Mtoto: Supporting Greater Access to Pre-and Post-Natal Care for Women Living in Rural Developing Economies

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Abstract

Regions in sub-Saharan Africa face many challenges around adequate healthcare services for their populations. One particular problem is the high mortality rate of mothers who live in rural areas. One of the most critical interventions for safe motherhood is ensuring that skilled professionals provide adequate care during pregnancy and childbirth. Given the challenges of providing quality pre- and post-natal care to women in developing regions, we examine the participatory design of a mobile app for pregnant and new mothers living in the rural town of Laare, Kenya. Results from two previous studies inform the design of a mobile app, MTOTO (Swahili for "baby") and provide insight into the notion of literacy, implications for the design of tools and technologies for women experiencing motherhood, and a framework for engaging targeted end-users as co-designers of tools and technologies.

Keywords: pre-natal, post-natal, mobile app, mother, baby, MTOTO

1. Introduction

Regions in sub-Saharan Africa face many challenges around adequate healthcare services for their populations. One particular problem is the high mortality rate of mothers who live in rural areas (WHO, 2010). One of the most critical interventions for safe motherhood is ensuring that skilled professionals provide adequate care during pregnancy and childbirth (WHO, 2010).

Across Kenya, 75% of all maternal deaths occurred during delivery and the immediate post-partum period with 58.7% of all births taking place at home. Rural Kenya has 81% of all births occurring across the country, and yet only 34.5% of those births had a skilled birth attendant (SBA) present at delivery as opposed to 72% of births in urban Kenya (representing only 19% of all births across the country) (ORC Macro, 2007). Given that the average Kenyan woman will have approximately

4 children by the end of her reproductive age (most likely in the absence of a skilled birth attendant) and the high percentage of maternal deaths occurring during and after delivery, ensuring that mothers in this community are healthy during pregnancy, delivery, and immediately after delivery is an extremely important healthcare issue that warrants research.

1.1 Demographic Information: Laare, Kenya

Our research focuses on Laare, a small rural market town that lies on the cusp of central and eastern Kenya. Laare has only one medical doctor for its population of 65,000, one government health center and two dispensaries, or small clinics (Thomas, 2009). The closest major hospital (i.e., one that has such services as x-ray, MRI, etc.) is in Nairobi, which is over 200 miles away. This distance would take 6 hours to travel by bus which for this community is cost-prohibitive. The two dispensaries are manned by healthcare professionals (i.e., nurses) that possess the skill set to treat minor injuries.

However, the dispensaries do not contain basic medical devices (e.g. blood pressure cuffs) and therefore, are unable to diagnose diseases that are prevalent in people of African descent (e.g., diabetes, hypertension, etc.) or those that may occur during pregnancy or shortly after labor and delivery (e.g., pre-eclampsia, toxemia, postpartum hypertension). In fact, a needs assessment survey of the larger Laare population identified medical practices and public health resources, identifying pre-and post-natal care as the third most important healthcare issue that needed to be addressed within that community (Mibuari, 2008).

1.2 Mobile Phone Use across Kenya

The use of mobile phones (aka cell phones) has increased enormously over the last 10 years, with over 6 million people owning a cell phone and subscribing to cell phone service in 2006, compared to only 2.7 million people who use the Internet (Eriksson, 2008). One in three adults in Kenya owns a cell phone (Mwakugu, 2007), and Kenyans use cell phones for all kinds of social, economic, and communicative tasks such as making calls, sending and receiving money, job hunting, and to a lesser extent, surfing the Internet (Eriksson, 2008; Fahamu, 2007; Clark, 2007; Nzwilli, 2010). Several factors have made Internet access through traditional broadband or wired means difficult, and these same factors have decreased the demand for landlines for people living in rural areas in Kenya. First, landlines are expensive to install. Second, the physical roads are poorly developed, which has lead to both a poorly developed communication infrastructure as well as a lack of widespread electricity. Third, maintenance of landlines is often poor and other environmental factors such as floods and the stealing of copper cables over which communications travel have resulted in landlines that frequently do not function properly.

The majority of communication happens via Short Message Service, or SMS, a communication service component of the Global System for Mobile Communications (GSM) which uses standardized communications protocols that allow the exchange of short text messages between mobile phone devices (Eriksson, 2008; Mibuari, Interview Notes, 2009). GSM is the most popular standard for mobile telephone systems in the world. SMS is cost-effective and efficient as a form of communication, allowing users to receive and reply to short messages at any time. For example, before the advent of cell phones, sending money to one's friends and family required waiting until someone was traveling up-country by bus to be able to pass the money along to their family and friends living there (Eriksson, 2008; Mibuari, Interview Notes, 2009). However, with the creation of cell phone functions or "apps", like M-Pesa (M stands for mobile, and Pesa means "money" in Swahili), users are able to go into a local Safaricom shop, a major cell phone company in Kenya, load money on the cell phone account which is then converted into "mobile money", and transfer it to the recipient via SMS. The recipient goes to a Safaricom shop, shows the code and identification, and collects the money (Mason, 2007). Many Kenyans also have access to phones that support images and Internet access (Thomas et. al., 2011; Thomas et al., 2014).

1.3 Leveraging Cell Phones for Maternal Health

Cell phones are being used in many parts of Africa in an effort to decrease the number of maternal and infant deaths. IRIN (2009) has reported a drop in the number of women dying during childbirth in a village in South-central Ghana. Prior to 2008, approximately 20 women died in childbirth each year, bleeding to death while trying to get word to an ambulance service to take them to the hospital. In 2008, after phone and Internet technology were introduced to this small village in Ghana, no women died in childbirth (IRIN, 2009).

In this instance, Ericsson teamed with Zain, a mobile telecommunications firm, to install Internet access and mobile phone coverage in the village in 2006, providing free handsets to health workers and selling handsets to villagers for US$10 each. While this approach was effective in this small South-central Ghanaian village, the ability to scale such an effort to all rural towns and villages in Africa is unknown, as attempts to lay broadband across the entire continent have been a slow and expensive effort happening over the last 10 years (IRIN, 2009).

1.4 Goals and Purpose of Our Research

While there is a wealth of research that focuses on maternal health for women living in urban areas in developing economies like Kenya (e.g., Silimperi, 2009; Ziraba, et. Al, 2009; Stanback, et.al, 2007), there exists a paucity of research that focuses on maternal health for Kenyan women living in rural areas, specifically research that focuses on leveraging cell phones to deliver pre-and post-natal information and services for rural Kenyan women. As such, the long-term goals of this research are to: 1) decrease the number of maternal deaths that occur during delivery and the immediate postpartum period; and 2) increase access to information and healthcare services for rural Kenyan women and their children.

Given the challenges women living in rural Kenya face, cell phones can provide access to crucial pre- and post-natal information for both mothers and those that assist them during labor and delivery. Our previous research indicates that leveraging existing technologies within a community and enlisting members of the community to be co-designers (not just consumers) of new tools and technology leads to successful adoption of these tools and technology, thereby creating a new community of practices that have a long-term impact on the community (Rankin, et. al., 2009; Thomas, et. al, 2011). Therefore, we focus on the participatory design of a mobile application called MTOTO (Swahili for 'baby') that provides new mothers with just-in-time pre-natal care information and that engages Laarean women as codesigners. In this section, we will present the method, findings, and implications for the two studies we have conducted thus far to help us understand the pre- and postnatal needs of women in this community as well as to engage them in the co-design of MTOTO.

2. Study 1: Understanding Pre- and Post-Natal Needs

2.1 Method

We wanted to understand not only what kinds of pre-and post-natal services are currently available to women in rural Laare, Kenya, but also how women in this community learn about and access these services. We also wanted to understand the use of cell phones by both service providers as well as women in this community who use pre- and post-natal services. Given that we could not initially travel to Kenya to observe and interview this community, we decided that we would utilize a local Laarean community member and fellow researcher to administer a survey to gather initial insights to inform and shape our understanding of the pre-and post-natal services ecosystem.

2.2 Setting

We focused our analysis on four areas of town: the Laare Market, Tuuru, the Ntobuine Church, and Kiraro and Ntobuine Village. The Laare market is the area's "town center" where people mostly go for purchasing and selling goods and government services. Tuuru is a church-run hospital, which runs basic outpatient care and has a maternity wing. Ntobuine church is a Catholic church in the community. Kiraro and Ntobuine are villages in the Laare area.

2.3 Participants/Respondents

To understand the different types of pre-and post-natal services provided to women in this community, we surveyed healthcare providers who had some degree of formal education or training in pre-and post-natal care (i.e., college, technical school, nursing school). We refer to this group as skilled birth attendants (SBAs). Given that most births that occur in rural areas in Kenya occur without a skilled birth attendant present, we also surveyed those attendants who had no formal education or training in pre-and post-natal care and yet provide pre-and post-natal care; we refer to this group as unskilled birth attendants (uSBAs). Additionally, we surveyed both women who were currently pregnant (CPs) as well as those who had given birth within the last three years (BL3Ys).

2.4 Surveys

We created three different surveys: one for SBAs, one for uSBAs, and one survey for the population of BL3Ys and CPs. Each survey consisted of two parts: one part that measured access to and use of pre-and post-natal services; and the second part that measured access to and use of technology.

For the SBAs, we asked them about the institutions that had provided formal training, the type and duration of training they had received, and the types of pre-and post-natal services they provide. We also asked them to identify available resources for finding information about pre-and post-natal care and any difficulties with acquiring access to such resources, as well as any difficulties providing services to women in the community. Finally, we asked SBAs about which pre-and post-natal services they would like to be able to provide the Laarean women. Likewise, for the uSBAs, we asked them about which resources they used for pre-and post-natal care, any difficulties they experienced with acquiring access those resources, and any difficulties they experienced with providing pre-and post-natal care. We also asked uSBAs about which pre-and post-natal services they would like to acquire knowledge of and which pre- and post-natal services Laarean women need.

We asked BL3Ys and CPs about their use of pre-and post-natal services. In particular, we focused on asking them about which services they used and how often, their use of pre-natal vitamins, and their difficulties acquiring access to pre- and postnatal services.

In addition, we asked them about resources they utilize when they have questions about pregnancy, labor and delivery, and newborn and infant care. We also asked them about which services or information they would like to know more about.

For all surveys, we asked respondents about their access to and use of technology, especially computers, Internet, and mobile phones. Finally, we asked respondents about their purposes for using mobile technology, how they maintain their mobile phones (e.g., charging, additional minutes, etc.), and whether the mobile phone is a personal device or one used by the entire family.

2.5 Findings

We have survey results regarding pre-natal experiences for 22 participants and results regarding use of technology for 20 participants. We wanted to understand their experiences with pre-natal services (either as providers or consumers) and we also wanted to understand their use of technology, particularly computers, Internet, and mobile phones. Table 1 shows a breakdown of respondents by role and region. The largest number of responses came from consumers of pre-and post-natal services, either women who are currently pregnant (CPs) or women who have been pregnant within the last three years (BL3Ys).

Among this group of women, the average number of children per woman was 3.86, which coincides with other data (WHO, 2010), with the least amount of children being none (i.e., a woman's first pregnancy) and the largest number of children being 10. Among pre-natal and post-natal services used, 14 of these 16 women stated that they currently or previously attended check-ups either monthly or more frequently. However, only 4 of these women stated that they take pre-natal vitamins. All currently pregnant women (CPs) stated that they plan to use a skilled birth attendant (SBA) to assist with delivery, while 6 of the 8 recently pregnant women (BL3Ys) stated that they had used a midwife to assist with delivery. However, the 6 BL3Ys who utilized midwives did not clearly indicate if any of them had formal training in pre-natal care, labor and delivery, or post-natal care.

While both CPs and BL3Ys did attend check-ups, 13 of the 22 women did not utilize hospitals, clinics, or SBAs as resources to find information about pre-and post-natal services. Instead, they stated that they talked to family, friends, co-workers, other women who had been pregnant, or older women in the community to glean useful information about taking care of themselves and their babies during and after pregnancy. Additionally, the women attended seminars, and listened to the news or read newspapers to find out about pre-and post-natal services. These same women cited the lack of money and the lack of knowledge as the most prevalent difficulties to acquiring access to pre-and post-natal services. Additional difficulties precluded access to pre-and post-natal care, including insufficient information, travel distance to better health care facilities, lack of skilled personnel, superstition and illiteracy. When asked about additional services they would like to have, respondents mentioned information about available drugs, maternal nutrition and diseases, information about what to do if they encounter complications during pregnancy, new advanced technologies to ensure that the mother and child are healthy, birth care, and vitamins.

2.5.1 Pre-and Post-Natal Experience of Skilled and Unskilled Birth Attendants

Three of our respondents were skilled birth attendants (SBAs) and 3 were unskilled birth attendants (uSBAs). These 6 pre-and post-natal service providers represented a combined total of 60 years of experience with 2 years being the least amount of experience and 23 years being the greatest. These service providers have delivered over 265 babies. Respondents listed regular pregnancy checkups, nutritional advice, vaccination information, and hygiene among the pre-and post-natal services they provide. Among SBAs, books were listed by all three as a resource used to find information about pre-and post-natal care. Additional resources mentioned by SBAs and uSBAs included medical journals, the Internet, information presented at seminars offered by trained personnel, and older women in the community who shared their knowledge and experiences. Lack of current medical books and journals, lack of funds, and lack of knowledge were among the difficulties SBAs and uSBAs faced when attempting to access information about pre-and postnatal care. Illiteracy was cited as the most common difficulty that precluded providing pre-and post-natal care to Laarean women. Other difficulties included detecting complications at an early stage, lack of equipment, lack of cooperation by mothers, poverty, unavailability of resources to enhance the diet of the mother, and young girls who are pregnant but do not know anything at all about pregnancy, childbirth, prenatal services, or caring for a child. Both SBAs and uSBAS indicated that they would like to offer additional services such as education on what to do in case of complications, advice on child hygiene, breastfeeding, nutrition, and taking care of newborn babies to mothers.

2.5.2 Technology Use of Pre-and Post-Natal Providers and Women

While only 4 of the 20 respondents indicated that they had access to computers, only 3 had access to the Internet. Furthermore, only one respondent had used a computer to enter patient information. In contrast, 17 of the 20 respondents, more than 80%, had access to cell phones. Most people used their cell phones daily to make calls and send text messages. Eleven respondents stated that their cell phones were owned and used by everyone in their household, with all but one respondent subscribing to a prepaid plan.

2.6 Discussion

Our analysis of survey results revealed several insights, but also raised additional questions around accessing pre-and post-natal information, providing pre and post-natal care, the use of technology, and the importance of leveraging cell phones to promote greater access to pre-and post-natal care.

2.6.1 Accessing Pre-and Post-Natal Information

While most women stated they used pre-and post-natal services (i.e., monthly checkups), the SBAs providing these services were not the sources these women turned to for information about pregnancy, labor and delivery, and taking care of a child. Instead they turned to family, friends, co-workers, women who had been pregnant before, and older women in the community. This suggests that additional entities exist within the pre-and post-natal care ecosystem that lack technical training, but have a great deal of societal capital. We call these additional entities atypical providers (Thomas, et. al, 2011), as they provide information and in some instances, services, but not for monetary gain. Besides providing information about pre-and post-natal services, the underlying question remains regarding additional roles these atypical providers play.

Survey results revealed that there were women who did not use pre-and postnatal care. Women felt pre-and post-natal services were too expensive, suggesting that an intervention must be cost-effective as well as provide easy access for utility. One respondent, who has 10 children and plans to have more, stated, "I have given birth to 10 healthy children. Why should I use expensive medicine for no apparent reason?" Her response suggests that she knows how to successfully birth babies that develop into healthy children and that this knowledge would benefit newly pregnant women in the community who do not possess such knowledge. Her response also identifies a potential access point to pre-and postnatal services and an opportunity to design a pre-and post-natal care information service that leverages communal knowledge and experiences that consequently, would benefit other women in rural areas like Laare.

2.6.2 The Use of Mobile Technology to Provide Access to Pre-and Post-Natal Care

Given the findings mentioned above, we identified three design implications for designing mobile-based services to provide access to and deliver pre-and post-natal care: 1. mobile technology that removes the barrier of illiteracy; 2. secure individual information on shared mobile devices; and 3. communal influencers as co-designers and advocates of pre-and post-natal interventions.

2.6.2.1 Mobile Devices that Eliminate the Barrier of Illiteracy

Illiteracy was cited by SBAs and uSBAs as the major difficulty in providing preand post-natal care for women in this community. Therefore, interventions promoting access to pre-and post-natal care must promote cross-cultural communication and be delivered in some form other than text (e.g., voice, visual images, etc.). Remembering that the overwhelming majority of respondents had access to a household cell phone, we posit that mobile technology is the ideal platform for providing access to pre-and post-natal supplementary care. The issue is designing user-friendly interfaces for mobile technology that either remove the literacy barrier or support users to overcome it.

2.6.2.2 Security and Privacy Issues for Shared Mobile Devices

The use of the cell phone as a communal device as opposed to a personal one raises questions about patient privacy, as pregnancy is subject to the same limitations of privacy as other medical issues. How do we keep sensitive individual information secure and private on shared mobile devices? For instance, if a pregnant woman's fetus is diagnosed with down syndrome, how could that information be shared with her via her cell phone without her husband getting access to her personal record, given that the cell phone is owned and used by them both? Service providers need to devise technical solutions that ensure individual privacy for shared mobile devices. Currently, no such privacy or security algorithms exist since the assumption in developing and offering mobile-based health care services is that each mobile device is a privately owned device.

One possible solution would be the use of biometrics (fingerprint) to identify the individual user; this information would be the reference key for accessing individual health care records, test results, and any other useful information.

2.6.2.3 Communal Influences as Co-Designers of Health Care Services

Understanding the communal influences of religious leaders and primary teachers, we acknowledge the need to engage these communal influences as codesigners and advocates of pre-and post-natal services. In addition to the SBAs and uSBAS, the religious leaders and teachers represent atypical service providers in that they wield their influence to determine which pre-and post-natal care services will be utilized and adopted by the community. The implications for service design argue for a participatory approach in which the communal influencers have a voice in the design of the technology and its use since they have the ear of the people. This does not imply that health care professionals or technology designers should ignore their respective expertise. Rather, the goal is to work together to uncover alternative solutions that will better service the pre-and post-natal needs of Laarean women. For example, the primary teacher could be an advocate by offering workshops that explain how to use mobile applications that feature pre-and post-natal information and how local women can utilize such technology to share their experiences with one another. This is just one example of a non-traditional approach to design and the justification for utilizing such an approach for rural developing economies like Laare.

3. Study 2: Participatory Design of a Mobile App

Armed with the insights gleaned from the survey, we began our enactment of a participatory design approach by once again engaging the women of Laare. In this study, we wanted to understand the types of pre- and post-natal information that Laarean women who were either currently pregnant or who had given birth within the last two or three years would like to have in a mobile app, as well as how they would like to see that information displayed on a mobile phone screen. To do this, we developed a large physical prototype of a mobile device so that the "screen" could easily be seen. Using the key words of *Kenya, pregnancy,* and *women*, we generated and printed a set of 2" x 2" Google images of various people and activities (e.g., a smiling pregnant woman, a woman holding her baby, a doctor giving an exam to a woman, a picture of a smiling male holding a baby, a woman in the hospital, etc.), and we conducted semi-structured interviews with the women interacting with both the pictures and the physical prototype.

We used a physical prototype with images instead of a software prototype because creating the physical prototype was cheaper and more flexible, allowing each woman to move the images on the "screen" easily without having to pause the study to reprogram the interface. Using this approach also meant that we did not have to make any design assumptions about what participants might select or how they might arrange images on the screen as a starting point. Instead, we were able to allow them to arrange the images in any style, pattern, or way that they deemed appropriate.

3.1 Setting

We returned to the same villages where we administered the surveys. All of the interviews were 45 minutes to an hour, video-recorded, and conducted either in the interviewees' homes or in the hospital. A native Laarean woman conducted the interviews to create a sense of rapport with the women.

3.2 Participants

We interviewed nine women from 17 years old to 39 years old, who had given birth to at least one child during the last two to three years. The pool of participants grew organically with one participant suggesting another woman we should interview, and so on. The younger mothers were interviewed at the local hospital, having recently given birth within one week, and the older women were interviewed in their homes.

3.3 Activity

We first asked participants questions about themselves (name, age, etc.). Then, we laid out the images and asked them to choose images that had meaning to them as it related to pre- and post-natal care. As the participants identified images, we asked them to describe the meaning they attributed to those images. Once participants identified images that were meaningful to them, we asked them to arrange those images on the physical prototype in any order they preferred. We then asked participants questions about their arrangement.

3.4 Preliminary Findings

Though we are still in the midst of analyzing the full set of interview data, the data suggests several important preliminary findings.

3.4.1 Identifying Images with Meaning

We asked participants to select images from the larger set of images we provided that seemed to have meaning for them as it related to pre- and post- natal care. Initial findings indicated that many women selected a subset of the same images and attributed the same meaning to them. For example, the majority of the women selected the picture of the woman in the hospital with two other women and referred to this image as being representative of the new mother receiving visitors in the hospital as a new mother (Figure 1). This suggests that the images, though selected by American researchers, created synergy and meaningful relationships for women in this community.

3.4.2 Organization of Images on Physical Prototype

We asked participants to arrange the images they selected from the larger set of images onto the physical prototype of the mobile phone. We did not restrict the organization of these images; women could place the images in any order or arrangement they wished, and they were free to rearrange the order or layout of the images. The data reveals that many women organized their images in similar ways. First, women placed the images on the prototype in a grid fashion, with an equal number of images on each row, which we expected as the icons on most of the phones they used were laid out in a similar fashion. Second, many women organized the images chronologically from conception through labor and delivery, with images near the top of the "screen" relating to pregnancy, images further down relating to labor and delivery, and images toward the bottom relating to newborn care. These preliminary findings caused us to revisit our initial ideas about the design of the preand post-natal care mobile application.

4. Discussion and Future Work

Our continued analysis of data from both the survey and the interviews raises additional questions and future directions for the research. For example, illiteracy remains a major barrier to accessing pre- and post-natal information for women in Laare. However, many Laarean women use their mobile devices to send text messages, indicating a degree of textual literacy. This suggests that literacy can be defined in multiple ways and designers of technology should account for different modes of communicative competency.

Furthermore, our initial ideas about the design of the mobile app involved arranging the images topically (e.g. nutrition, medication, etc.). However, we were surprised to discover that all nine women chose to arrange the images in chronological order, even providing similar meaning to the images. As such, we utilized the fluid design of the physical prototype and the set of images to help transition the women into the role of co-designers of MTOTO, allowing their voices to be heard and included as an integral part of the design process. Utilizing fluid design techniques (i.e. interchangeable components of the mobile app interface) to engage targeted communities, of which we are not members, as co-designers of tools and technologies is critical in addressing language and cultural barriers and opens the door to understanding and designing what users really want.

We will continue our analysis of the interview data from the second study to glean additional insights. We are currently implementing the software prototype of MTOTO and plan to return to Laare to conduct additional user studies to understand the efficacy of the software prototype, get feedback on the usability and design of the software prototype, and glean additional recommendations regarding MTOTO's design, functionality, and use. The software prototype is visual and auditory with no text. Instead, as the user touches an image (Figure 2), the topic represented by that image is spoken in Kimeru. Once the user selects the image related to the topic they want to know more about, images of women within the community appear (Figure 3).

Users can then select the image of the woman they would like to learn from, and an audio file will play in which the selected woman will tell a story about her experience related to that topic or give some advice about that topic to help the user.

This experience or advice will also be given in Kimeru In addition, we also plan to replicate the two studies described here as well as the user study around the software prototype in other developing economies, namely Haiti, Uganda, and Cameroon to help us understand the similarities and differences in both pre- and post-natal care needs among women living in rural developing economies as well as the resulting co-designs of MTOTO across these communities. Our analysis of the data from these other regions will allow us to expand the software prototype to also include interfaces for women living in these countries (Haiti, Uganda, and Cameroon).

5. Acknowledgment

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Tables and Figures

Table 1: Number of Respondents by role and Region

Role	Laare Market	Tuuru	Kairo & Ntobuine Village	Ntobuine Church	Total/(Role)
SBA	0	3	0	0	3
uSBA	0	0	2	1	3
CP	2	0	4	2	8
BL3Y	2	4	0	2	8
Total (region)	4	7	6	5	N/A

Figure 1: New Kenyan mother in the Hospital Receiving Visitors

Figure 2: Software Prototype of MTOTO App - Screen of Topics

Figure 3: Software Prototype of MTOTO – Women Sharing Experiences and/or Advice