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Running Head: MOBILE PHONE IN RURAL HEALTH

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Abstract

This study developed and tested a theoretical model that explains the underlying process through which the use of mobile phones can facilitate the capacity of community healthcare workers (CHWs) in developing regions. Based on a study conducted on 223 midwives in rural regions of Indonesia, the results showed that mobile phone use was positively associated with midwives' access to institutional and peer resources. Access to institutional resources was associated with midwives' health knowledge. Further, access to peer resources was associated with higher self-efficacy beliefs, which was positively associated with health knowledge. The study provides implications for information and communication technology (ICT) intervention strategies targeted to CHWs in rural communities.

Keywords: Mobile phone, Midwives, Health knowledge, Self-efficacy, Maternal health, Community healthcare workers, Rural communities

Midwives' Mobile Phone Use and Health Knowledge in Rural Communities

Decentralized and accessible health knowledge has been one of the prominent goals of primary health care in developing countries. Yet, lack of knowledge and information remains a significant deterrent to health practices, leading in turn to heightened health risk (e.g., Kargbo, 2008; Rhine, 2006). In particular, individuals often lack direct access to health institutions and services due to geographical, economic, and social barriers. Therefore community health workers (CHWs; also referred to as village health workers) in developing countries are critical intermediaries between higher-level health institutions and the community in need of medical care (Batchelor et al., 2003; Iluyemi, Fitch, Parry, & Briggs, 2007; Mchombu, 2003). Consequently, health-related knowledge of CHWs is an essential resource for the improvement of health care quality. While a number of studies examined predictors of information and knowledge acquisition in various health contexts (e.g., Guerra, Dominguez, & Shea, 2005; Muturi, 2005), research that involves that of CHWs remains scarce.

Knowledge is an important indicator of health outcome, potentially leading to changes in health behavior (Stephens, Rimal, & Flora, 2004). Past literature suggests that knowledge increases individuals' capability to critically assess health-related benefits and issues, thus leading to the formation of positive health attitudes. For example, studies suggest that greater knowledge is correlated with positive attitudes about the benefits of genetic testing of cancer risk (Rose, Peters, Shea, & Armstrong, 2005). In another study about genetic testing of cancer, it has been found that greater knowledge helps individuals establish their own attitudes rather than unambiguously accept others' attitudes (Jallinoja & Aro, 2000). [More about the importance of CHWs' health knowledge].

Interest has been growing in the idea that information and communication technologies (ICTs) could extend the reach of remote CHWs in providing medical services. It has been suggested that facilitating ICT access could enable rapid and sustainable gains in healthcare delivery. In particular, mobile devices and applications could provide beneficial results (Bali & Singh, 2007; Mirza & Norris, 2007). Two primary benefits of mobile accessibility are the ability of remote CHWs to access advice and information from experts, and the ability to access and deliver health records from and into the medical information system respectively. The literature lists instances of both referral systems (Sherwani et al., 2007) and medical records systems (Kinkade & Verclas, 2008). [More about ICT and resource access]

Given the increased attention to ICTs, the goal of this study is to examine the underlying processes through which ICTs can have a positive influence on CHWs' health knowledge in developing country settings. Efforts to use ICTs for development goals have been criticized for the lack of theory-based implementation strategies (Heeks, 2007). The current study attempts to address this issue in the context of midwives' mobile phone use in rural communities. In particular, the study examines the association between mobile phone use and midwives' access to resources, as well as their self-efficacy beliefs. In other words, this study proposes a theoretical framework to examine ICT use and health outcomes, focusing on both sociostructural (resources) and cognitive (self-efficacy) predictors that are associated with health knowledge.

The current study is conducted in the context of maternal and infant health practices in rural Indonesia. The empirical setting provides a unique opportunity to test the theoretical framework in two ways. First, CHWs such as midwives perform significant functions in developing countries, including pregnancy care, emergency obstetric care, management of infant illness, and improvement of nutrition (Haines et al., 2007). Thus knowledge held by CHWs plays

critical role in health practices. Second, rural Indonesia provides a useful context because it has shown a rapid growth of mobile phone penetration (International Telecommunications Union, 2007). The Indonesian Ministry of Communications and Information predicts mobile penetration will grow at a rate of 26.7 percent in the next two years, reaching half the population (Telecom Asia, 2007). With the rapid growth of mobile phone penetration combined with gains in economic affordability, the use of such everyday technologies will become increasingly popular among CHWs (for a review, see United Nations, 2007, Volume 1: Mobile applications on health and learning).

Mobile Phone Use and Access to Resources

Along with a variety of health intervention efforts to promote health knowledge, recent studies have evidenced the potential of information and communication technologies (ICTs). Studies have examined the role of ICTs in facilitating the improvement of health outcome in various domains, including knowledge, attitude, and behavior (e.g., Grigsby, 2002; Matusitz & Breen, 2007; Suggs, 2006). A well-established set of literature claims that the core role of ICTs in developing communities is enhanced communication and connectivity (e.g., The Wireless Internet Institute (W2i), 2003; United Nations Development Programme (UNDP), 2005; Wilson, 2004). In rural settings, studies have focused on telehealth and telemedicine such as video-conferencing (Nesbitt, Marcin, Daschbach, & Cole, 2005) as well as technological devices and applications in hospitals (Casey, Moscovice, & Davidson, 2006). Recently, relatively newer ICTs such as mobile phones and wireless technologies have proven to be effective in rural and remote environments by providing benefits such as low-cost deployment, flexible infrastructure, and community-shared resources. Several recent studies indicate that mobile phones can be adopted as an effective tool for health intervention (Husler, 2005; Kaplan, 2006).

In line with this set of literature, this study suggests that one way midwives' use of mobile phones may be useful is by improving access to health-related resources. Specifically, two types of resources need to be distinguished: formal resources, which reside in health institutions or medical professionals; and informal resources, which can be drawn from peer health workers. Mobile phone eases midwives' access to health information and they can easily seek professional support in the healthcare system (Chib, Lwin, Ang, Lin, & Santoso, 2008). Especially, given the geographic sparseness and lack of transportation infrastructure, timely access to community health resources has been considered as critical in rural communities. At the same time, informal resources are particularly relevant to developing communities where individual and social contacts are based on tight-knit relations. Use of mobile phones for is expected to enhance communication and interaction among peer health workers. In summary, it is hypothesized that use of mobile phone will help midwives better utilize their resources. Therefore:

H1: Midwives' mobile phone use is positively associated with their access to (a) institutional and (b) peer resources.

Determinants of Health Knowledge

It has been a long-standing pursuit to establish a comprehensive model that takes into account both individual and social factors that affect health outcomes. In particular, scholars have argued that previous approaches to health promotion have largely focused on individual cognitive determinants, often neglecting the social structure that surrounds those individuals (Green, Richard, & Potvin, 1996; Patrick, Intille, & Zabinski, 2005; Sallis & Owen, 2002).

Sociostructural Determinants: Institutional and Peer Resources

The importance of social structure in influencing individual health behavior has been

studied to a great extent. Because individuals are not isolated from social structure, the way in which they are embedded in institutions or groups is likely to influence their knowledge and behavior. Therefore studies have increasingly emphasized social contexts in addition to individual psychological and cognitive attributes. Past literature has identified the importance of interpersonal sources of information and communication in behavior change (e.g., Chaffee, 1982; Hornik, 1989), such as the influence of peers on sexual attitudes and behavior (Chia, 2006) and adolescent smoking behaviors (Gunther, Bolt, Borzekowski, Liebhart, & Dillard, 2006). The effects of personal networks on the processes of health behavior change have been suggested in a number of studies (e.g., Boer & Westhoff, 2006; Bond, Valente, & Kendall, 1999; Rogers & Kincaid, 1981; Valente & Saba, 1998). For example, in a study on the use of contraception for family planning in Bolivia, Valente and Saba found that the extent to which individuals are exposed to messages through their personal networks was more strongly associated with behavior change compared to the effect of mass-media campaigns. Further, Viswanath and Emmons (2006) studied how message effects can be moderated and mediated by social factors such as class, organizations, and neighborhoods.

As suggested above, two types of resources need to be distinguished: formal resources, which reside in health institutions; and informal resources, which can be drawn from peer health workers. First, formal resources refer to medical help and information from health institutions including doctors and professionals. Access to these resources is likely to be a predictor of health knowledge held by midwives. Second, informal resources involve those obtained from peer workers. It is suggested that information flow and interaction among colleague midwives is likely to influence midwives' knowledge as well. Bandura (1986) argued that the numbers and patterns of social linkages influence the conveyance of information. Further, Mphahlele and

Maepa (2003) found that knowledge is transmitted through social networks to a larger extent in rural communities. Further, as Valente and Saba (1998) suggest, discussion among network members can enhance learning and knowledge about the health topic. Therefore, the more the midwives have access to both formal and informal resources, the more they are likely to have better health knowledge from the interactions. Therefore, the following hypothesis is proposed:

H2: Access to (a) institutional resources and (b) peer resources is positively associated with midwives' health knowledge.

Cognitive Determinants of Health Knowledge: Self-Efficacy

The role of self-efficacy has been emphasized in the context of health communication to a great extent. Bandura (2003) suggests that given similar circumstances, self-efficacious individuals have greater perceptions and beliefs about their abilities, and therefore show greater tendency to exhibit agency than those who are low in self-efficacy. Self-efficacy thus becomes a critical determinant in acquisition of knowledge and skills, motivation, and performance accomplishment. Rimal's (2000) review of literature shows that people with higher self-efficacy are more likely to perform and sustain health behaviors than those with low self-efficacy. For example, self-efficacy of adolescents increased their resistance to negative peer pressure (Haignere, Freudenberg, Silver, Maslanka, & Kelley, 1997).

Social cognitive theory suggests that people's acquisition of knowledge, attitude, and behavior are mediated through individuals' cognition (Bandura, 1986). In this sense, the role of self-efficacy has been examined in the domain of health information and knowledge. Studies suggested that self-efficacy had significant effects on health-information seeking activities. For instance, more self-efficacious individuals will achieve more accurate health information and attitudes (Rimal, 2000, 2001) and subsequent actions (Rimal & Real, 2003). Rains (2008) also

argued for the role of self-efficacy in Internet-based health information seeking. Self-efficacy has also been found as an important determinant of breast cancer knowledge among low-income women (Chen, Diamant, Thind, & Maly, 2008).

A majority of previous research in self-efficacy has examined its effects on patients, such as in studies ranging from self-care (Wu et al., 2007), adoption of health behaviors (Maibach, Flora, & Nass, 1991), and presumed influence (Gunther & Storey, 2006). Although the role of self-efficacy for CHWs is a critical issue in rural health, there is only a small number of studies that provide evidence for this issue. In a study of remote workers, Meyers and Hearn (2007) find that self-efficacy in contacting peer colleagues supported tele-work productivity. In the current context of maternal health, this study hypothesizes the role of self-efficacy in midwives' health knowledge. Specifically, the more CHWs attain self-efficacy about their perceived capabilities of mobilizing and utilizing resources for accomplishing goals and dealing with problems, the more health knowledge they will have. Therefore:

H3: Midwives' self-efficacy beliefs are positively associated with their health knowledge.

Self-efficacy theory suggests prior experience as one of the factors that increases self-efficacy (Bandura, 2003). As individuals acquire positive experiences of completing a task, they will become more confident about their perceived capability. Human agency is critical in the sense that people have the potential for self-development, adaptation, and change in response to sociostructural influences (Bandura, 2001). Specifically, factors such as socioeconomic conditions, social structures, and educational effects do not directly impact human behavior. Instead, they are mediated by individuals' beliefs about their thoughts and actions. Of various mechanisms, self-efficacy is a core concept for explaining "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of

performances" (Bandura, 1986, p. 391).

Bandura (1995) also posits that an individual's self-efficacy can be influenced through specific and targeted interventions. As individuals increase their exposure to health information from various sources, and have greater information use and interaction with peers, they will become more aware of the issues and develop perceptions about their capabilities to utilize the resources. For example, a previous study found that users of Internet health information shows higher levels of self-efficacy in terms of accomplishing positive cancer-related health behaviors compared with nonusers (Bass et al., 2006). In highly co-dependent environments such as those of remote CHWs, access to institutional resources as well as peer resources becomes vital. For instance, by calling peer midwives about information needed for performing particular tasks, midwives will be able to develop confidence about their ability to solve problems. Therefore, this study suggests the following hypothesis:

H4: Access to (a) institutional and (b) peer resources is positively associated with midwives' self-efficacy beliefs.

Method

Subjects: Midwives in Indonesia

Indonesia has a poor record in childbirth-related health statistics. The maternal mortality rate reaches up to 262 per 100,000 births (Analen, 2007) and infant mortality reaches up to 35 infant deaths per 100,000 live births (BAPPENAS, 2007). Further, the lack of infrastructure is a significant problem in Aceh Besar province of Indonesia. The situation has worsened in the wake of the December 2004 tsunami that resulted in unprecedented destruction of infrastructure and widespread changes in access to health services. In Banda Aceh region in particular, lack of social infrastructure has become a significant problem since the tsunami (Chib, 2007).

Within the Indonesian context, the health service delivery system is organized at five levels: central, provincial, districts, subdistricts, and villages. *Puskesmas* (public health centers) at the subdistrict level deliver primary health care services via midwives, and are crucial for delivering maternal, newborn, and child health care. Growing attention has been paid to ICTs, including mobile phones, since they are expected to reduce health risks by improving the communication structure. This includes communication with senior midwives, obstetricians and community health institutions, access to information on handling complicated obstetrical cases and life saving treatments, and transfer of routine health data to a central information system. ICTs could also help midwives organize transportation to the closest hospital in an emergency.

A survey was conducted in November 2006 to assess midwives' knowledge, health practices, technology use, resource use, self-efficacy, and demographics. Approximately 600 midwives work in Aceh Besar region associated with 22 medical centers. Participating midwives were stratified by their referral public health centers as defined by the partner midwife association, Ikatan Bidan Indonesia (IBI). [More about how this sampling was conducted –what criteria were used for inclusion/exclusion, etc. Response rate.]. Data collection was performed on a total of 223 village midwives in fifteen subdistricts of Aceh Besar (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, and Darussalam).

The midwives who responded to the survey have been using mobile phones for approximately 2.7 years on average (minimum 1 month, maximum 12 years). [More information: Who is providing the mobile phones?, etc.] The average age of midwives who responded to the survey was 30 years old, with the youngest midwife being 23 years and the eldest being 46 years old. On average, the midwives have 7 years of midwifery work experience

(minimum 2 months, maximum 19 years).

Instrument and Measurement

The survey was created based on multiple sources (The Rapid Knowledge, Practices and Coverage (KPC) Survey by United States Agency for International Development (USAID); The Monitoring and Evaluation Toolkit by The Reproductive Health Response in Conflict (RHRC) Consortium; The Maternal and Newborn Standards and Indicators Compendium by USAID and CORE group). The questionnaire was translated into Bahasa Indonesian 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 of data management and data entry software was also provided so that the data collectors could enter the individual survey sheets during the survey. The survey sheets were then collated in their final form after the surveys were completed. Details on the measurement of each of the variables are explained below.

Mobile phone use. The extent of midwives' mobile phone use in general as well as for health information was measured by the following three items. First, midwives were asked about their frequency of mobile phone use on a 5-point scale of "Never" (1), "Rarely" (2), "Sometimes" (3), "Often" (4), and "Very often" (5). Second, the extent to which midwives use mobile phone as a source of health information was asked. Specifically, the questionnaire asked, "How often have you obtained health information in the past 30 days from mobile phone?" on a 5-point scale of "Never" (1), "Rarely" (2), "Sometimes" (3), "Often" (4), and "Very often" (5). Third, midwives' trust of health information obtained from mobile phone was asked by the following question: "How much do you trust the information about health from mobile phone", followed by a 4-point scale of "Not at all" (1), "A little" (2), "Some" (3), and "A lot" (4) ($\alpha = .65$).

Access to institutional resources. Access to institutional resources was measured by the following question: when you need medical information for your work, how likely are you to turn to the following resources? Institutional resources were divided into three types of health-related resources present in community institutions: health center personnel, gynecologist or doctor at hospital, and private gynecologist or doctor. The question was followed by a 5-point scale anchored by “Not at all likely” (1) and “Strongly likely” (5) ($\alpha = .75$).

Access to peer resources. Access to peer resources was operationalized by the frequency with which midwives obtained health information from people in the health center for advice about issues concerning midwifery. The question identified the frequency of midwives talking to up to five people they identified as their contacts, measured by a 5-point scale ranging from “Never” (1), “Rarely” (2), “Sometimes” (3), “Often” (4), to “Very often” (5). A composite measure was obtained by averaging the frequency of access to these contacts ($\alpha = .77$).

Self-efficacy beliefs. Efficacy was composed of eight items regarding midwives’ confidence about their abilities, which were drawn from Bandura’s (1986) suggested scales. The items specifically focused on their capability of accessing and using resources in the community: I feel confident that... I can use the health center for getting training related to my work; I can adequately use my training to deal with birth complications; the facilities/equipment provided to me are adequate to deal with birth complications; I can use the health center to get information for my work; I can store all the health data for my patients effectively; I can get a midwife coordinator to help me when I have a work problem; I can get another midwife to help me when I have a work problem; I can get a friend to help me when I have a work problem ($\alpha = .75$).

Health knowledge. Knowledge related to substantive areas in maternal health practices was assessed in the areas of family planning practices, pre-natal, and child delivery processes.

Midwives' responses to statements were recorded on a 5-point scale of "Strongly disagree" (1) to "Strongly agree" (5). Items were listed in a way to make higher scores on a scale represent more accurate knowledge. Midwives were tested on a total of thirty-four items, and a composite measure based on their average score was used as the indicator of health knowledge ($\alpha = .75$).¹

Control variables. Age and experience were included as control variables to test whether they influenced midwives' health knowledge. Older midwives as well as those with longer work experiences may have acquired greater knowledge about health. On the other hand, age or experience could be associated with inaccurate knowledge derived from traditional beliefs and values. Test of the effects of age and experience did not have a significant effect on health knowledge and therefore, the variables were excluded from the final model testing.

Analysis

Table 1 provides the correlations, means, and standard deviations of the variables incorporated in the final model testing. The hypothesized model presented in Figure 1 was analyzed using structural equation modeling (SEM) techniques (Bollen, 1989; Byrne, 1998; Jöreskog & Sörbom, 1996) with EQS 6.1. The model was run as a structural model in which the observed model was compared to the hypothesized model to demonstrate how well they fit. To evaluate the proposed structural equation models, we adopted commonly used model fit indices: χ^2 and its degree of freedom, Comparative Fit Index (CFI), Root-Mean-Square-Error-of-Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). To judge the adequacy of the model fit, we also applied the Hu and Bentler (1999) joint-criteria approach. A model was considered tenable when it achieved or approached $CFI \geq .96$ and $SRMR \leq .10$ or $RMSEA \leq .06$ and $SRMR \leq .10$. When our models achieved a reasonable model-data fit, we interpreted their paths to evaluate the hypotheses.

Results

Structural Model Testing and Hypotheses Testing

According to Hu and Bentler's (1999) joint criteria, the structural model reached an acceptable level of model fit (see Figure 2). We proceeded to interpret the model parameter estimates to test the hypotheses. Results for all structural paths are illustrated in Figure 2.

Hypothesis 1 expected positive relationships between the extent of mobile phone use and access to institutional (H1a) and peer (H1b) resources. We found support for both hypotheses: H1a: .52, $p < .01$ and H1b: .22, $p < .05$. In other words, midwives' mobile phone use was positively associated with access to both institutional and peer-network resources.

The second set of hypotheses assumed positive associations between midwives' access to institutional (H2a) and peer (H2b) resources and health knowledge. H2a was supported with a positive path coefficient (.26, $p < .001$), yet H2b was not supported (.00, *n. s.*). The results indicate that access to institutional resources had a direct positive effect on midwives' health knowledge, while access to peer resources did not.

H3 expected a positive relationship between self-efficacy beliefs and health knowledge in midwifery operation. The results showed support for the hypothesis (.16, $p < .05$): self-efficacy was positively associated with midwives' health knowledge. The next set of hypotheses predicted a positive association between access to institutional (H4a) and peer (H4b) resources and self-efficacy beliefs. The results indicated no support for H4a (-.05, *n. s.*), but significant support for H4b (.25, $p < .001$). These results show that midwives' access to peer resources increased their self-efficacy but access to institutional resources did not. [JN and I will add results about mediation test.]

Discussion

The major goal of this study was establishing and testing a theoretical model that explains the paths between mobile phone use and health knowledge in rural communities. In particular, the study focused on examining sociostructural factors (resource access) at the community level and cognitive factors (self-efficacy beliefs) at the individual level. CHWs in developing countries are critical intermediaries in the social structure who create linkages between higher-level health resources and patients. Therefore, facilitating health workers' access to resources is imperative, whether they come from institutional or peer sources. This study assessed whether mobile phones play a beneficial role in this process, and further, whether the increased mobilization of resources was associated with better health knowledge.

Overall, the results demonstrated the potential of mobile phones for rural health care where individuals lack direct access to health institutions and services. Specifically, results show that mobile phone use had a direct positive effect on midwives' access to institutional and peer resources. As shown in the support for Hypotheses 1a and 1b, the study suggests that technologies with networking capability, such as mobile phones, have the potential to facilitate communication between CHWs and higher institutions as well as among CHWs. The comparison of path coefficients suggests that mobile phones had a larger impact on midwives' access to institutional resources such as health centers and medical professionals (.52), than to fellow midwives (.22). These results indicate that mobile phones can play a role as effective tools in seeking institutional resources, such as for calling doctors or organizing transportation in emergency situations (Chib et al., 2008).

One of the goals of the study was to simultaneously examine the role of sociostructural and cognitive predictors of health knowledge held by midwives. The results suggested mixed support for the hypothesized relationships, and the differential processes found in terms of

institutional versus peer resources are worth further attention. First, as shown in the testing of Hypotheses 2a and 2b, access to institutional resources was positively associated with health knowledge (.26), while access to peer resources did not show a significant association. These results indicate that the more midwives had access to institutional resources such as health centers, hospitals, and medical professionals, the more accurate their knowledge was about midwifery operation. This suggested the potential benefit of established channels through which community healthcare facilities can provide training and education to the midwives.

The insignificant path between peer resources and knowledge merits consideration. The results suggest that although there might be potential support midwives can get through communicating with peer midwives, it was not necessarily translated into more accurate health knowledge. This suggests that information or knowledge circulated among midwives might not necessarily be the accurate ones, and might be susceptible to misconceptions. Misconceptions, which originate from a combination of ignorance, cultural beliefs and values, and lack of communication, have been addressed as an important barrier to health behavior and practices (Muturi, 2005). A number of studies show that in the realm of reproductive health and family planning in particular, misconceptions and traditional notions have impeded health behavior and practices (Ferguson, 1991; Johansen, 2006; Muturi, 2005). The results of the current study suggest the importance of examining the accuracy of health knowledge held by midwives, providing proper education and training, and consequently, making an effort for the communication among peer midwives to be a facilitator for the enhancement of health knowledge.

Another point to note is the support for Hypotheses 3. The results indicated that midwives' self-efficacy was positively associated with their health knowledge. These findings

imply that midwives' confidence about their use of resources had a positive association with health knowledge. Previous studies had shown that more self-efficacious individuals are likely to engage in a higher level of information seeking and knowledge acquisition (Rains, 2008; Rimal, 2001). Altogether, this study added to the emphasis on the reciprocal relationship between personal cognitive factors and behaviors (Bandura, 2003). The study also examined the relative influence of midwives' access to institutional resources and peer resources on their self-efficacy beliefs. As the results of H4a and H4b indicate, communicating with peer midwives had a positive effect on midwives' perceived capabilities about their work. This result suggests the potential social support generated through interaction among peer CHWs. On the other hand, while access to institutional resources did not have a significant association with self-efficacy beliefs (non-support for H4a) although it had a direct association with health knowledge (support for H2a). In other words, social or emotional support among peer workers can be considered as an antecedent of midwives' confidence, which is not obtainable through interaction with institutional sources of health information.

Another set of results from this study provides important theoretical understanding about cognitive processes of health knowledge. Based on social cognitive theory, the study suggests that use of technologies does not directly influence knowledge. Instead, they are mediated by individuals' cognitive systems, as measured by self-efficacy in the current study. This argument was supported in the case of peer resources. Interestingly, as was represented in the Sobel test of the paths suggested in H1b and H4b as well as H4b and H3, a notable mediation effect was found from mobile phone use to midwives' health knowledge. Specifically, there was a path between midwives frequent use of mobile phone in general and for obtaining health information from it, midwives' access to peer resources, midwives' self-efficacy beliefs, and finally, health

knowledge held by midwives. This finding is consistent with the propositions in social cognitive theory in that individuals' cognitions (e.g., self-efficacy) mediate the effects of social determinants (e.g., use of ICTs) on individuals' knowledge and attitudes.

This research provides several practical implications. In general, as emphasized in the call for theory-based health intervention strategies (Heeks, 2007), ICT intervention projects need to be based not only on the investment of technologies but also on follow-up strategies for having them mobilized for relevant tasks. First, the current study showed that mobile phones could be utilized as tools for better mobilizing resources via enhancing the communication structure within the community. Mobile phones can provide successful experiences with accomplishing goals – therefore, help midwives increase their perceived capability of utilizing resources and successfully carrying out midwifery tasks. As such, it needs to be emphasized that the effectiveness of health system infrastructure designed to support CHWs is dependent on the ability of the individuals to access available resources. Second, the importance of self-efficacy in the ICT intervention process was suggested by the results. It has been argued that the use of ICTs will aid in establishing the authority of CHWs among community members by providing critical medical information instantaneously (Ramachandran & Canny, 2008). Overall, studies have suggested that intervention strategies aimed for increasing patients' self-efficacy are effective (Chen et al., 2008).

While advancements in telemedicine and telehealth have been rapid, there has been relatively less attention paid to the potential of ICTs in everyday life that rely on the existing community social structure. In particular, communication structure that links health workers with institutional and community resources is of critical importance. The implementation of health care technologies has often faced challenges in rural settings (Bahensky, Jaana, & Ward, 2008).

One reason is the lack of economies of scale, which is caused by the limited number of patients as well as healthcare providers (Nesbitt et al., 2005). In this sense, this study emphasizes the potential associated with successful use of ICTs, such as mobile phones that are not initially designed for health care purposes. In particular, the benefits of mobile phone in enabling communication among peer workers are noticeable. As research on health care information technology advances, the importance of understanding the social structure of community such as the communication activities among peer workers will become more important.

This study also emphasized the role of midwives as intermediaries connecting higher-level health institutions to the local community. Considering the heavy reliance of local communities on midwives, the accuracy of health knowledge midwives hold about childbirth and family planning are critical to health risks such as mortality rates (Muturi, 2005). Further, negative effects from the presence of inaccurate health knowledge held by CHWs can be risky. Given the finding that midwives rely on peers for information, it is critical to enhance the knowledge of CHWs. Subsequently, facilitating the communication structure through which knowledge and resources can be shared will be essential for effective ICT-based health interventions.

Limitations and Future Research

Interpretation of the above findings needs to be made with caution, due to several limitations. First, the dispersed and remote nature of the health environment in which the study was conducted needs to be considered. The disconnection between the midwives and the formal health infrastructure may be the reason for some of the findings, such as the rejection of H4a. Thus it is to be noted that these findings may not be generalizable in a more contained health institutional setting and in more developed regions.

In this study the effects of ICTs on ultimate health outcome are left for further investigation. A considerable amount of research on the knowledge-attitude-behavior (KAB) paradigm has been conducted in the field of health communication (Hornik, 1989). This body of research explains the mechanism through which knowledge acquisition and attitudinal changes lead to behavior changes (e.g., Ajzen & Fishbein, 1980; Valente, Paredes, & Poppe, 1998). Although this study examined health knowledge as a critical health-related outcome, they may not necessarily translate into behavior. Therefore it is important to understand how health knowledge and attitudes may affect actual health behaviors (Burgoon & Hall, 1994). Further, this study did not incorporate indicators of health improvement such as infant and maternal mortality rates. An extended study setting both in terms of scale and length of observation would allow such important investigations.

There are a few methodological limitations in the study. First, the study does not guarantee the representativeness of the sample because the subjects were recruited nonrandomly from a single region in Indonesia. Other rural communities may have unique characteristics in terms of both CHWs and community health institutions. Second, the cross-sectional nature of the current study made it difficult to claim an over-time enhancement of health knowledge. If longitudinal data could be acquired it would be worthwhile to examine whether mobile phone use in a previous point of time affects resource access, self-efficacy, and knowledge at later time points. Third, most of the measures in this study were based on self-reports, including variables such as mobile phone use and access to resources. Therefore there may be social desirability bias associated with the responses of midwives. Ideally, future studies should consider including observed measures of these variables, such as statistics that might be obtained from mobile phone operators or health institutions.

Despite these limitations, results from this study suggest a number of possibilities for future research. First, the current study largely focused on the use of mobile phones as a basic voice-based communication tool. Yet, recent technological developments have opened up broader utilization of mobile phones. For example, mobile phones can be used as an enhanced system for health data transfer and information sharing. It is recommended that future studies consider these broader applications of mobile phones. In addition, the theoretical framework developed in this study can be applied to other types of communication technologies that are either present in the rural communities or provided as a part of intervention projects. These include not only traditional mass media (e.g., television, radio, newspaper) and information materials (e.g., posters, booklets) but also the Internet and more recent wireless technologies.

Second, the results demonstrate the importance of communication among peer networks. To further examine this aspect, future studies are encouraged to examine these patterns of interaction through social network approaches and methodologies. A body of literature deals with this issue in rural health context (e.g., Valente, 1995). Such an approach would allow making a fine-grained assessment of both structural position of individuals (e.g., centrality, brokerage, tie strength) and the overall network structure of a group of individuals (e.g., centralization, density, cliques, and clusters). Further, a more concrete examination of the effects of social structure and influence on health-related processes can be made.

Finally, the current study demonstrates the importance of understanding the social dynamics of communities through which the design and evaluation of ICT intervention projects can be improved. The unique research setting presented in the current study allowed us to highlight an underexamined area in health communication research: CHWs and their use of ICTs. This study also showed the importance of resource access and self-efficacy as determinants of

health knowledge. Further, this study compared resources that reside in institutions and peer workers. The framework and findings suggested in the study will help conduct longitudinal analyses of the effects of ICTs. Specifically, the findings can provide a useful framework for future projects aiming to extend the benefits of ICTs in reducing risks among pregnant women and children. In summary, this study added to the body of literature on the importance of theory-based design and evaluation of intervention projects (e.g., Fishbein & Cappella, 2006; Fishbein & Yzer, 2003) for effective health communication strategies.

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Footnote

¹ The following thirty-four items were used to test midwives' health knowledge. (R) indicates that the answers were reverse-coded so that higher score indicates more accurate health knowledge.

1. Family planning methods are effective to avoid pregnancy.
2. Condoms are effective to avoid HIV/AIDS.
3. Condoms can be used to avoid pregnancy.
4. Family planning is bad because it destroys the organ's functioning. (R)
5. Sexually transmitted diseases and AIDS only happen to homosexuals and prostitutes. (R)
6. Only husband can decide whether to participate in family planning. (R)
7. People need more money to participate in family planning. (R)
8. Contraceptives are hard to find. (R)
9. Participants of family planning come only from rich people. (R)
10. Hysterectomy is a permanent method of family planning. (R)
11. Participants of family planning give better education to their children. (R)
12. IUDs can cause perforation of the uterus. (R)
13. Participant of family planning give more care and love to their children.
14. Participant of family planning have more time for other activities.
15. Abortion is one method of family planning. (R)
16. After use of IUDs, women cannot have children ever again. (R)
17. Lack of salt avoids pre-eclampsy. (R)
18. Limit food and drink to avoid a large baby. (R)
19. Calcium supplementation tablets to avoid cramps. (R)
20. Lactating mother should not eat fish or egg. (R)
21. Partograf should be used with complicated pregnancies. (R)
22. Partograf helps midwife make decisions during child birth.
23. Women should do PAP smear.
24. Shaving of the pubis is a routine activity. (R)
25. Washing hands is a practice to avoid cross-contamination.
26. Magnesium sulfate therapy is more effective than Diazepam to manage convulsion on pre-eclampsy.
27. Iron supplementation and folic acid are effective to decrease anemia during child birth or 6 weeks after.
28. Needle and swab are only to be used once.
29. Ask mother to take long and deep breath during the child birth process. (R)
30. Use hand gloves before touching injured skin, mucous, blood or other body-fluid.
31. Use protective equipment such as glasses, masks, apron every time during work.
32. Cauterization of vesica urinaria is a routine activity. (R)
33. Torn hand gloves cannot be used anymore.
34. Problems at childbirth can be serious.

Table 1

Means, Standard Deviations, and Correlations of Variables in the Final Model (N =223)

<i>Variable</i>	<i>Mean (S.D.)</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>	<i>12</i>	<i>13</i>	<i>14</i>	<i>15</i>
1. Mobile phone use (frequency)	3.61 (.88)	1														
2. Mobile phone use (obtain health information)	2.54 (1.18)	.23**	1													
3. Mobile phone use (trust health information)	2.53 (.73)	.08	.42**	1												
4. Institutional resources (health center personnel)	4.17 (.70)	.12	.02	.08	1											
5. Institutional resources (gynecologist/doctor at hospital)	3.78 (.93)	.05	.13	.08	.32**	1										
6. Institutional resources (private gynecologist/doctor)	3.63 (.92)	.12	.19**	.25**	.29**	.68**	1									
7. Peer resources	3.71 (.58)	.14*	.09	.15*	.29**	.14*	.21**	1								
8. Self-efficacy (get training from health center)	4.31 (.63)	.03	.02	.04	.08	-.04	.03	.20**	1							
9. Self-efficacy (training for birth complications)	4.16 (.78)	-.04	-.05	.04	.10	.04	.12	.10	.35**	1						
10. Self-efficacy (facilities for birth complications)	4.27 (.86)	.01	-.13	-.03	.10	.01	.17*	.07	.35**	.35**	1					
11. Self-efficacy (information from health center)	4.31 (.58)	.07	-.09	-.01	.12	-.11	-.02	.08	.36**	.24**	.35**	1				
12. Self-efficacy (health data storage)	4.31 (.69)	.05	-.01	.06	.12	.01	-.02	.18**	.33**	.27**	.32**	.40**	1			
13. Self-efficacy (help from midwife coordinator)	4.24 (.69)	.14*	.05	.23**	.10	.01	.08	0.11	.30**	.14*	.28**	.31**	.20**	1		
14. Self-efficacy (help from another midwife)	4.11 (.72)	.09	.06	.11	.25**	.00	.13	.20**	.22**	.09	.21**	.31**	.16*	.47**	1	
15. Self-efficacy (help from friend)	3.90 (.86)	.12	.06	.07	.20**	-.06	-.05	.20**	.22**	.07	.10	.36**	.19**	.21**	.48**	1
16. Health Knowledge	3.76 (.21)	.17*	.03	.10	.23**	.23**	.17*	.10	.05	.10	-.05	.10	.10	.05	.19**	.08

Note. * $p < .05$, ** $p < .01$.

Figure 1. Hypothesized model of midwives' mobile phone use, access to resources, self-efficacy, and health knowledge

Figure 2. Summary of hypothesis testing results: Structural model of midwives' mobile phone use, access to resources, self-efficacy, and health knowledge.