The Aceh Besar midwives with mobile phones project: Design and evaluation perspectives using the information and communication technologies for healthcare development model

Arul Chib

ArulChib@ntu.edu.sg, Nanyang Technological University

The introduction of information and communication technologies (ICT) such as mobile phones to basic health service providers in rural areas can help bridge lacunae in their work environment, resulting from under-capacitated resources, constrained access to information and delayed interventions. The midwife mobile phone project was implemented in 15 health centres in Aceh Besar, Indonesia involving 223 midwives. The study group (121 participants) used project cell phones to transmit health statistics to a central database, contact coordinators and peers for health advice and information, and communicate with doctors and patients.

The ICT for healthcare development model (Author, Lwin, Ang, Lin, & Santoso, 2008) was used a heuristic to determine project effectiveness. Findings from the project indicate that the mobile phone has proven to be an effective and efficient device for facilitating smoother communication, and allowing speedier emergency response. The system also aids in gathering and disseminating health-related information to midwives, who in turn convey this knowledge to the patient community. The Technology-Community-Management model (Author & Zhao, 2009; Lee & Author, 2008) was used as a conceptual framework for probing the design of ICT for development projects. In particular, infrastructural, economic, technological, and socio-cultural barriers were examined to highlight the tension between a top-down hierarchical model of technology diffusion versus a more participatory bottom-up approach.

One of the greatest challenges in the domain of public health in developing countries is the ensuring of adequate maternal and infant health care. Many actions have been taken over the past two decades. One early program was the Safe Motherhood Initiative, launched in 1987 by the World Bank, WHO and UNFPA (Starrs, 2006). More recently, 191 member states pledged to collaborate in realizing the United

Nation's Millennium Development Goals. The goals to be achieved by the year 2015 included the reduction of maternal deaths by three quarters, and the infant mortality rate by two thirds (United Nations, 2007; United Nations Development Programme, 2005). Despite improvements, these are still far from being achieved. Globally, maternal mortality rates remain alarming—over half a million die annually due to pregnancy-related causes, with ninety-nine percent of these deaths occurring in developing countries (World Health Organization, 2007). In 2006, 9.7 million children died under the age of five, of which 4 million did not even live past their first month (UNICEF, 2007).

Indonesia, in particular, has a poor record in maternal and infant mortality (Analen, 2007; World Health Organization, 2005), especially compared with regional neighbors. To improve health services, Indonesian government initiatives, such as 'Making Pregnancy Safer' and the 'National Programme for Indonesian Children', focused on ensuring access to appropriate skilled healthcare (United Nations Population Fund, 2005). However, despite a decreasing number of deaths over the years, "safe motherhood programmes are not yet effective," according to the Indonesian State Minister for Women's Empowerment, Meutia Hatta Swasono (Agustiar, 2007). Improving maternal and infant health, hence, continues to be a serious challenge in Indonesia. Despite investments in the recruitment and training of novice midwives (Vivio & Kinzie, 2005), the presence of skilled birth attendants during complicated deliveries was identified as an issue (Zahr & Wardlaw, 2001; Romano & Luthian, 2008).

The introduction of information and communication technologies (ICTs) to rural community health workers (CHWs) has been shown to bridge lacunae in their work environment resulting from under-capacitated facilities, constrained access to information and delayed responses to emergencies (Ganapathy & Ravindra, 2008; Kanter, Mechael, Lesh, Dhadialla, & Kramers, 2008). In particular, the use of mobile phones has been noted in the monitoring of pregnancies, for treatment, and for post-natal healthcare support (Maniam, Chin, & Chenapiah, 2007; Mirza & Norris, 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; International Telecommunication Union, 2007; Kinkade & Verclas, 2008; McConnell, Chathoth, Pardy, Boostrom, Boostrom, Louw, et al., 2008; Mishra & Singh, 2008; United Nations, 2007). Case studies have recorded the use of 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 the use of Personal Digital Assistants (PDAs) to collect data and teach medical students in Ghana and Uganda respectively (Chetley, 2006).

Other benefits of using mobile technologies include access to accurate medical information in a timely manner (Angelidis, 2008), pre-treatment of primary healthcare problems (Bali & Singh, 2007), improving internal communication within the complex healthcare system (Malkary, 2006), and with the external 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, drawbacks exist. Mobile technologies need to be integrated into the broader healthcare and social system, such that they complement existing ICTs 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. However, 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 another oft-overlooked component, particularly for the segment most resistant to adoption, such as senior physicians (Fontelo, Liu, Muin, Tolentino, & Ackerman, 2006; Malhotra & Gardner, 2008).

Broadly speaking, the study and application of mobile technologies for healthcare in developing country situations is at a nascent stage, with limited development and application of standards, restricted coverage and generalizability, and little rigorous scientific evidence (Author, 2009; Varshney, 2006). The extant literature needs to provide a robust frame of reference that links to existing theory, a roadmap to policy makers (Broens, van Halteren, van Sinderen, & Wac, 2007), and empirical evidence of effectiveness in the form of multiple indicators (Katz, Rice, & Acord, 2006). The 5C's framework (Drury, 2005) comprising context, content, connectivity, capacity building, and community development is a useful tool, but fails to explicate the challenges in implementing healthcare technology projects.

This paper attempts to address these concerns by situating the analysis within the framework of the ICT for healthcare (ICT4H) development model (Author, Lwin,
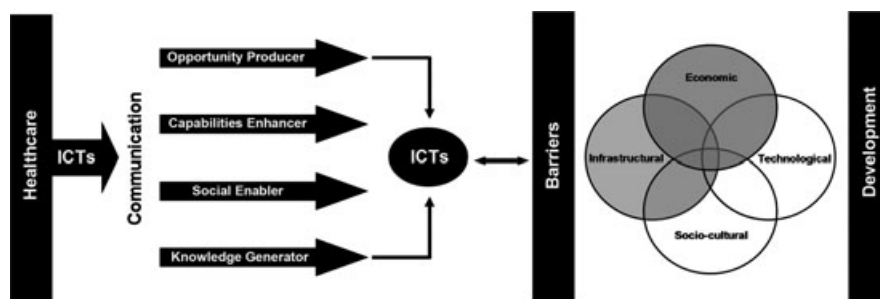

Figure 1 ICTs for healthcare development model

Ang, Lin, & Santoso, 2008). I examine the deployment of a mobile telephony-based system to rural midwives (MWs), and analyze the impacts and constraints that arise. The broad research question I aim to answer pertains to the design and evaluation of mobile phone-based healthcare projects.

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). The ICT4H 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.

Research question 1. Examine the benefits of mobile usage in the rural health-care context; specifically opportunity production, capabilities enhancement, social enabling and knowledge generation.

The ICT4H model simultaneously 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. Since the individual barriers associated with this particular study have been studied previously (Author, Lwin, Ang, Lin, & Santoso, 2008), the focus of the examination here is the interplay of these factors at an organizational level.

The mediatory role of mobile phones 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). Such an analysis needs to be cognizant of inter-related constraints within the sociologically gender-bound roles in traditional societies, such as the lack of economic decision-making power, limited technological education opportunities, as well as mobility issues (Ahmed, Islam, Hasan, & Rahman, 2006; Dunn & Dunn, 2006; Hafkin & Taggart, 2001; World Bank, 2004).

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). The economic issues presented by mobile technologies vis-à-vis technologies such as computer access to the internet have been lessened due to the increasingly cost-effective market-driven system (International Telecommunication Union, 2007). Scholars note , however, that that an individual's economic background can affect one's adoption of ICTs (Neelameghan, 2004).

From a sociological perspective, scholars note the issues of control of technology, particularly decision-making, within the context of roles and responsibilities assigned to women (Gadio, 2001; Chiwara & Sibanda, 2006; Tshukundu, 2002). Hafkin (2002) has criticized development projects for failing to address the lack of gender-neutrality of technology within already disparate social systems.

ICT4D projects need to recognize the multiple roles of women, such as family- and community-oriented roles, in addition to their work functions (Ramilo, 2002). The social connectedness function of the phone for women (Lee & Robbins, 2000; Rakow & Navarro, 1993) should be incorporated into the project design to allow for greater communication across the health infrastructure. The potential of greater mobility offers the ability to pursue opportunities farther afield while maintaining familial relationships from afar (Alcántara, 2001; Kopomaa, 2000; Mechael, 2006), but could strengthens the bonds of these responsibilities, leading to an increased burden. 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.

From a technological point-of-view, 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). Further, 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).

Socio-cultural constraints extend to educational opportunities, 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).

Research question 2. Examine the inter-related constraints to mobile usage in the rural healthcare context; specifically infrastructural, economic, technological, and socio-cultural factors from an organization perspective. Specifically, probe the tension

between hierarchical (top-down) versus participatory (bottom-up) approached to development projects as related to these factors.

The organization of this paper first details the design of a specific ICT4H project and then describes the research design. Next, the findings are presented in two sections; the first explaining the baseline results and the resultant design changes made, while the second part comprises the evaluation of the effectiveness by comparing the endline results versus the baseline. In conclusion, I discuss the implications of the findings, list the limitations, and offer suggestions for future research.

The Aceh Besar midwives mobile-phone project

The rural province of Aceh, located at the northern tip of the Indonesia island of Sumatra, suffered from a lack of widespread health infrastructure. The Aceh Strategic Plan estimated infant mortality at 42 per 1,000 live births and maternal deaths at 373 per 100,000 live births (Smidt, 2007). Despite national policies and programmes initiated by the Indonesian government (United Nations Population Fund, 2005), there remained room for improvement. Particularly worrisome was the scarcity of medical, transportation and communication infrastructure due to the protracted decades-long civil unrest (Chalk & Rabasa, 2001; Kell, 1995), now ended.

The situation was further compounded by the 2004 tsunami that caused unprecedented destruction, with an enormous humanitarian disaster, impacting medical services severely. Estimates of midwives killed or missing ranged from nearly 600 by the midwives association, Ikatan Bidan Indonesia, to 1650 (United Nations, 2005), causing further decline in the standards of maternal health services and newborn care.

With scarce healthcare facilities available to scattered and remote rural communities, the importance of midwifery services was identified as paramount (JHPIEGO, 2005). To provide healthcare expertise, an ICT4H intervention[1] aimed to improve maternal healthcare in the region. The intention was to utilize mobile communications technology to facilitate, accelerate, and improve the quality of health services by supporting midwives (MWs) in close proximity to these rural communities (Author, 2007). The pilot project used simple voice communications to facilitate communication between midwives and obstetrician-gynaecologists (OBGYNs), while simultaneously using mobile phones data-transfer 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 centres (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. MWs are associated with PHCs, where midwife coordinators (MWCs) are located. 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 (Statistics Indonesia, 2003).

Phones were provided to MWs, MWCs, and OBGYNs at the provincial hospital. A technical infrastructure was developed for the health centres, the provincial hospital, the midwife association, as well as the administrative and research staff on the project—linking a communication infrastructure through provided computers, as well as locating a central server with the telecom provider for receiving, collating and uploading data. An application provider developed a Java applet for the mobile phones to transmit data to the server, as well as a database for managing the health information.

All levels of the government health infrastructure, and partner organizations such as UNICEF and UNFPA, would be able to access the system via an internet interface to monitor and track health statistics in the populations served. Mobile use thus aimed to facilitate access to time-sensitive information by midwives, improve the quality of information accessible to them by connecting with senior staff, create an information sharing system within their networks, and allow tracking and collection of health related information.

Methodology

Approximately 600 midwives were located in Aceh Besar associated with 22 public health centres. Two types of centres existed: six had recently expanded emergency response capabilities, while the remainder had only basic capabilities. Participating midwives were stratified by their referral centres (PHC) as defined by the midwife association: 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: 122 MWs) and those that did not (control group: 101 MWs).

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, with the final endline survey completed in December 2007. The objective of the survey was 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 a medical consultant from JHPIEGO. Various sources[2] 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 entry and management was provided.

The quantitative questions in the survey were pre-coded and closed-ended as far as possible. Open-ended questions were recorded to capture the qualitative aspects. 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 13.0 for all variables. An alpha level of 0.10 was used.

Qualitative methodology

Experienced moderators and interviewers were hired to conduct the in-depth interviews and focus group discussions (FGDs). They were briefed on the proper procedures of eliciting responses, including the appropriate techniques of asking questions, and were handed specific topical areas to probe. In December 2006 and December 2007, qualitative interviews/FGDs were conducted with MWs (7/25), MWCs (4/3), OBGYNs (5/0), and beneficiaries, such as patients (11/29).

All qualitative measures were recorded with a digital audio recorder for transcription and translation. Further, to ensure accuracy in the transcription of the respondents' answers in FGDs, each session was recorded with a camcorder. A debrief session was held at the end of each day. Each respondent was presented a food hamper in appreciation of participation.

The audio and video recordings were handed to local transcribers to ensure accuracy, as respondents often used local slang. The transcripts were translated into English at a Singapore university by Indonesian undergraduates to ensure quality. Respondent comments are summarized as examples; however, individual names are withheld for reasons of confidentiality.

Findings

The findings section first outlines the analysis from the baseline research, conducted prior to the implementation of the project, and relates the resultant programmatic changes made. Secondly, the results of the evaluative comparison between the endline and baseline is presented as evidence of project effectiveness.

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
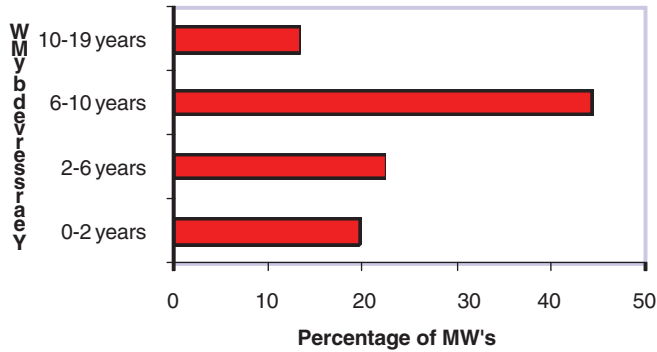
Figure 2 Midwife experience

the loss of personnel and the urgent need for maternal health and trauma care (See Figure 2). The disaster 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). Realistically though, these participants required a significant amount of training and assistance to be able to perform effectively.

In terms of 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 mobile phones were expensive) would prevent optimal utilization unless the device hardware and monthly subscription costs were subsidized. The project was therefore designed to fully absorb costs related to acquisition, operation, and maintenance of the mobile phones. However, beyond economic sustainability, the project noted the importance of the mobile phone as a social enabler. Social connectedness was ensured by allowing phone calls to social networks beyond their work environment.

Nonetheless, 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 more experienced MWs 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%),

Table 1 Midwife experience

	d.f.	t	p	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

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%).

Capabilities enhancement

Midwives capabilities were measured in terms of job-related capacity, the ability to harness technological resources effectively, and training imparted for capacity building. 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. This suggests 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)

MW 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 reinforces the fact of MW reliance on support from 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.

Since training modules were conducted infrequently at health centres, help was forthcoming from MW colleagues and MWCs. Nonetheless, 86.1% of MWs were confident of adequately using the training to deal with birth complications. However, to what extent the training had been comprehensive was questionable, given the somewhat weak results in the medical information section of the survey. The project initiated weekly SMS updates of health information to supplement the infrequent
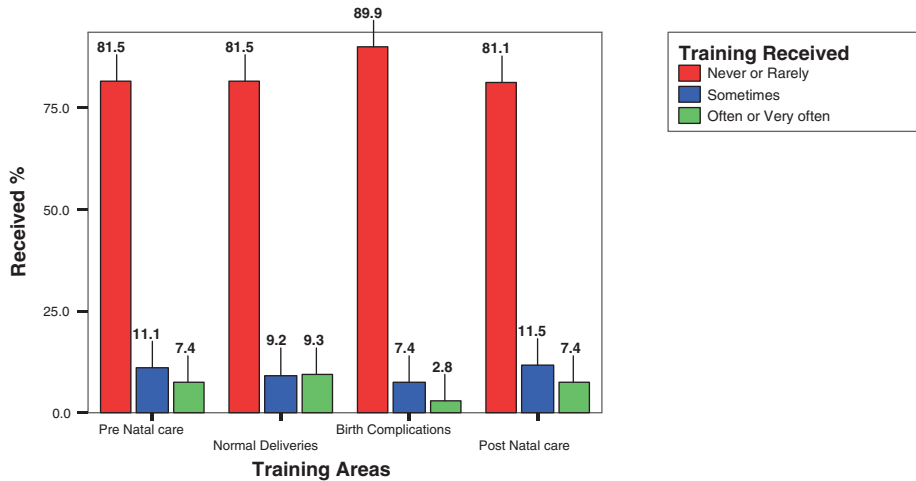
Figure 3 Frequency of midwife training

training. The project was thus cognizant of creating sources of information that were both centralized (SMS updates), and de-centralized (voice communication amongst MW peers).

Midwives exhibited the capability to use mobile technologies towards beneficial health outcomes, but 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 the majority (81.1%) exhibiting little or next to no experience. In terms of frequency of media usage, mobile phone usage was predominant (See Figure 4). Other mediums of communication, such as the line phone and computers, were used less frequently, with internet usage negligible. The rapid adoption of the mobile phone by CHWs, on the move for a significant portion of the day, underlines the importance of the technology for an occupational group characterized by the need for mobility.

As an example of bottom-up design, MWs requested, and were granted, training in the database used for storage of patient data. MWs felt a strong responsibility towards patients in the their care, leading to a desire for the ability to conduct their own analysis of the data rather than be dependent on centralized instructions.

> *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)
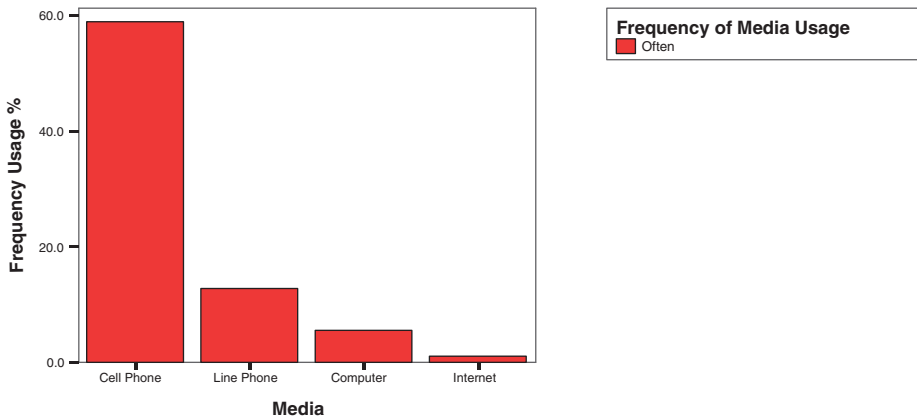
Figure 4 Frequency of media usage

Mobile phone ease of use was a key motivation for most (92.4%) of the respondents. Technological familiarity was generally high, with the functional basics of 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 JAVA application used for data collection and information disbursement, and therefore training sessions were conducted.

Social enabler

The pilot project aimed to enhance existing social networks to foster greater collective efforts in the community's health care. The 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. So were the collective ties between the MWs in terms of trust (94.2%) and support for each other' in times of stress (83.4%).

Indeed, the MWCs (90.2%) were heavily relied on to help in medical situations, compared to OBGYNs (63.7%), corresponding to the degree of satisfaction with the information gained from them (MWCs, 76.7%; OBGYNs, 66.6%). Conversely, both MWC (91.9%) and OBGYNs (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, and the relative accessibility of, MWCs based at PHCs, hospital-based doctors might have been unapproachable with regards to the formal chain of command. In order to address the deeply entrenched hierarchy, and catalyze communication across the different levels, the project organized sessions to allow informal interaction between MWs and doctors.

Social contacts and written material functioned as the most common modes of obtaining information (See Figure 5), with electronic means lagging behind considerably. Instead, traditional methods, such as social networks, brochures,
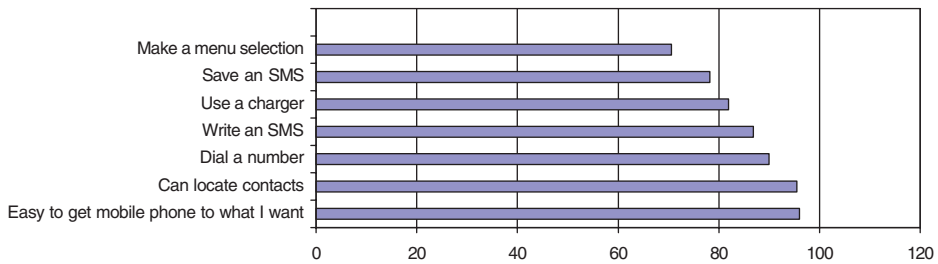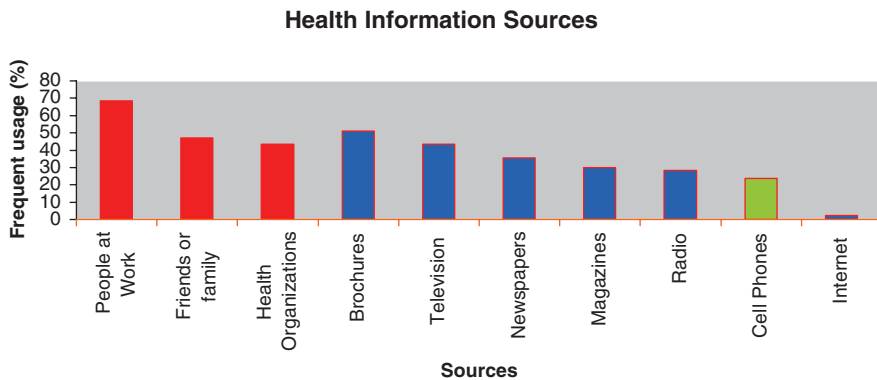
Figure 5 Technological familiarity

Figure 6 Obtaining health information

newspapers and magazines, where accessibility, approachability and trust play a major role in shaping the efficacy of assimilating information, continued fervently.

Health magazines were provided to ensure MWs developed personal knowledge-seeking capabilities, and were less reliant on centralized sources. Consequently, the project linked old ways of accessing information that MWs trust and were accustomed to, with new technology in information systems that increased the channels of access to this 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. A sixth (16%)

could not identify a single symptom for the first stage of pregnancy, whilst a quarter (24.5%) opted for only one symptom out of a possible four correct answers. A minority answered correctly for stages II (20%) and III (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). Moreover, 90% of MWs were confident that they could use the mobile phone to get information about midwifery, 85% agreed that it was relevant to their needs, and 70.5% felt that it would influence 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 centre using mobile phones. It is revealing that MWs had apprehensions about completely trusting the sources of information available to them professionally, despite accessing these sources frequently. This may have been a consequence of the fact that the health system supporting MWs was often unprepared to deal with direct consultation requests. A challenge for the project was to establish protocols for speedy and reliable means for replying to MW queries.

> *We often meet at health centre. . .. 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)

Endline results

The findings from a comparison of the quantitative endline survey versus the baseline survey follow. This 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 over the course of the project. This may have been accentuated by the boom in the local economy following the tsunami, and relatedly, by the huge influx of agencies disbursing aid and providing 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. We should note that the control group was neither subsidized for the subscription, nor connected to the JAVA-enabled database. As a consequence, the results are still encouraging, and can be divided into four key benefit areas based on the ICT4HC model.

Opportunity production

The study 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 study group also found it inexpensive to use the mobile phone ($p < 0.10(0.03)$, $MD = -0.40$), and intended to increase their usage ($p < 0.10(0.04)$, $MD = -0.39$). This was possibly because the mobile subscription bills were not borne by the MWs themselves, but by the project donors. However, the qualitative findings suggest that midwives would continue mobile usage, regardless of source of funding, due to acceptance of the noticeable benefits.

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 midwifes are able to call doctors directly to get a reference. (Respondent: MW)

Capabilities enhancement
The study group increased in their confidence to solve difficult problems if they tried hard enough ($p < 0.10(0.07)$, $MD = 0.21$). This suggests that MWs 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 the fact that they were more likely to turn to work networks for required medical information.

> *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 study group increased in their confidence that the facilities and equipment provided were adequate to deal with birth complications ($p < 0.10(0.09)$, $MD = 0.25$). This confidence of this group to store health data for patients effectively ($p < 0.10(0.09)$, $MD = 0.20$) also increased.

> *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: OBGYN)

The study group felt that the mobile phone was a well-known resource ($p < 0.10(0.09)$, $MD = 0.26$). With increasing familiarity, this group 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, particularly GPRS.

Unfortunately 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 study group were more likely to turn to health centre personnel for medical information needed ($p < 0.10(0.09)$, $MD = 0.20$), and access health information from the health centre using their mobile phones ($p < 0.10(0.09)$, $MD = -0.36$). Over the course of the project, improved relationship across the levels of the healthcare system hierarchy were observed.

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 technological knowledge, the study group found it easier to (i) search for numbers in mobile phone lists ($p < 0.10(0.02)$, $MD = 0.27$), and (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 mobile phone functions.

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 ($p < 0.10(0.04)$, $MD = 0.26$). Using mobile phones more frequently and obtaining health information from mobile phones could positively affect midwives' readiness to obtain and accept health information from alternate sources of information.

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

This project subsequently increased the placement of health brochures in participating health centres, in order to provide more sources of self-learning for MWs. 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 medical question scores of the study group increased for Q42 ($p < 0.10(0.06)$, $MD = 0.41$), 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 suggested that mobile phone use did have marginal impact on specific knowledge levels of the midwives, through targeted messages.

Unfortunately, the study group 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 suggested that the mobile phones are being under-utilized as a resource for disseminating specific health-related information.

Discussion

This article demonstrates that mobile phones 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, the geographical spread of their work, time-sensitivity of the medical service, health knowledge insufficiency and lack of training.

This study addresses a critical current problem in public health, and the results can be generalized to other remote, rural locations, especially in developing nations. 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 project 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.

The ICT4H model proved valuable as an analytical tool for evaluation. However, it was less practical for practitioners and policy-makers involved in the design and facilitation of development projects. An examination of the inter-related *infrastructural, economic, technological,* and *socio-cultural* factors within the context of top-down versus bottom-up development approaches requires a project management framework. The Technology-Community-Management (TCM) model (Author & Zhao, 2009; Lee & Author, 2008) is a conceptual framework more relevant for project management. This proposed 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.

From a technological standpoint, much of the software design and hardware procurement was conducted from a technical specifications perspective. However, designing the technology was aided by conducting needs assessment. Designers recognized infrastructural constraints of limited connectivity associated with MW mobility to remote areas without telecommunication coverage. Also recognized was the cumbersome nature of a data-entry system based on SMS requiring multiple button clicks. As a consequence, the application was designed to alleviate such problems. 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.

While such system re-configuration, despite being based on user testing, can be argued to be a centralized design response, the emphasis on usability led to a focus on understanding not only MW needs, but their psychological motivations as well. Beyond fixing problems, the project was designed to encourage user-led innovation as well. It was discovered serendipitously that MWs were using the mobile phones to capture images of new-borns within their care. While not a part of the design, the visual nature of the data was encouraged as an additional reference point, particularly as this increased MW engagement with the iterative design aspect.

From a community perspective, the needs assessment suggested that newer technologies like the mobile phone applications needed to be bolstered with directed training. Further, MW engagement was furthered by the participatory design of the training modules, allowing them to develop skills to access and analyze patient data. By responding to MWs requests to be analyzers of data, rather than mere recorders, the project aimed to alleviate perceptions of MWs as mere recipients of technological change, rather as producers of knowledge (Henwood, 1993). Further, the organized action of MWs instead of as individual users, had the possibility of leading to collective empowerment (Martinez & Reilly, 2002).

In terms of medical knowledge, alternatives to the inadequacy of training the midwives was made available on a regular basis, through both centralized and de-centralized means. Information about medical resources available was disseminated via SMS updates, and disseminated through more traditional forms of media, through incorporation of printed materials such as brochures and magazines for distribution to the health centres. MWs were thus encouraged to develop self-learning skills that would make them less dependent on the hierarchical system. Developing capacity for women, both technological and occupation-related, has the advantage of increasing motivation and ability to engage in ICT projects, and increase chances of programmatic success (Mijumbi, 2002)

From a management perspective, project managers overcame the major hurdle of economic constraints by completely subsidizing the mobile phone system. However, issues of misuse needed to be reconciled with allowing freedom for social connectedness. Thus, protocols for limiting excessive usage were developed, though rarely used, to balance the rejection of a system that allowed professional calls solely within the health network. Thus MWs were able to extend their social networks within the community, gaining prestige and developing self-esteem as professional women (Hafkin, 2002). Finally, the interactions across the different levels of the medical infrastructure eased, though not completely eliminated, the hierarchical constraints binding the women at the bottom. The system itself benefited from being perceived as a dynamic response system rather than a method of policing, i.e., collecting data from the lower levels as a form of marking attendance and ensuring compliance.

It is evident that the project administrators aimed to, and succeeded to an extent, to involve participatory approaches, particularly in relation to hierarchical issues. Less visibly acknowledged was the gender aspect of the project. However, it should be noted that no development project operates in isolation of the broader socio-cultural, political, and organizational environment. Moreover, development projects, by their very nature, focus on specific development objectives. Project managers, given the exigencies of their deliverables, thus have to deal with the very real tensions between delivering project goals versus nurturing broader social change. Certainly, taking a longer-term societal perspective may be desirable, but can be seen as a luxury in the field.

Limitations The analysis could have been strengthened by an examination of ultimate benefits, i.e., health indicators of maternal and infant mortality. However, we came to realize that, such as in the post-conflict and post-disaster situation in Aceh, legacy data was not available. The lack of reliable mortality records to form a baseline certainly hinders a rigorous evaluation effort, but can prove useful as future baseline.

Suggestions for future research 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. A cost-benefit analysis could provide critical evidence for policy-makers to base future investment decisions. However, 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 can also contribute to sustainable social change as well. Proceeding with valid and tested conceptual frameworks can aid greatly in the design and evaluation of such programs, as well as increases the chances of meeting broader development goals.

Acknowledgement

Notes

1 The project was funded by the United Nations Children's Fund (UNICEF) the United Nations Population Fund (UNFPA), and World Vision, which was also the implementing agency.
2 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.

References

Agustiar, D. R. (2007). Gerakan sayang ibu belum efektif menekan angka kematian [The mother friendly movement not yet effective to reduce deaths]. *Retrieved February 17*, 2008, from http://www.tempointeraktif.com/hg/nasional/2007/05/03/brk,20070503-99308,id.html

Ahmed, A., Islam, D., Hasan, A. R., & Rahman, N. J. (2006). *Measuring the impact of ICT on women in Bangladesh*. Paper presented at the 2006 International Conference on e-Learning, e-Business, Enterprise Information Systems, e-Government, & Outsourcing, Las Vegas, USA. Retrieved November 15, 2008, from http://ww1.ucmss.com/books/LFS/CSREA2006/EEE4168.pdf

Alampay (2006). Regional Development Dialogue, Vol. 27, No. 2 Autumn 2006, United Nations Centre for Regional Development, Nagoya, Japan, pp. 189–199.

Aminuzzaman, S., Baldersheim, H., & Jamil, I. (2002, July 7). *Talking back! Empowerment and mobile phones in rural Bangladesh: A study of the village pay phone of Grameen Bank*. Paper presented at the International Society of Third Sector Research (ISTR) Fifth International Conference: Transforming Civil Society, Citizenship and Governance - The Third Sector in an Era of Global (Dis)Order, Cape Town, South Africa.

Analen, C. (2007). Saving mother's lives in rural Indonesia. *Bulletin of the World Health Organization*, *85*(10), 740–741.

Anantraman, V., Mikkelsen, T., Khilnani, R., Kumar, V. S., Machiraju, R., Pentland, A., et al. (2002, December). Handheld computers for rural healthcare: Experiences from research concept to global operations. *Proceedings of Development by Design Conference, Bangalore, India*, 1–10. Retrieved November 10, 2008, from http://kaash.sourceforge.net/doc/dyd02.pdf

Angelidis, P. (2008). Mobile telemonitoring insights. *Medical informatics: Concepts, methodologies, tools, and applications*, *1*, 107–112. Retrieved November 15, 2008, from http://www.vidavo.gr/files/encyclopedia_article_angelidis.pdf

Anon. (2005). Indonesia 2002–2003: Results from the demographic and health survey. *Studies in Family Planning, 36*(1), 85–89.

Atun, R. A., & Sittampalam, S. R. (2005). *Uses and benefits of SMS in healthcare delivery.* Retrieved October 22, 2008, from http://www3.imperial.ac.uk/portal/pls/portallive/docs/1/5375912.PDF

Author. (2007). *Information and communication technologies for health: Midwives with mobile-phone project in Aceh Besar baseline report.* World Vision Asia Tsunami Response. Singapore: Author.

Author, Lwin, M. O., Ang, J., Lin, H., & Santoso, F. (2008). Mobiles and midwives: Improving healthcare communications via mobile phones in Aceh Besar, Indonesia. *Asian Journal of Communication. 18*(4), 348–364.

Author. (2009). The Role of ICA in Nurturing the Field of Information and Communication Technologies for Development. *International Communication Association newsletter*, *37*(2), 13–16.

Author, & Zhao (2009). Sustainability of ICT interventions: Lessons from rural projects in China and India. In L. Harter & M. J. Dutta (Eds.), *Communicating for Social Impact: Engaging Communication Theory, Research, and Pedagogy.* (pp. 145–159). ICA 2008 Conference Theme Book. Hampton Press.

Baker, B. (2006). *Mobile phone text message based consultation: An investigation of current practice and associated best practice recommendations.* Retrieved November 22, 2008, from http://www.ehealthnurses.org.uk/pdf/mobreport.pdf

Bali, S., & Singh, A. J. (2007). Mobile phone consultation for community health care in rural north India. *Journal of Telemedicine and Telecare 2007, 13*(8), 421–424. Retrieved November 15, 2008, from http://jtt.rsmjournals.com/cgi/reprint/13/8/421

Bhavnani, A., Chiu, R. W. W., Janakiram, S., & Silarszky, P. (2008). *The role of mobile phone in sustainable rural poverty reduction.* Retrieved November 22, 2008, from http://siteresources.worldbank.org/EXTINFORMATIONANDCOMMUNICATIONAN DTECHNOLOGIES/Resources/The_Role_of_Mobile_Phones_in_Sustainable_Rural_Poverty_Reduction_June_2008.pdf

Broens, T., van Halteren, A., van Sinderen, M., & Wac, K. (2007). Towards an application framework for context-aware m-health applications. *International Journal of Internet Protocol Technology, 2*(2), 109–116. Retrieved October 25, 2008, from http://eprints.eemcs.utwente.nl/7052/01/broens_final_EUNICE05.pdf

Chalk, P., & Rabasa, A. (2001). *Indonesia's transformation and the stability of Southeast Asia.* CA: Rand Corporation.

Chandrasekhar, C. P., & Ghosh, J. (2001). Information and communication technologies and health in low income countries: the potential and the constraints. *Bulletin of the World Health Organization, 79*(9), 850–855. Retrieved October 30, 2008, from http://www.who.int/bulletin/archives/79(9)850.pdf

Chetley, A. (2006). *Improving health, connecting people: The role of ICTs in the health sector of developing countries.* Retrieved October 30, 2008, from http://www.asksource.info/pdf/framework2.pdf

Chiwara, L., & Sibanda, A. (2006, November 28). *Gender and human rights principles and approaches to evaluation.* Paper Presented at the Regional Workshop on the UNDP Evaluation Policy, Johannesburg, South Africa.

Darby R. (2004). *Five new trends to watch in healthcare information technology.* Retrieved November 18, 2008, from http://www.medimage.co.za/Richard's%20articles/five_new_trends.htm

Domingo, A. A. (2006). M-DOK: *Mobile telehealth and information resource system for community health workers.* Retrieved November 11, 2008, from http://www.amic.org.sg/ict/external/awards/0501A3_L19_interim_report1.pdf

Donner, J. (2008). Research Approaches to Mobile Use in the Developing World: A Review of the Literature. *The Information Society, 24*(3), 140–159.

Donner, J. (2004). *Innovations in mobile-based public health information systems in the developing world: An example from Rwanda.* Retrieved November 18, 2008, from http://jonathandonner.com/donner-mobhealth.pdf

Drury, P. (2005). eHealth in developing countries: A framework. *eHealth International Journal, 2*(2), 20–26. Retrieved November 22, 2008, from http://www.ehealthinternational.org/vol2num2/Vol2Num2p19.pdf

Dunn, H. S., & Dunn, L. (2006). *Genderstanding mobile telephony women, men and their use of the cellular phones in the Caribbean.* Retrieved October 12, 2008, from http://www.dirsi.net/english/files/background%20papers/070216-dunn.pdf

Elnaggar, A. (2007). The status of Omani women in the ICT sector. *International Journal of Education and Development using Information and Communication Technology, 3*(3), 4–15.

Fontelo, P., Liu, F., Muin, M., Tolentino, H., & Ackerman, M. (2006). Txt2MEDLINE: Text-messaging access to MEDLINE/PubMed. *Proceeding of the AMIA Annual Symposium, Washington, DC, 259–263.* Retrieved November 22, 2008, from http://lhncbc.nlm.nih.gov/lhc/docs/published/2006/pub2006044.pdf

Gadio, C. (2001). *Exploring the gender impact of the world links program in some selected participating African countries: A qualitative approach.* World Links: Washington.

Ganapathy, K., & Ravindra, A. (2008, July 13). *mHealth: A potential tool for health care delivery in India.* Paper presented at the Making the eHealth Connection: Global Partnerships, Local Solutions Conference 2008, Bellagio, Italy. Retrieved November 18, 2008, from http://www.ehealth-connection.org/files/conf-materials/mHealth_A%20potential%20tool%20in%20India_0.pdf

Geray, H. (1999). Network policy formation between idealist and strategic models: A political economy perspective from Turkey - Owenership and control of the information highway in developing countries. *Telecommunications Policy*, *23*(6), 495–511

Hafkin, N. (2002, November 11). *Gender issues in ICT policy in developing countries: An overview.* Paper presented at the UN Division for the Advancement of Women Expert Group Meeting on Information and Communication Technologies and Their Impact On and Use as an Instrument for the Advancement and Empowerment of Women, Seoul, Republic of Korea. Retrieved October 13, 2008, from http://www.un.org/womenwatch/daw/egm/ict2002/reports/Paper-NHafkin.PDF

Hafkin, N., & Taggart, N. (2001). *Gender, information technology, and developing countries: An analytic study.* Academy for Educational Development LearnLink for the Office of Women in Development, United States Agency for International Development. Retrieved November 22, 2008, from *http://www.aed.org/Publications/upload/CPGenderSummary MF5Macol.pdf*

Harper, A. (2006). *The role of mobile phones in increasing accessibility and efficiency in healthcare.* Retrieved November 22, 2008, from http://www.remindpatients.com/alan_harper.pdf

Henwood, F. (1993). Establishing gender perspectives on IT: Problems, issues and opportunities. In Green E., Owen J. and Pain D. (Eds.) *Gendered Design? IT and Office Systems.* London: Taylor & Francis.

Hewitt de Alcántara, C. H. (2001). The Development Divide in the Digital Age: An Issues Paper, *UNRISD Programme on Technology, Business and Society, Paper No. 4.* Geneva, United Nations Research Institute for Social Development. Retrieved September 16, 2006, from http://www.utsc.utoronto.ca/~chan/istb01/readings/digital_divide_hewitt.pdf

Iluyemi, A. (2007, November 13). *Mobile e-Learning for community based health workers in developing countries: A proposed model.* Paper presented at The First International m-libraries Conference, Milton Keynes, United Kongdom.

International Telecommunication Union. (2007). *World Information Society report* 2007: *Beyond WSIS.* Retrieved March 21, 2009, from http://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-WSIS.RPT-2007-SUM-PDF-E.pdf

JHPIEGO. (2005, December 20). *Progress made in rebuilding Indonesia's health care system one year after the tsunami: Johns Hopkins affiliate JHPIEGO re-establishes services to women and families in Aceh.* Retrieved October 22, 2008, from http://www.jhpiego.org/media/releases/nr20051220.htm

Kanter, A. S., Mechael, P. N., Lesh, N., Dhadialla, P., & Kramers, A. (2008, May 26). *Open source mHealth applications and the Millennium Development Goals for Africa.* Paper presented at the MIE 2008: eHealth beyond the horizon - Get IT there, Goteborg, Sweden. Retrieved November 22, 2008, from http://www.hst.aau.dk/~ska/MIE2008/Panels/MIE2008_UID445_BID292.pdf

Katz, J. E., Rice, R. E., & Acord, S. (2006). Uses of internet and mobile technology in health systems: Organizational and socio-cultural issues in a comparative context. In M. Castells & G. Cardoso (Eds.) *The network society: From knowledge to policy* (pp. 183–214). Washington: Brookings Institution Press. Retrieved November 22, 2008, from http://cies.iscte.pt/linhas/linha2/sociedade_rede/pr_htdocs_network/apps/katz.pdf

Kell, T. (1995). *The roots of Acehnese rebellion, 1989–1992.* Ithaca, NY: SEAP Publications.

Kinkade S., & Verclas, K. (2008). *Wireless technology for social change: Trends in mobile use by NGOs.* United Kingdom: UN Foundation–Vodafone Group Foundation Partnership. Retrieved November 15, 2008, from http://mobileactive.org/files/MobilizingSocialChange_full.pdf

Kopomaa, T. (2000). *The city in your pocket: Birth of the mobile information society. Helsinki*: Gaudeamus.

Kouroubali, A. (2002, January 7). *Structuration theory and conception-reality gaps: Addressing cause and effect of implementation outcomes in healthcare information systems.* Paper presented at the 35th Hawaii International Conference on System Sciences, Hawaii, USA.

Lee, R. M., & Robbins, S. B. (2000). Understanding social connectedness in college women and men. *Journal of Counseling and Development, 78*, 484–491.

Lee, S. & Author. (2008). Wireless initiatives for connecting rural areas: Developing a framework. In N. Carpentier & B. De Cleen (Eds.), Participation and media production. Critical reflections on content creation. ICA 2007 Conference Theme Book. Newcastle, UK: Cambridge Scholars Publishing.

Ling, R. (1999, July). *We release them little by little: Maturation and gender identity as seen in the use of mobile telephony.* Paper presented at the International Symposium on Technology and Society (ISTAS'99) Women and Technology: Historical, Societal and Professional Perspectives, New Brunswick, New Jersey.

Malhotra, K., & Gardner, S. (2008). Impact of awareness of mobile internet technologies on the healthcare sector in India. *Indian Journal of Medical Informatics*, *3*(1), 1–13. Retrieved November 12, 2008, from http://openmed.nic.in/2875/01/Malhotra.pdf

Malkary, G. (2006). *Healthcare without bounds: Trends in mobile communications*. Retrieved October 12, 2008, from http://www.spyglass-consulting.com/Abstracts/Spyglass_Mobile_Comm_abstract.pdf

Maniam, J., Chin, C. K., & Chenapiah, K. (2007, February 6). *Mobile phone based pregnancy support system*. Paper presented at the eHealth Asia Conference, Kuala Lumpur, Malaysia. Retrieved November 22, 2008, from http://ehealthonline.org/ehealthasia/2007/fullpapers/Jayanthy_eHealthAsia07ABS116.pdf

Martinez, J. & Reilly, K. (2002). Empowering women for public policy advocacy: Looking behind the Internet to enable citizen information systems. Background paper prepared for the INSTRAW Virtual Seminar Series on Gender and ICTs.

Maru, D. S. R., Basu, S., Andrews, J., Acharya, B., & Khoshnood, K. (n.d.). *Alma-Ata in the digital era: Telemedicine for community health workers*. Retrieved November 22, 2008, from http://www.nyayahealth.org/Library/AlmaAta_DigitalEra.pdf

McConnell, H., Chathoth, P., Pardy, A., Boostrom, C., Boostrom, E., Louw, K., et al. (2008). Leapfrog technologies for health and development. *Global Forum Update on Research for Health*, *5*, 130–135.

Mechael, P. N. (2006). *Exploring health-related uses of mobile phones: An Egyptian case study*. Unpublished doctoral dissertation, London School of Hygiene and Tropical Medicine, University of London. Retrieved October 5, 2008, from http://www.mvpafrica.org/wiki/pub/Sandbox/Chapter1-WhySoilIsNeat/PatriciaMechaelThesisFinalDecember2006.pdf

Mijumbi, R. (2002). The use of information and communication technologies as a tool to bridge the gender digital gap. Background paper prepared for the INSTRAW Virtual Seminar Series on Gender and ICTs.

Mirza, F., & Norris, T. (2007). Opportunities and barriers for mobile health in New Zealand. In K. A. Kuhn, J. Warren, & T. Y. Leong (Eds.) *Medinfo: Proceedings of the 12th World Congress on Health (Medical) Informatics: Building Sustainable Health Systems* (pp. 102–106). Amsterdam: IOS Press.

Mishra, S., & Singh, I. P. (2008, July 13). *mHealth: A developing country perspective*. Paper presented at the Making the eHealth Connection: Global Partnerships, Local Solutions Conference 2008, Bellagio, Italy. Retrieved November 12, 2008, from http://www.ehealth-connection.org/files/conf-materials/mHealth_%20A%20Developing%20Country%20Perspective_0.pdf

Neelameghan, A. (2004). Information and communication technologies: Applications and limitations. In K. Prasad (Ed.), *Information and communication technology: Recasting development* (pp. 52–65). New Delhi, India: B. R. Publishing Corporation.

Rakow, L. F., & Navarro, V. (1993). Remote mothering and the parallel shift: Women meet the cellular telephone. *Critical Studies in Mass Communication, 10*(2), 144–157.

Ramilo, C. (2002, November). *National ICT policies and gender equality: Regional perspective - Asia*. Paper presented at the conference on United Nations Division for the Advancement of Women Expert Group Meeting on Information and Communication Technologies and Their Impact On and Use as an Instrument for the Advancement and Empowerment of Women, Seoul, Republic of Korea. Retrieved November 11, 2008, from http://www.un.org/womenwatch/daw/egm/ict2002/reports/Paper-CRamilo.pdf

Richardson, D., Ramirez, R., & Haq, M. (2000). *Grameen Telecom's village phone program in rural Bangladesh: A multi-media case study final report.* Gatineau, Canada: Canadian International Development Agency. Retrieved November 14, 2008, from http://www.telecommons.com/villagephone/finalreport.pdf

Romano, A. M., & Lothian, J. A. (2008). Promoting, protecting, and supporting normal birth: A look at the evidence. *Journal of Obstetric, Gynecologic, & Neonatal Nursing, 37*(1), 94–105.

Sherwani, J., Tongia, R., Rosenfeld, R., Ali, N., Memon, Y., Karim, M., et al. (2007). *HealthLine: Towards speech-based access to health information by semi-literate users.* Retrieved November 25, 2008, from http://www.cs.cmu.edu/~jsherwan/pubs/simpe 2007.pdf

Smidt, P. (2007). *MOU signing between the Provincial Health Department, the BRR and the University of Indonesia.* Retrieved October 30, 2008, from http://www.adb.org/Documents/Speeches/2007/sp2007034.asp

Starrs, A.M. (2007). Delivering for women. *The Lancet*, *370*, 1285–1287.

Statistics Indonesia. (2003). *Indonesia Demographic and Health Survey 2002–2003.* Ministry of Health, Indonesia.

Thas, A. M. K., Ramilo, C. G., Cinco, C. (2007). *Gender and ICT.* United Nations development programme–Asia-Pacific development information programme. India: Elsevier. Retrieved November 4, 2008, from http://www.apdip.net/publications/iespprimers/eprimer-gender.pdf

Tshukundu, P. (2002, May). *Empowering people to cross the digital divide: A gender dimension.* Paper presented at World Telecommunications Day, Gaborone, Botswana.

United Nations. (2005, January 19). *Tsunami survivors give birth without basic necessities.* Retrieved October 2, 2008, from http://www.un.org/News/Press/docs/2005/iha999.doc.htm

United Nations. (2007). *The millennium development goals report 2007* [Electronic version]. New York, USA: United Nations, Department of Economic and Social Affairs.

United Nations. (2007). *Compendium of ICT applications on electronic government.* Retrieved November 14, 2008, from http://unpan1.un.org/intradoc/groups/public/documents/UN/UNPAN030003.pdf

United Nations Children's Fund. (2007). *The state of the world's children 2008* [Electronic version]. New York, USA: United Nations Children's Fund.

United Nations Development Programme. (2005). *Promoting ICT for human development in Asia: Realizing the millennium development goals.* India: Elsevier.

United Nations Population Fund. (2005). *Making villages in Indonesia more 'mother-friendly'.* Retrieved October 03, 2008, from http://www.unfpa.org/news/news.cfm?ID=670

Varshney, U. (2006). Using wireless technologies in healthcare. *International Journal of Mobile Communications*, *4*(3), 354–368. Retrieved November 04, 2008, from http://www.cis.gsu.edu/~uvarshne/papers/IJMC3.pdf

Venkatesh, V., & Morris, M. G. (2000). Why don't men ever stop to ask for directions? Gender, social influence, and their role in technology acceptance and usage behavior. *MIS Quarterly*, *24*(1), 115–139.

Vivio, D. & Kinzie, B. (2005). Improving maternal health. *eJournalUSA, Economic Perspectives, 10*(3), 28–31. Retrieved December 17, 2005, from http://usinfo.org/enus/government/forpolicy/docs/ijee0805.pdf

World Bank. (2004). *Engendering information & communication technologies: Challenges & opportunities for gender-equitable development.* Gender and Development Group and Global Information and Communication Technologies Department of the World Bank, Washington, DC: World Bank. Retrieved November 05, 2008, from http://siteresources. worldbank.org/INTGENDER/Seminar-Series/20260878/ictbrochure.pdf

World Health Organization. (2005). *eHealth tools and services: Needs of Member States.* Retrieved November 12, 2008, from http://www.who.int/kms/initiatives/tools_and_ services_final.pdf

World Health Organization. (2007). Maternal Mortality in 2005. Estimates developed by WHO, UNICEF, UNFPA, and The World Bank. Retrieved February 15, 2008, from http://www.unfpa.org/webdav/site/global/shared/documents/publications/2007/mm_up date05.pdf

Zahr, C. A., & Tessa Wardlaw (2001). Maternal mortality at the end of a decade: signs of progress? *Bulletin of the World Health Organization*, 2001, *79*, 561−568.