security concerns about patient privacy, which gets accentuated in conservative societies.

The use of mobile phones in healthcare settings can potentially deliver important benefits, because of their ability to provide and improve access to communication and information resources. This

can occur both within the healthcare system, allowing remote community healthcare workers to communicate with physicians (Maru, Basu, Andrews, Acharya, & Khoshnood, n.d.) with external medical resources, and with beneficiaries, such as patients and their communities (Chandrasekhar & Ghosh, 2001). However, the mediatory role of ICTs depends not merely on access and adoption by the different players in the health system, but on their willingness to communicate across the levels. Organizational resistance from those higher in the hierarchy to participate in information-sharing to remote CHWs has led to limited effectiveness (Kouroubali, 2002). For those with limited or no access to modern technologies, traditional forms of communication in the form of social relationships and 'old' media need to be maintained even within the deployment of a technology project (Geray, 1999).

The organization of this paper explains the design and evaluation of a specific ICT4H project using the ICT4HC model. It begins by detailing the origins of the research project and then describes the research design. The findings are presented in two sections; the first explaining the baseline results and the resultant design aspects, while the second part comprises the evaluation of the effectiveness using a comparison of the endline results versus the baseline, and finally, a discussion of the implications.

### **The World Vision Aceh Besar Midwives Mobile-Phone Project**

In Aceh, a region located at the northern tip of the Sumatran island of Indonesia, the maternal mortality rate and infant mortality remain high relative to other regions in Indonesia (Smidt, 2007). Despite national policies and programmes initiated by the Indonesian government (United Nations Population Fund, 2005), there has not been any significant improvement.

The 2004 tsunami left Aceh Besar, one of the districts in Aceh province, with an enormous humanitarian disaster. This issue worsened with the scarcity of medical, transportation and communication infrastructure due to the protracted decades-long civil unrest (Chalk & Rabasa, 2001; Kell, 1995). With such basic healthcare facilities, JHPIEGO (2005) identified the importance of midwifery services as paramount for rural village healthcare. However, estimates of midwives killed or missing range from nearly 600 by the midwives association, Ikatan Bidan Indonesia (IBI), to 1650 (United Nations, 2005), causing further decline in the standards of maternal health services and newborn care.

World Vision, an international non-governmental organization (NGO), established the Aceh Besar Midwives Mobile-Phone Project in 2005 with the main purpose of improving maternal healthcare in the region. The intention was to utilize mobile communications and technology to facilitate, accelerate, and improve the quality of health services (Author, 2007). The pilot project aimed to provide simple voice communications to reduce maternal and infant mortality by facilitating communication between midwives

and obstetrician-gynaecologists (OBGYNs), as well as develop mobile phones as a reliable, efficient, timely, and cost-effective tool for data collection.

Within the Indonesian context, the health service delivery system is organized at five levels: central, provincial, districts, sub-districts and villages. *Puskesmas*, the primary health centers (PHC) at the sub-district level, deliver primary health care services, and are responsible for delivering neo-natal, delivery, and post-partum healthcare services, particularly for patients with birth complications. For perspective, only a fifth of births occur in some form of healthcare facility, while up to 7% of births take place with professional assistance. The pilot project provided 122 midwives at pre-selected PHC with mobile phones to monitor the impact on the quality of their work, and compared the results versus a similar control group of 101 midwives<sup>2</sup>. Phones were also provided to 15 midwife coordinators (MWCs), and doctors at the hospital. Aside from mobile phones, a technical infrastructure was developed for the health centers, the district hospital, the provincial hospital, the midwife association, as well as the administrative and research staff on the project—providing mobile-phones, computers, and a communication infrastructure, as well as locating a server with the telecom provider for uploading data.

An application provider developed a Java applet for the mobile phones, as well as a database for managing the health information. Health advisors, MWCs and doctors, and partner organizations such as UNICEF and UNFPA would be able to access the system via an internet interface to monitor and predict complicated birth situations, and tracking health statistics in the populations served. Mobile use aimed to facilitate access to time-sensitive information by midwives, improve the quality of information accessible to midwives by connecting with senior staff, create an information sharing system within their networks, and allow tracking and data collection of health related information.

## **Methodology**

Approximately 600 midwives are located in Aceh Besar associated with 22 medical centers. Two types of centers exist: six have recently expanded emergency response capabilities, while the remaining 16 have only basic capabilities. Participating midwives were stratified by their referral centers (PHC) as defined by the partner midwife association, IBI. Darul Imarah; Suka Makmur; Seulimum; Indra Puri; Kuta Malaka; Kahju; Kota Jantho; Lhoknga; Simpang Tiga; Ingin Jaya; Lhoong; Kota Cot Glie; Darul Kamal; Krueng Barona Jaya; Darussalam. The PHC were randomly assigned to one of two groups; those that received a mobile device (test group) and those that did not (control group).

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<sup>2</sup> Under *IRB Approval*: University Of XXX Institutional Review Board reviewed the information submitted pertaining to the proposal and approved under expedited review by designated IRB reviewer -45 CFR 46.110 Category #7.

Both quantitative and qualitative tools were used for eliciting information. The findings rely primarily on a presentation of quantitative results, with qualitative comments used to support the arguments offered.

### *Quantitative Methodology*

As a preliminary assessment, a baseline survey was conducted with 223 participants in November 2006. Follow-up surveys were conducted as a midline in July 2007, with the final endline survey completed in December 2007. The objective of the survey was to track quantitative data relevant to both groups, to assess basic information about demographics, media and ICT usage, knowledge, attitudes and practices of midwifery, technological familiarity, personal efficacy, and sources of knowledge. The survey was developed in collaboration with Dr. N. P. Harahap, a medical consultant (JHPIEGO). Various sources<sup>3</sup> were used to create the survey questionnaire, informed consent form, interview protocol, recruitment script, and survey instructions.

The questionnaire was translated into Bahasa Indonesia and administered by students hired from the local Aceh University. Training workshops for data collection and survey techniques were held for the entire team. Basic knowledge for data management and data entry software was also provided so that individual survey sheets could be entered in MS Excel by the data collectors, which were then collated. Data from 223 MW participants and 15 MWC were gathered in-person by the enumerators.

The quantitative questions in the survey were pre-coded and closed-ended as far as possible. However open-ended questions were re-coded in MS Excel sheets to capture the qualitative aspects of the issue. A five-point Likert scale was used, and data indicating agreement on a particular topic are presented by summing the top two positive responses. For example, agreement on the scale of ranging from strongly disagree, disagree, neutral, agree, and strongly agree, sums the last two responses. Data was treated for errors, double entry's and missing values. Descriptive analysis and tests were carried out on the data collected using SPSS 12.0 for all variables. Conceptual analysis on trends and behavior patterns was conducted in accordance with project objectives to draw out recommendations for current midwife practices in usage of technology and medical capabilities.

### *Qualitative Methodology*

In December 2006 and December 2007, qualitative interviews were conducted with midwives, midwife coordinators and OBGYN, which were recorded on video. Midwife comments are summarized as examples; however, individual names are withheld for reasons of confidentiality. Throughout this

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<sup>3</sup> USAID Population Council, UNICEF and Care rapid knowledge, practices and coverage survey; Reproductive Health Response in Conflict Consortium monitoring and evaluation toolkit; USAID and CORE maternal and newborn standards and indicators compendium.

project, the World Vision research team in Aceh Besar provided logistical support, and specific procedures were followed.

Experienced moderators and interviewers were hired to conduct the focus group discussions (FGDs) and in-depth interviews. Before commencing, they were briefed on the proper procedures of conducting a FGD or an in-depth interview, including the appropriate techniques of asking questions and were handed specific areas to probe. All the FGDs and in-depth interviews were recorded with a digital recorder for transcription and translation after each phase was completed. To ensure accuracy in the transcription of the respondents' answers in FGDs, each session was recorded with a camcorder. At the end of each day, a debrief was held to go through the day's findings. All the respondents involved in the study were each given a food hamper in appreciation of their participation.

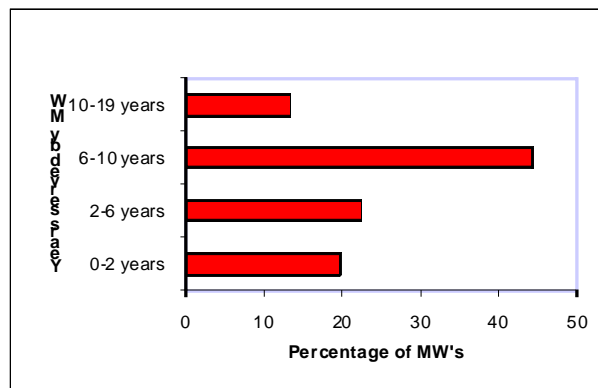
Local transcribers were hired as respondents – such as the midwives, patients and villagers – often used local slang. After the completion of each phase, the audio and video recordings were handed over to local transcribers in Aceh Besar for transcription to ensure accuracy. The transcripts were then translated at a Singapore university by local Indonesian undergraduates, as they had a better command of English and thus ensured the quality of the translated transcripts for analytical purposes.

## Findings

### *Baseline results*

Survey results revealed that the respondents were of a fairly young demographic with the average age being 29 years, while 46 years was the maximum age in the all-female group. One-fifth of the MWs had less than 2 years of experience, indicating that they were recruited after the tsunami, possibly as an immediate response to the loss of personnel and the urgent need for maternal health and trauma care (See Figure 2). The tsunami created a vacuum of essential health safety-nets that the communities relied on, emphasizing the role played by these CHWs; which resulted in rapid recruitment and training by recovery and rehabilitation programs (Vivio & Kinzie, 2005). These participants required a significant amount of training and assistance to be able to perform effectively.

Figure 2. Midwife Experience





In terms of their economic status (quantified on monthly household earnings), the maximum concentration (57.9%) of MW incomes lie in the middle ranges of US\$133- US\$265. Only 13.9% claim a monthly income exceeding US\$265. Clearly, economic barriers (42% agreed that the mobile phones were expensive) would prevent them from optimally utilizing mobile phones unless the device hardware and monthly telecommunication costs were subsidized. The project was designed to fully absorb costs related to acquisition, operation, and maintenance of the mobile phones. To guard against inappropriate usage (45.1% agreed that they used mobile phones a lot for personal calls), and ensure sustainability, the ownership of the phones was awarded to the PHCs, and a monetary ceiling for monthly calls was established. The protocol developed to deal with repetitive excess usage was rarely employed.

#### *Opportunity production*

The younger age group had less midwifery experience, thus the mobile phone facility could potentially have a greater impact, translating into more calls to the senior health staff. T-tests revealed that MWs with more experience were older on the age scale, more confident in solving problems, and having acquired basic health information, were more confident to access alternate sources than their less experienced colleagues (See Table 1). However, for the group as a whole, the key sources of opportunity production were that the mobile phone project would save time for work (92.4%), and provide up-to-date information related to work (91.4). Respondents agreed that the mobile phone would increase productivity (93.2%), and improve the quality of work (95%).

Table 1

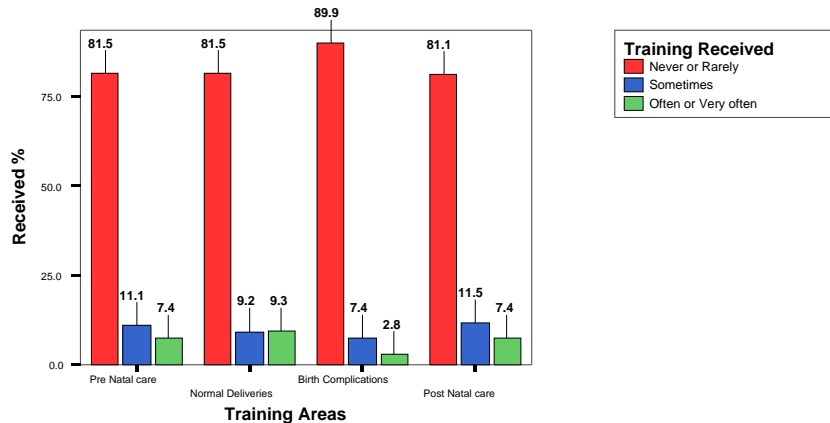
	d.f.	<i>t</i>	<i>p</i>	Mean High Experience	Mean Low Experience
Age	219	4.57	.01	30.71	28.90
Obtained health information from Television	221	2.58	.05	3.46	3.15
Obtained health information from newspapers	219	2.19	.05	3.21	2.94
Confident that they can manage to solve difficult problems if they try hard enough	219	2.44	.05	4.53	4.28

#### *Capabilities enhancement*

Midwives capabilities were measured in terms of job-related capacity and ability to harness technological resources effectively. Midwife training appeared to be sparse in the preceding quarter with less than a tenth having received it often in most areas of healthcare (See Figure 3). This finding supports the reliance on the initial training and subsequent support from their colleagues, with 69.2% accessing health information from people at work, compared to only 43.5% claiming to have done so from their health organizations. Training modules were conducted infrequently at health centers, instead help was provided from colleagues and MW coordinators. 86.1% were confident that they could adequately use

their training to deal with birth complications. However, to what extent the training had been comprehensive is questionable, given the somewhat weak results in the medical information section of the survey.

Figure 3. Frequency of Midwife Training



In terms of personal efficacy, the confidence levels for personal drive to accomplish goals and resolve situations were high (90.2%), yet the handling of unexpected situations (64.6%) and remaining calm when facing difficulties (75.3%) were lower, suggesting the potential of a mobile communication system to aid in likely events requiring medical expertise such as complicated obstetrical procedures.

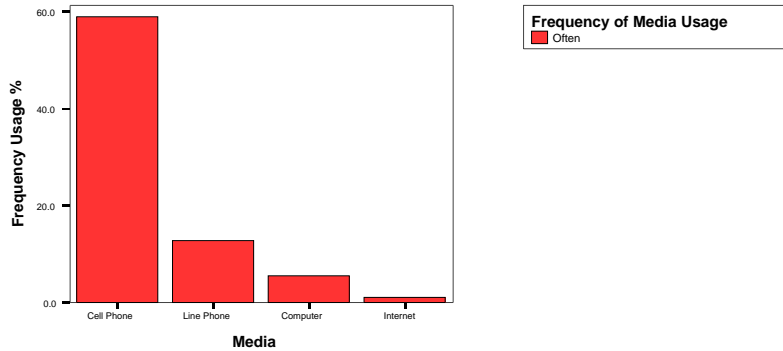
*She (MW) has a lot of confidence now with the cell phone because when she is dealing with a patient with delivery complications, she is able to call the doctor immediately.*

(Respondent: MWC)

Midwives exhibited the capability to use mobile technologies towards beneficial health outcomes, but they required help in using the associated technologies of the computer and the internet. As far as media experience was concerned, most MWs were familiar with the line phone, which, although infrequently used, had an average experience of 8 years, compared to newer technologies such as the mobile phone (2.7 years), and less than 2 years each for the computer and internet, with 81.1% showing little or next to no experience with them. In terms of frequency of media usage, predominantly in use by MWs was the mobile phone. Other mediums of communication such as the line phone, internet or computer, were rarely used (see Figure 4). The rapid adoption of the mobile phone by CHWs who are on the move for a significant portion of the day underlines not only the importance of the technology, but the ease of use as well.

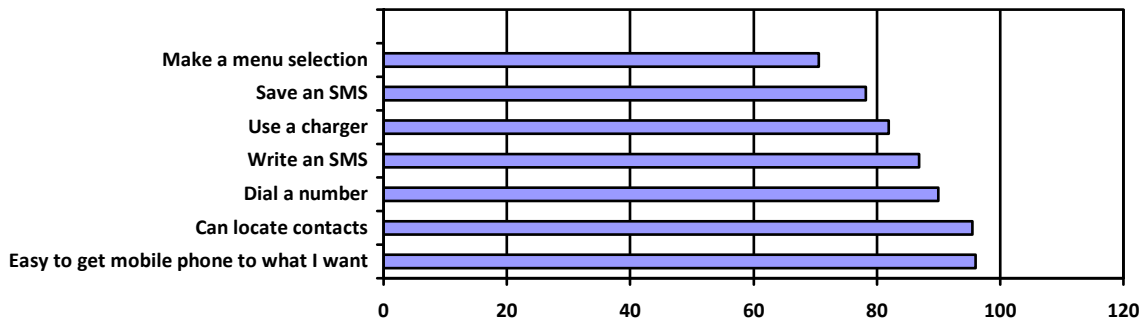
*Midwives did not have any problems using mobile phone but they still have a problem while using the computer to record data and have asked for the appropriate training and minimum computer application skills.* (Respondent: Midwife coordinator)

Figure 4. Frequency of Media Usage



Mobile phone ease of use was a key motivation for the majority (92.4%) of the respondents. Technological familiarity was generally high, with functional basics on making calls and sending SMS's, sufficiently understood (See Figure 4). However, making menu selections on the mobile phone remained an issue, with only 70% exhibiting confidence. This capacity was fundamental to the mobile phone application used for data collection and information disbursement, and therefore training sessions in the proper usage were required..

Figure 5. Technological Familiarity



*Social enabler*

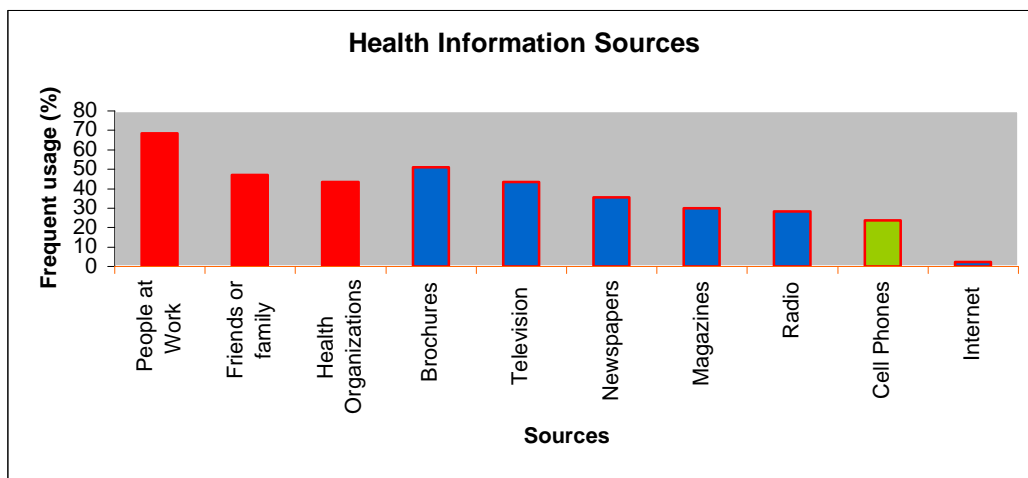
The pilot project aimed to enhance existing social networks to foster greater collective efforts in the community's health care. MW's ability to enlist social resources, such as MWCs (87.9%) and MW colleagues (83.9%), to aid them with work problems was high. The collective ties between the MWs in terms of trust (94.2%) and support for each other' in times of stress (83.4%), are strong.

The MW coordinators (90.2%) were heavily relied on to help in medical situations, compared to OBGYNs or doctors (63.7%), corresponding to the degree of satisfaction with the information gained from them (MWCs, 76.7%; OBGYNs/doctors, 66.6%). Conversely, both MW coordinator (91.9%) and OBGYNs/doctors (88.8%) are seen as fairly equal in terms of the relevancy of information that MW seek

during work. While these results are likely due to the MWs familiarity with coordinators and their relative accessibility, gynecologists and doctors might be unapproachable with regards to the hierarchy within the work structure, despite the advanced advice they provide. The mobile phone project being a more convenient and formal system was expected to catalyze paths of communication across the levels of the health care system in a formal way, making it easier for the village MW to make informed decisions.

Social contacts and written material functioned as the most common modes of obtaining information (See Figure 5), with electronic means of obtaining health information lagging behind considerably. Instead, traditional methods, where accessibility, approachability and trust play a major role in shaping information efficacy (social networks, brochures, newspapers and magazines) of assimilating information continued fervently. Consequently, the project linked old ways of accessing information that MWs trust and are accustomed to, with new technology in information systems that increased the channels of access to this information.

Figure 6. Obtaining Health Information



### *Knowledge generator*

The levels of medical knowledge held by midwives indicates a clear need for improvement. Midwives fared moderately in certain areas of expertise such as family planning; understanding the effectiveness (94.6%), and in explaining methods (71.3%) and side effects (77.6%) to expectant mothers. Their attitudes were positive, agreeing with the ideas that family planning can make possible better education for children (96.9%), giving them greater care and love (98.2%), and disagreeing with myths such as family planning destroying organs (85.7%), and people needing more money to participate in such programs (97.3%). However, MWs responses were weaker in terms of their knowledge of pregnancy related issues. 16% could not identify a single symptom for the first stage of pregnancy, 24.5% opted for only one symptom out of a possible four correct answers. A minority answered completely correct for stages two (20%) and three (33%) of pregnancy.

There is a strong case to be made for promoting mobile phones for accessing health knowledge, as 23.9% already used the mobile phone often for obtaining relevant information (compared with 2.2% for the internet). Over 90% of respondents were confident that they could use the mobile phone to get information about midwifery, 85% agreed that it was relevant and related to their needs, and 70.5% felt that it had influenced the way they sought medical advice.

However, there were issues with credibility within the health system, seen in the low trust in information provided by people at work (14.5%) and health organizations (27.7%). Further, 31% felt that it was difficult to access medical information from the health center using mobile phones. It is revealing that MWs had apprehensions about completely trusting the sources of information available to them professionally, despite often accessing information from these sources.

*We often meet at health center.... with mobile phones from World Vision, village midwives often call me, depending on the amount of patient, sometimes too often, I cannot keep track, mostly regarding patient consultation, some complication issues also.*

(Respondent: MWC)

The health system supporting MWs is often unprepared to deal with the consultation requests. A direct challenge for the project was to establish a standard for the information disbursed via the mobile phones, in the automated information delivery process or in direct consultation with senior staff such as MWCs or the OBGYNs.

## **Endline results**

The findings from a comparison of the quantitative endline survey versus the baseline survey follow. The analysis compares the study group, those midwives with project mobile phones, with a control group, those midwives who were not provided project mobile phones. It should be noted that, with the rapid growth of cellular telephony in developing markets such as Indonesia, the latter group of control midwives was seen to be contaminated. This may have been accentuated by the boom in the local economy following the tsunami by the huge influx of aid agencies providing aid and employment opportunities. Many of those who were not provided with project mobile phones ultimately came to own personal devices, and used them for similar purposes as the study group. Nonetheless, the results are still encouraging, and can be divided into four key benefit areas based on the ICT4HC model.

### *Opportunity production*

The test group that had mobile phones decreased in their usage of line phones ( $p < 0.10$  (0.04),  $M = -45.68$ ). This suggests that the midwives who had mobile phones switched from using the line phone to using the mobile technology for communication purposes.

This test group also found that it was not expensive to use the mobile phone ( $p < 0.10$  (0.03),  $MD = -0.40$ ), and intended to increase their use of the mobile phone ( $p < 0.10$  (0.04),  $MD = -0.39$ ). This was possibly because the mobile phone bills were not borne by the midwives themselves, but by the project donors. Midwives' decision to increase use of the mobile phone could change if the mobile phone bills were to be borne by the midwives. However, the qualitative findings suggest that midwives would continue their usage of mobile phones due to their acceptance of the benefits on their work output.

*Mobile phone helps the village midwife to speak directly about the patient case to the midwife coordinator if she cannot handle it in emergency situation and also midwives are able to call doctors directly to get a reference. (Respondent: MW)*

#### *Capabilities enhancement*

The group that had mobile phones increased in their confidence to solve difficult problems if they tried hard enough ( $p < 0.10$  (0.07),  $MD = 0.21$ ). This suggests that they could be using the mobile phone as a medium to solve difficult problems, for example, by calling someone during a crisis. This is further supported by their response that they were more likely to turn to health center personnel for medical information needed for their work.

*We use the mobile phone to call and ask our colleagues to help when we cannot handle the patient on our own. (Respondent: MW)*

The mobile phone seemed to have an impact on the confidence of midwives with regard to medical facilities, and for storing health data on patients. The group that had mobile phones increased in their confidence that the facilities and equipment provided to them were adequate to deal with birth complications ( $p < 0.10$  (0.09),  $MD = 0.25$ ). This group also increased in their confidence that they could store health data for patients effectively ( $p < 0.10$  (0.09),  $MD = 0.20$ ).

*It's better with data. With data we can observe better. We can observe 1 column, 2 columns. We cannot add numbers while talking on the telephone. If the data come, we can immediately see the significant indicators. (Respondent: Doctor)*

The test group felt that the mobile phone was a well-known resource ( $p < 0.10$  (0.09),  $MD = 0.26$ ). As they got more familiar with using the mobile phone, midwives who were given mobile phones also found it increasingly easy to use the mobile phone in general ( $p < 0.10$  (0.06),  $MD = 0.19$ ). However, technology infrastructure issues remain, with MWs complaining about telecom connectivity. System design was critical in creating applications that would work given the infrastructure constraints. The JAVA application was re-designed from requiring instant connectivity to a store-and-send system, recognizing that MWs might not always be in areas with mobile connectivity.

*Unfortunately it is GPRS, loading time is long, and GPRS reception in villages is bad and sometimes none, sometimes midwives forget to save data, so when reception is up again, the application has nothing to send. (Respondent: MW)*

#### *Social enabler*

The test group with mobile phones were more likely to turn to health center personnel for medical information needed for their work ( $p < 0.10$  (0.09),  $MD = 0.20$ ), and get access to health information from the health center using their mobile phones ( $p < 0.10$  (0.09),  $MD = -0.36$ ).

*Midwives who call me usually consult patient complication during pregnancy, what midwives should do, five to six times per month....They call because they are having difficulty handling a patient.... Relationship between doctors and midwives today are wonderful, we are meant to be partners .... With mobile phones, doctors and midwives are closer, because communication is easier. (Respondent: OBGYN)*

Qualitative findings suggest that MWs access other professional resources, as well as are accessible to their patients.

*Midwives use mobile phone for other kinds of important networking besides those in the project, such as the district head, official persons and are able to discuss with other NGO's. (Respondent: MW)*

*Now is much better, when we need midwives they can come quickly, imagine if they haven't got mobile phones, our house is far, to get to her house takes 20 minutes, waiting for her to arrive is another 20 minutes, that's total of 40 minutes...now it is only 20 minutes. (Respondent: Patient's husband)*

#### *Knowledge generator*

With regard to specific mobile phone functions, the study group found it easier to (i) search for phone numbers in their mobile phone lists ( $p < 0.10$  (0.02),  $MD = 0.27$ ), (ii) get the mobile phone to do what they wanted it to do ( $p < 0.10$  (0.00),  $MD = 0.44$ ). This suggests that the midwives have the capacity to learn new technologies, as they found it increasingly easy to use the different functions of the mobile phone.

Additionally, the group that had mobile phones increased in their trust of obtaining health information from the cinema ( $p < 0.10$  (0.06),  $MD = 0.35$ ) and brochures ( $p < 0.10$  (0.04),  $MD = 0.26$ ). Increasing use of an alternative source of obtaining health information such as mobile phones increased the MW's trust in other sources of health information as well.

*They (MWs) use these forms of information to update and inform themselves with health information relevant for use with their patients. (Respondent: OBGYN)*

Using mobile phones more frequently and obtaining health information from mobile phones could positively affect midwives' readiness to obtain and accept health information from other impersonal sources of information, such as the health center personnel, the cinema and brochures. This project also placed health information brochures in all the participating health centers. This method of information dissemination seems to have yielded positive results. Health information can thus be disseminated through different forms of media without fear that midwives would mistrust the content on the basis of the media form.

The group that had mobile phones increased in their medical question scores ( $p < 0.10$  (0.06),  $MD = 0.41$ ), and Q46 ( $p < 0.10$  (0.01),  $MD = 1.88$ ), for the standard procedures in childbirth process Stage III, and about their opinion about the childbirth process stage respectively. This suggests that mobile phone use does have some impact on the knowledge levels of the midwives.

Unfortunately, the group that had mobile phones also showed a decrease in their medical question score ( $p < 0.10$  (0.03),  $MD = -0.29$ ) for their knowledge of the conditions required for a postpartum mother to be referred to a hospital. This could indicate that more information for this particular condition should be disseminated. More generally, this limited medical knowledge growth suggests that the mobile phones are being under-utilized as a resource for disseminating specific health-related information.

## **Discussion**

Through the course of this project, mobile phones, notwithstanding some issues, have generally proven to be a beneficial means of improving the healthcare system. The project permitted new ways of addressing systemic constraints, by accelerating access to information, reducing response time on critical cases and expanding network's of communication amongst health workers. The findings indicate that the intervention was appropriate for MWs, given the nature of their peer networks, place of work, time-sensitivity of their medical service, medical knowledge insufficiency and lack of training.

Mobile phones not only provided an efficient means of communication, but also improved access to information, particularly in conjunction with the computer-based data delivery system. The ease of communication enabled helped to improve communication and enhance relationships among healthcare workers and with the community. There was also better collaboration within the healthcare system, a stronger referral system and more efficient data collection. However, MWs required to gain confidence in talking to higher levels of the medical system hierarchy. In particular, their hesitancy to contact OBGYNs at the hospitals needs to be addressed with confidence-building measures. Improved access to information using mobile phones helped to increase knowledge among healthcare workers.

The ICT4HC model proved effective as an analytical tool for evaluation. However, it is less practical as a means to aid in design of projects. A better conceptual framework for project managers may



be the Technology-Community-Management (TCM) model (Author & Zhao, forthcoming; Lee & Author, 2008). This proposes that software and hardware dimensions of technology, project management dimensions of finance, legal, and stakeholder issues, in conjunction with community participation in needs assessment, ownership, and training, would lead to greater financial and social sustainability.

The adoption of technology was aided by conducting needs assessment and designing the technology taking to account midwives needs. The JAVA application offered a menu-driven system instead of using a laborious texting system to deliver health indicators. Design issues regarding ease-of-use, however, needed to be balanced with security of the data. Password access to the application was retained when moving from the instant connectivity to the store-and-send system. Newer technologies like the computer-based system handling the data needed to be bolstered with directed training. This not only delivered greater efficiency, but indicated the bottom-up approach of participatory design, by responding to MWs requests to be analyzers of data, rather than mere recorders.

The evidence suggests that the community of health stakeholders have benefited from the introduction of the project. On a macro perspective, the benefits that ICTs bring to the healthcare system should transcend down to ultimately benefit the community. From a technology perspective, but also in terms of medical knowledge, alternatives to the inadequacy of training the midwives need to be made available on a regular basis. Information about medical resources and training available to the midwives should also be disseminated via the mobile phone, and disseminated through more traditional forms of media, for example, regular health updates via SMS on the cell-phones, and incorporation of printed materials such as brochures for distribution to the health centers.

From a management perspective, various stakeholders access to the health data via an internet-based interface needed to be balanced with the quantity of variables required to be collected. Overloading the requirements on MWs in term of data collection could be minimized by utilizing data from existing sources within the health system. However, one needs to recognize that in some cases, such as in the post-conflict situation in Aceh, legacy data may not be available. The lack of reliable mortality records to form a baseline also hinders evaluation efforts.

Financial sustainability is dependent on a viable exit strategy by the implementing agency and donors, with an effective hand-over to the government medical agencies ensuring MWs continue to get the subsidy. Beyond notions of financial sustainability, the social benefit of the program should be incorporated into determining future support levels. The social benefit themselves should include a gender analysis, an issue recommended for further examination (Morgan, Heeks, & Arun, 2004), in addition to the direct impact on maternal and infant health.

By addressing the issues above, ICTs have the potential to help developing countries achieve not only the ultimate goal of improving maternal and infant healthcare but other areas of healthcare as well.

Proceeding with valid conceptual frameworks can aid greatly in the design and evaluation of such programs, as well as increases the chances of success.

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