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Cell Phones to Collect Pregnancy Data From Remote Areas in Liberia

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Abstract

Purpose: To report findings on knowledge and skill acquisition following a 3-day training session in the use of short message service (SMS) texting with non- and low-literacy traditional midwives.
Design: A pre- and post-test study design was used to assess knowledge and skill acquisition with 99 traditional midwives on the use of SMS texting for real-time, remote data collection in rural Liberia, West Africa.
Methods: Paired sample t-tests were conducted to establish if overall mean scores varied significantly from pre-test to immediate post-test. Analysis of variance was used to compare means across groups. The nonparametric McNemar's test was used to determine significant differences between the pre-test and post-test values of each individual step involved in SMS texting. Pearson's chi-square test of independence was used to examine the association between ownership of cell phones within a family and achievement of the seven tasks.
Findings: The mean increase in cell phone knowledge scores was 3.67, with a 95% confidence interval ranging from 3.39 to 3.95. Participants with a cell phone in the family did significantly better on three of the seven tasks in the pre-test: "turns cell on without help" ($\chi^2(1) = 9.15$, $p = .003$); "identifies cell phone coverage" ($\chi^2(1) = 5.37$, $p = .024$); and "identifies cell phone is charged" ($\chi^2(1) = 4.40$, $p = .042$).
Conclusions: A 3-day cell phone training session with low- and nonliterate traditional midwives in rural Liberia improved their ability to use mobile technology for SMS texting.
Clinical Relevance: Mobile technology can improve data collection accessibility and be used for numerous health care and public health issues. Cell phone accessibility holds great promise for collecting health data in low-resource areas of the world.

There is a well-recognized irony when considering rural health care in low- and middle-income countries: while there is limited access due to poor roads and geographic distance, at the same time, there is widespread access to cellular phones, with instantaneous communication across great distances. A report in 2010 by the International Telecommunication Union (ITU) reported over 5 billion wireless subscribers. Over 90% of the world's population and 80% of the population living in rural areas have access to mobile networks (ITU, 2010). Mobile communications are experiencing faster rates of growth in low- and middle-income countries compared with developed countries (ITU, 2011), with Africa being the fastest-growing market (ITU, 2009; Vodafone, 2005).

Indeed, the infrastructure and technological resources that support cellular phones has far outpaced general health promotion services such as transportation infrastructure, clean water, dependable electricity, and even adequate sewage systems (Byass & D'Ambruoso, 2008; Vital Wave Consulting, 2009; World Health Organization [WHO], 2011). Even in many poor rural corners of the world there is access to cellular telephone technology (Vital Wave Consulting, 2009; WHO, 2011).

The purpose of this article is to report on knowledge and skill acquisition following a 3-day cell phone training session in the use of a short message service (SMS) texting protocol employing a pre- and post-test study design with 99 traditional midwives (TMs).

Mobile Technology in Health Care

Given the global use of cellular phones, it is not surprising that the use of mobile technologies in health care and health research is rapidly increasing. The increased availability and use of mobile technology has been described by Berg and Modi (2010) as a paradigm shift, systematically changing the way healthcare interactions take place and altering public health data collection.

To foster the growth of mobile technology use in healthcare settings, multiple public and private partnerships have formed around the concept of mobile health (mHealth; Epstein & Bing, 2011). Although no standardized definition exists, mHealth has been defined by the WHO as the "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices" (2011, p. 6). mHealth is currently being utilized in low-resource countries in four key areas to improve health: (a) communication and training for healthcare workers, (b) increased access to healthcare education and information, (c) enhanced monitoring to track and diagnose diseases, and (d) improved accessibility to public health information (Epstein & Bing, 2011; Vital Wave Consulting, 2009). In addition, mobile technology can also be used to improve communication among healthcare providers. Following a review of the challenges to the management of postpartum hemorrhage in low-resource countries, Karoshi and Keith (2009) recommended that cell phones be considered as a means to improve communication between healthcare workers and communities.

The use of mobile technology in health care has resulted in both clinical and process improvements in studies evaluating its link with transmitting health information and education (Krishna, Boren, & Balas, 2009). Developed countries are engaged in more mHealth activities than low-resource countries (WHO, 2011). For example, in developed countries, mobile technology has been used to improve training, supervision, and accessibility of learning resources or continuing education for healthcare providers and students (Frank, Adams, Edelstein, Speakman, & Shelton, 2005; Walton, Childs, & Blenkinsopp, 2005). Mobile technology is also being employed as a means to provide health information on such topics as sexually transmitted infections (Menon-Johansson, McNaught, Mandalia, & Sullivan, 2006), smoking cessation (Rodgers et al., 2005), and obstetric care (Tezcan, Von Rege, Henkson, & Oteng-Ntim, 2011). Additionally, mobile technology is being utilized to monitor individuals with preexisting health conditions such as asthma (Cleland, Caldow, & Ryan, 2007), to track and provide support of medication adherence in chronic diseases such as HIV/AIDS (Vidrine, Arduino, Lazev, & Gritz, 2006), and to improve glucose levels in patients with diabetes (Cho, Lee, Lim, Kown, & Yoon, 2009). According to a systematic review by Krishna et al. (2009), chronic diseases and health conditions that require ongoing support and management benefit the most from cell phone interventions.

Cell Phone Use in Liberia

In 2005, postconflict Liberia had one of the lowest rates of cell phone ownership among African countries (Vodafone, 2005). Liberia suffered a civil war lasting from 1989 to 2003 destroying most of the fixed-line telephone infrastructure (Best et al., 2007). Due to the lack of communication infrastructure, cell phones became a necessary mode of communication. The Liberia Telecommunications Authority was established in 2003 to facilitate organization and control of the newly developed communication industry (Public-Private Infrastructure Advisory Facility, 2011). Since that time, the number of cell phone carriers has remained steady, including Lonestar Communications Corporation, Comium, LiberCell, and Cellcom (Public-Private Infrastructure Advisory Facility, 2011). The rate of cell phone penetration has steadily increased from approximately 15% in 2008 (ITU, 2009) to 45% in 2011 (Public-Private Infrastructure Advisory Facility, 2011). Alternately, the WHO (2011) reported mobile cellular subscriptions at 21.29 per 100 population members in Liberia, ranking it among the lowest of its member states.

Guiding Framework

Social empowerment theory was used as the guiding framework for our study. Social empowerment refers to the expansion of mechanisms by which people can express their needs and concerns, devise strategies for involvement in decision making, and achieve political, social, and cultural action to change conditions that affect their lives (Zimmerman, 2000). Social empowerment allows groups to collectively gain greater influence and control over the determinants of health and the quality of life in their community (Purdey, Adhikari, Robinson, & Cox, 1994).

Mobile technology can contribute to social empowerment, especially in rural and under-resourced communities where the potential to elicit significant social and economic change exists (Sofowora, 2009). Social empowerment expands individual and collective freedom of choice and the ability of community members to take action, which in turn increases a sense of authority and control over the resources and decisions that impact their well-being (Perkins & Zimmerman, 1995; Zimmerman, 2000).

Methods

The training sessions were conducted as part of a larger U.S. Aid for International Development (USAID) funded project, currently underway, to evaluate the feasibility of maternity waiting homes as a mechanism to overcome the critical barrier of distance to women accessing safe delivery services in rural health facilities. Discussions with the Liberian Ministry of Health and Social Welfare (MOHSW) prior to implementation of the study revealed the lack of accurate data on the number of pregnancies in rural areas. Effective pregnancy registration and utilization of services requires community awareness. The MOHSW requested collection of data on the number of pregnant women and number of teen pregnancies in the catchment communities being studied. A catchment community refers to the geographic area served by a rural health clinic. This geographic area is relatively large and contains many small villages. This remote data collection is needed by the ministry to inform programmatic and policy decisions. Institutional review board approval was obtained from the University of Michigan, Health Sciences and Behavioral Sciences Review Board, and cleared with the Liberian MOHSW.

Study Setting and Participants

Toward the goal of better understanding whether cell phone technology can be used in low-resource countries to collect health data, a team of three U.S.-based researchers trained one Liberian research nurse and 11 two-person teams of certified and TMs in the construction and use of short message service (SMS) text messages to transmit pregnancy data from their rural, remote communities in Liberia using a training of trainers (TOT) model. In turn, these 11 two-person teams, termed master trainer teams, returned to their communities and with the support and supervision of the Liberian research nurse trained 99 low- and nonliterate TMs in the SMS protocol. A standardized protocol for teaching was developed and used in all community training sessions by the research nurse and master trainer teams. The training sessions included pictorial handouts with graphic designs of the cell phones (and how to use them). These training materials were provided to all participants and used to guide the training.

Data collectors were TMs recruited from one north-central rural county in Liberia where the majority of the population identifies as Kpelle, the largest indigenous ethnic group in the country (Lori & Boyle, 2011). Rural clinics, routinely staffed by one certified midwife and one registered nurse or physician assistant, provide maternity care for approximately 2,000 to 20,000 residents, while the TMs provide support to pregnant women in the community. Because TMs are trusted members of their communities and often engage with pregnant women, even before they are seen in a clinic, we chose them to collect and remotely transmit data.

Ninety-nine low- or nonliterate TMs, recruited from catchment communities by the certified midwife posted at the referral clinic, were trained as data collectors. Inclusion criteria to serve as a data collectors included (a) active in supporting pregnant women in their communities, (b) willing to work with clinic staff to identify pregnant women from their communities, (c) willing to take part in a 3-day cell phone training session, and (d) fluent in Kpelle or English. Each of the 99 data collectors was given a cell phone, a charger, and a solar panel to charge their phones.

Study Design and Data Collection

Eleven teams of master trainers, each composed of a certified midwife and a TM, were selected from the 10 clinic areas identified for inclusion in the larger USAID-funded study. An additional team from the referral hospital outpatient department was also included. Two 6-day TOT workshops were held for the master trainer teams, with half the participants in each 6-day training session held at a central location. Content of the workshops included how to use the mobile phone using pictographic instructions and interactive exercises allowing the learner to sequentially build messages and send them in real time. The two-person master trainer teams then returned to their home communities to conduct and lead a 3-day training session with TMs at the rural healthcare center. Between March and July 2011, the master

Table 1. Pregnancy Reporting Protocol

Pregnancy	Unique ID	Unique Location	Age	Referred to Clinic
Enter: 9	–	–	Enter: Age or 99 for unknown	Enter: 1 for Yes 0 for No

Table 2. Items on Pre- and Post-Test Cell Phone Skill Checklist

1. Able to turn on cell phone without help
2. Able to use cell phone to make a call
3. Able to recognize they are in a cell phone coverage area (identifies bars)
4. Able to recognize the cell phone is charged (identifies battery icon)
5. Able to create a SMS text message without help
6. Able to send a SMS text message without help
7. Able to use a scratch card to add minute credit to the phone

trainer teams were responsible for teaching the cell phone protocol to an additional 99 TMs (9 from each of the 10 rural clinics plus 9 from the referral hospital area).

The TMs were instructed in cell phone use for SMS texting and taught a simple 10-digit pregnancy reporting protocol (**Table 1**). Each data collector was assigned a unique three-digit ID code and a unique three-digit location code, making the first seven digits of the protocol repetitious for each SMS report.

Master trainer teams were supported in this training by the Liberian research nurse on the larger USAID-funded project trained in the SMS protocols. All data collectors were provided with a cell phone to use for SMS texting, cell phone minutes (distributed throughout the project by the certified midwife assigned to the clinic), pictorial instructions, and reading glasses to assist those older TMs who experienced difficulty seeing the small screen or keypad of the cell phone.

When a pregnant woman was identified in the community by the TM, she sent an SMS text of the sequenced protocol to a secure, remote server using a preprogrammed number on her phone. She then gave the pregnant woman a pink wristband to wear until she delivered her baby. The bracelet was to prevent double counting by another data collector.

A pre- and post-test design was used to assess knowledge and skill acquisition with the 99 TMs who became the data collectors. Prior to the start of the training session, basic demographic information was collected, including the data collector's age, sex, and whether anyone in her immediate family owned a cell phone. Using a skill checklist, data collectors were asked to perform seven cell phone skills in a pre-test prior to the start of the training session. **Table 2** shows the skills evaluated on the checklist. These skills were then reevaluated in a post-test demonstration at the end of the 3-day training period.

Table 3. Percentage of Correct Responses on Individual Pre- and Post-Test Items ($N = 99$)

Skill	Pre-test n (%)	Post-test n (%)[a]
Turns on cell without help	31 (31.3)	98 (99.0)
Makes call without help	35 (35.4)	69 (69.7)
Identifies cell coverage	29 (29.3)	76 (76.8)
Identifies cell is charged	27 (27.3)	95 (96.0)
Creates text without help	1 (1.0)	74 (74.7)
Sends text without help	1 (1.0)	46 (46.5)
Adds credit by scratch card	3 (3.0)	28 (28.3)

[a] All items significantly different from pre-test score ($p < .001$ by McNemar test).

Data Analysis

Data were analyzed using IBM SPSS Statistics 19.0 (SPSS, Inc., Chicago, IL, USA). To evaluate the impact of cell phone training on the participants' cell phone knowledge, paired sample t tests were conducted to establish if overall mean scores varied significantly from pre-test to immediate post-test. Analysis of variance (ANOVA) was used to compare means across groups. To assess for skill and knowledge acquisition of the seven critical steps involved in SMS texting, the nonparametric McNemar's test was used to determine significant differences between the pre-test and post-test values. Pearson's chi-square test of independence was used to examine the association between ownership of cell phones within a family and achievement of the seven tasks. All p values were two-tailed and set at .05.

Findings

Ninety-nine TMs were trained as data collectors by two-person master trainer teams at 11 different sites in north-central Liberia. All data collectors were female and ranged in age from 22 to 68 years ($M = 42$ years).

Analysis of the data revealed a statistically significant increase in total knowledge scores from the pre-test ($M = 1.27$, $SD = 1.73$) to the post-test ($M = 4.94$, $SD = 1.41$; $t\ (98) = 25.93$, $p < .001$) using the cell phone skills checklist. The mean increase in cell phone knowledge scores was 3.67, with a 95% confidence interval ranging from 3.39 to 3.95. The data collectors also demonstrated a significant increase in their ability to perform each individual cell phone task (**Table 3**).

A large proportion of our participants (73.7%) reported cell phone ownership within their families. In order to evaluate whether family ownership of cell phones impacts knowledge scores, the data were also analyzed by groups based on whether the participants reported cell phone ownership in their families. This analysis indicated

Table 4. Pre- and Post-Test Performance Scores on Individual Items by Group ($N = 99$)

	Cell phones in family $n = 73$ (73.7%)			No cell phones in family $n = 26$ (26.3%)		
Skill	Pre-test *n* (%)	Post-test *n* (%)	*p*	Pre-test *n* (%)	Post-test *n* (%)	*p*
Turns on cell without help	29 (39.7)	72 (98.6)	< .001	2 (7.7)	26 (100.0)	< .001
Makes call without help	30 (41.1)	52 (71.2)	< .001	5 (19.2)	17 (65.4)	< .001
Identifies cell coverage	26 (35.6)	59 (80.8)	< .001	3 (11.5)	17 (65.4)	< .001
Identifies cell is charged	24 (32.9)	70 (95.9)	< .001	3 (11.5)	25 (96.2)	< .001
Creates text without help	1 (1.4)	59 (80.8)	< .001	0 (0)	15 (57.7)	< .001
Sends text without help	1 (1.4)	40 (54.8)	< .001	0 (0)	6 (23.1)	.031
Adds credit by scratch card	3 (4.1)	26 (35.6)	< .001	0 (0)	2 (7.7)	.500

there were significant differences in the mean number of cell phone skills the participants were able to complete between the pre-test and post-test in both groups. The mean increase in cell phone knowledge scores for the "cell phone in family group" was 3.67 ($SD = 1.46$; $t\ (72) = 21.44$, $p < .001$), while the "no cell phone in family group" displayed a mean increase in knowledge scores of 3.65 ($SD = 1.26$; $t\ (25) = 14.75$, $p < .001$).

Additional analyses of the data collectors' ability to perform each individual skill between the pre-test and immediately post-test indicated significant gain for those with cell phones in their family on all seven skills (**Table 4**). However, data collectors who reported they did not have cell phones in their families demonstrated a significant increase in their ability to perform six of the seven tasks.

Pearson's chi-square test was performed to detect whether there was a significant association on the pre- and post-test between groups (those with cell phones in the family and those without cell phones in the family). Participants with a cell phone in the family did significantly better on three of the seven tasks in the pre-test: "turns cell on without help" ($\chi^2(1) = 9.15$, $p = .003$); "identifies cell phone coverage" ($\chi^2(1) = 5.37$, $p = .024$); and "identifies cell phone is charged" ($\chi^2(1) = 4.40$, $p = .042$).

There was no significant difference between the two groups on the pre-test for the more difficult tasks: "creates text without help," "sends text without help," and "adds credit by scratch card." However, those participants with cell phones in the family did significantly better on the post-test for these complex tasks: "creates text without help" ($\chi^2(1) = 5.43$, $p = .034$); "sends text without help" ($\chi^2(1) = 7.75$, $p = .006$); and "adds credit by scratch card" ($\chi^2(1) = 7.37$, $p = .006$).

A one-way between-groups ANOVA was then conducted to explore the impact of training location on skill acquisition. This analysis revealed there was not a significant difference in cell phone skill acquisition between locations (F (10, 88) = 1.08, $p = .390$). Post-hoc comparisons using the Tukey honest significant difference (HSD) test indicated no significant differences between groups. These finding demonstrate no significant differences in the knowledge attained by the TMs during the educational sessions conducted at the 11 different locations.

Discussion

Cell phones are a fundamental technology in modern life in both low-resource and developed countries, providing users with the ability to easily communicate with individuals in all corners of the world. Using an intervention designed to improve antiretroviral therapy adherence in HIV-positive patients in Kenya, Lester and colleagues (2010) found that rates of medication adherence and viral suppression were improved with the use of SMS text messaging. The Cell-PREVEN study reported successful use of mobile technology to collect data on adverse events related to metronidazole administration for bacterial vaginosis in Peru (Curioso et al., 2005). The project demonstrated that cell phones are a feasible method of real-time data collection, allowing rapid analyses of data and reporting back to the community (Curioso et al., 2005). Cell phone accessibility holds great promise for collecting health data in low-resource countries.

This study is one of the first to evaluate a training protocol using SMS technology for data collection in a low-resource rural setting with low- and nonliterate participants. The results demonstrate that a 3-day training protocol, using a TOT model, was able to improve overall knowledge and skill acquisition related to cell phone use regardless of previous cell phone ownership or training location. Our findings suggest that TMs without cell phones in their families had greater difficulty learning more complex tasks. This finding recognizes that data collectors with less baseline cell phone knowledge may need additional training and practice on the more complex skills related to cell phone use.

Poor infrastructure challenges data collection in remote, rural areas. Our findings corroborate the work of Andreatta, Debpuur, Danquah, and Perosky (2011), who examined the use of a cell phone protocol with low-literacy, community-based healthcare providers to report health-related outcome data in Ghana. However, reports of data collection protocols in the literature with low-literacy participants are scarce.

Our data show that low- and nonliterate data collectors can be trained in the use of cell phones for the purpose of transmitting basic health data for health research. However, we recognize the limitations with our study design, and thus, our data should be viewed as preliminary. We used a convenience sample of certified and traditional midwives. These midwives may not be representative of other groups that could be trained as data collectors. We also chose a country with relatively low cell phone coverage. It is possible that in other countries, potential data collectors may have greater knowledge of cell phones and demonstrate better competencies or learn more quickly. Despite these acknowledged limitations, this study is important. It provides evidence that in a postconflict country with no established electrical grid, low- and nonliterate women can be taught to use cell phones and to transmit health data from remote, rural areas.

Undeniably, mobile technology and its feature of SMS text messaging offer an innovative and advantageous way to involve those in the margins of society– who may live in hard-to-reach areas, may be illiterate, or may have stigmatizing illnesses– to be involved in healthcare data collection (Villagran, 2011). Mobile technology can improve data collection accessibility and be used for numerous healthcare and public health issues. It has the potential to avoid data entry errors and storage costs associated with paper surveys (Tomlinson et al., 2009). mHealth initiatives allow for immediate digitization of data to facilitate speedy data aggregation and analysis (Patnaik, Brunskill, & Thies, 2009).

Conclusions

Ongoing data collection and record keeping are a challenge in low-resource areas. A defined protocol for SMS texting requires minimal skills. A 3-day cell phone training session with low- and nonliterate TMs in rural Liberia improved their ability to use mobile technology for SMS texting. This training protocol has implications for structuring future training to conduct mobile technology data collection in low-resource countries.

This intervention has the potential to involve community stakeholders by strengthening basic life skills and capacities of individuals, as well as influencing underlying social and economic conditions, which impact upon health (Laverack, 2006). Simple text messaging can potentially be used to address old problems in new ways and empower community members to gain greater control over decisions and actions affecting their health. Our findings reveal one way forward in the use of mHealth as a means to improve data collection of public health information. Remote data collection can be used to provide information in real time with the potential to improve healthcare service delivery and health outcomes. SMS texting from community members presents one way to fill data collection gaps and identify service delivery needs.

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Clinical Resources

- Information and Communication Technologies and Development, http://hdl.handle.net/1721.1/60077
- mHealth for Development: The Opportunity of Mobile Technology for Healthcare in the Developing World, http://www.mobileactive.org/files/file_uploads/mHealth_for_Development_full.pdf
- mHealth: New Horizons for Health Through Mobile Technologies, http://www.who.int/goe/publications/goe_mhealth_web.pdf
- Africa: The Impact of Mobile Phones, http://www.sarpn.org/documents/d0001181/P1309-Vodafone_March2005.pdf
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- Wireless Technology for Social Change: Trends in Mobile Use by NGOs, http://mobileactive.org/files/MobilizingSocialChange_full.pdf
- Towards the Development of an mHealth Strategy: A Literature Review: http://www.mobileactive.org/files/file_uploads/WHOHealthReviewUpdatedAug222008_TEXT.pdf

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