Maternal health behavior change:
Women's experiences as participants of an mHealth program in Timor-Leste

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Abstract

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Background: Global maternal and neonatal mortality rates are unacceptably high. Programs that harness mobile technology represent a promising method to cost-effectively address profound maternal and neonatal health needs. The ways in which mHealth programs influence an individual's decision-making regarding their health are underexplored. This study examines the influence of Liga Inan (LI), an mHealth program in Timor-Leste, on preventive maternal, neonatal, and child health (MNCH) behavior through the lens of women participating in the intervention.

Methods: Qualitative data on participation in an mHealth program and self-reported maternal health behavior were collected through in-depth, semi-structured interviews (27) with participants of LI. The Social Ecological Framework, Health Belief Model, and techniques used by LI to target behavioral determinants guided qualitative analysis.

Findings: This research demonstrates that LI influences important determinants of behavior among participants through the use of behavior change techniques at the individual, social, and health system levels, likely promoting healthier choices among participants during and immediately after pregnancy.

Conclusion: mHealth can be an effective tool to influence key individual, social, and health system determinants of behavior and promote healthier choices among program participants while strengthening established health systems.

Introduction

Access to quality maternal services that ensure safe pregnancy and childbirth is considered a human right.[2] However, nearly 800 women die daily from preventable complications during pregnancy or childbirth.[3] Ninety-nine percent of these maternal deaths—the death of a woman during pregnancy, childbirth, or in the 42 days after delivery—occur in low- and middle-income (LMIC) countries.[3] These numbers are unacceptably high. Moreover, the mother-baby dyad is a synchronized system and an increased risk of morbidity and mortality among mothers directly translates to higher risk of morbidity and mortality for the infant.

Most maternal deaths occur just before, during, or just after delivery. The major complications, which include severe bleeding, infections, high blood pressure during pregnancy (pre-eclampsia and eclampsia), complications from delivery, and unsafe abortion, account for almost 75% of maternal deaths.[4] While many of these obstetric complications are not predictable, many are preventable through safe deliveries with the presence of a skilled attendant and adequate maternal care during antenatal, intrapartum, and postpartum periods.[5]

More distally, there are numerous interrelated factors that contribute to maternal mortality. These factors include limited community understanding of optimal healthy behaviors during pregnancy, limited contact with midwives, and limited access to maternal and newborn health services including antenatal care (ANC), skilled birth attendant (SBA) and facility delivery.[6] Delay also emerges as the prominent factor contributing to maternal mortality globally.[7] Delays in 1) deciding to seek appropriate medical help; 2) reaching an appropriate facility; and 3) receiving adequate care when a facility is reached all contribute to negative outcomes related to obstetric emergencies.

With the recent proliferation and utilization of mobile technology globally[8], programs that harness this technology represent a promising method to cost-effectively[1] address these profound maternal and neonatal health needs. Mobile health projects, coined "mHealth", use mobile technology to support health services and health education. Primarily used to disseminate accurate and reliable health information, support drug adherence, and promote behavior change, results have been heartening.[9,10,11,12,13] In the context of maternal and child health, one-way and two-way mobile phone text messaging can help pregnant women access information as well as provide a ready means of communication with midwives. It has the potential to empower them to

make informed decisions about their own and their babies' health and facilitate improved links with health facility staff resulting in an uptake of services. Because of this potential, research examining the impact of mHealth projects is crucial.

While limited in LMIC settings, quantitative research shows the potential and opportunities for the use of mHealth interventions to facilitate behavior change in preventive health behaviors. In high-income countries, improvements in preventive health behaviors and successful behavior change as a result of implementing mHealth interventions have been seen.[14,10,11] Similarly, in LMICs, research shows the facilitation of behavior change and cost-effectiveness of delivering SMS messages in both non-health and health related interventions.[1] Evidence also suggests that the provision of accurate and timely information regarding new practices or technologies can have a positive impact on behavior change.[15,16,17,14]

Research examining the application of mHealth strategies specifically for maternal, newborn, and child health (MNCH) is limited. A 2012 systematic review examining 34 studies using mHealth along three stages of the continuum of MNCH care found that mHealth can be part of a comprehensive approach in expediting emergency obstetric referrals and enabling health workers to collaborate and improve delivery of care.[18] Likewise, researchers found that the use of mHealth can support preventive services through the enhanced dissemination of prenatal and neonatal education and promotion of antenatal care.[18]

While many mHealth programs have been implemented, little is known about the ways in which mHealth programs influence an individual's decision-making regarding their health. Qualitative research examining the use of mHealth technology has been in the formative stage, helping program planners to examine topics including perception of the service; usage behavior; perceived knowledge, behavior, and attitude changes; and user experience.[19,20]

This paper aims to add to a limited body of research by identifying and describing the influence of Liga Inan (LI), an MNCH mHealth program in Timor-Leste, on preventative MNCH behavior through the lens of women participating in the intervention.

Maternal and neonatal health in Timor-Leste

After decades of brutal occupation by Portugal and Indonesia, Timor-Leste gained independence in 2002. Timor-Leste is a half-island nation comprised of 1.2 million people[21] with 30% percent

of the population living in urban areas, and the remainder living in mountainous, rural interiors of the country. While independence marked a new beginning for the country, many women are still living with the trauma incurred as a result of the Indonesian military occupation from practices such as coercive family planning programs sterilizing women without their knowledge or consent.[22],[23] As a result Timorese women began to avoid state-run clinics and stayed at home, even in the face of severe sickness or pregnancy complications.[22] The lack of health service infrastructure, which was destroyed when Indonesia withdrew from the country in 1999, further compromised health services for women[21] and left Timor-Leste with some of the highest rates of maternal and neonatal mortality in the world.

The 2010 Demographic and Health Survey (DHS) reports that the maternal mortality ratio (MMR) is 557 per 100,000 births and neonatal mortality is 22 per 1000 live births.[21] ANC from a SBA is common in Timor-Leste, with 86% of women reporting receipt of such care at least once. However, only 30% of births are delivered by an SBA (doctor, nurse, or midwife), with a nurse or midwife being the most common.[21] However, when urban and rural environments are disaggregated, 59% of mothers living in urban areas utilize a SBA, whereas only 21% of mothers living in rural areas utilize a SBA.[21] Research points to multiple factors contributing to utilizing maternal health services ranging from the cognitive and psychological aspect of individuals to external social and political influences.[6] Barriers to accessing life-saving health services are geographic, cultural/social, economic, and knowledge-based, and include gaps in communication and transportation, lack of birth planning and women's power and familial responsibility.[6,24]

Description of the Intervention

In response to these challenges, Health Alliance International (HAI), in partnership with the Timor-Leste Ministry of Health (TLMOH) and Catalpa International, implemented the first mHealth project in Timor-Leste in 2011. Implemented in Manufahi and Ainaro districts, the Mobile Moms project, locally called "Liga Inan" (LI), aims to reduce maternal and neonatal morbidity and mortality by improving the health and care-seeking behavior of pregnant women. LI consists of three components:

1. Training and monitoring community health workers to deliver maternal and neonatal health education at the household level;

2. Supporting basic Emergency Obstetric Care training and supporting supervision for district health staff;
3. Mobile health (mHealth) technology.

The aim of the mHealth component is to improve pregnancy outcomes by bolstering existing efforts to promote both healthy maternal behaviors and increased access to skilled care. The expectation is that providing women and their families with information and a ready means of communication with midwives will empower them to make informed decisions about their own and their babies' health and facilitate improved links with health facility staff resulting in an uptake of services. The mHealth component is the focus of this research.

From the time of enrollment, which occurs at the first ANC visit, the program facilitates one-way communication by sending health promotion text messages to pregnant women automatically, twice weekly, through six weeks postpartum. The text messages are timed to each mother's stage of pregnancy. Secondly, the LI service will encourage and facilitate women to contact their midwife with concerns or problems. Telephone numbers for the midwife, emergency staff on call and ambulance drivers are written on a sticker that is put on her take-home pregnancy and post-natal health record. In addition to providing emergency telephone numbers, women and families can send a simple Short Message Service (SMS) text message to the LI service, which will initiate a message to their registering health facility and will trigger the midwife on duty to contact the woman via voice call.

It has been shown that the integration of behavior change theory into such programs results in more successful programs, making the application of theoretical frameworks an important part of mHealth program design.[25] LI program design documentation mentions only the Health Belief Model (HBM) explicitly as theory applied during program design. A retrospective analysis shows that in addition to the HBM, there are other aspects of the LI intervention that target key behavioral determinants that can achieve a change in behavior. Among a set of twelve behavioral determinants agreed upon by a consensus of experts to explain behavior change, nine were identified as being targeted by LI including important individual, social, and health system determinants pertinent to the context of Timor-Leste.[26]

Framework for Understanding Decision-Making in the Use of Maternal Services

LI was designed to address important individual, social, and health system determinants to promote behavior change among participants. To this end, we use both the Social Ecological Model and the Health Belief Model to understand the mechanisms of maternal behavior change in LI.

The Social Ecological Model (SEM) is a theory-based framework for understanding the multifaceted and interactive effects of personal and environmental factors that determine behaviors, and for identifying behavioral and organizational leverage points and intermediaries for health promotion within organizations. There are five nested, hierarchical levels of the SEM: Individual, interpersonal, community, organizational, and policy/enabling environment (Figure 1). The overlapping rings in the model illustrate how factors at one level influence factors at another level. In this paper, we use the SEM as an overarching framework to examine proximal and distal influences on health behavior.

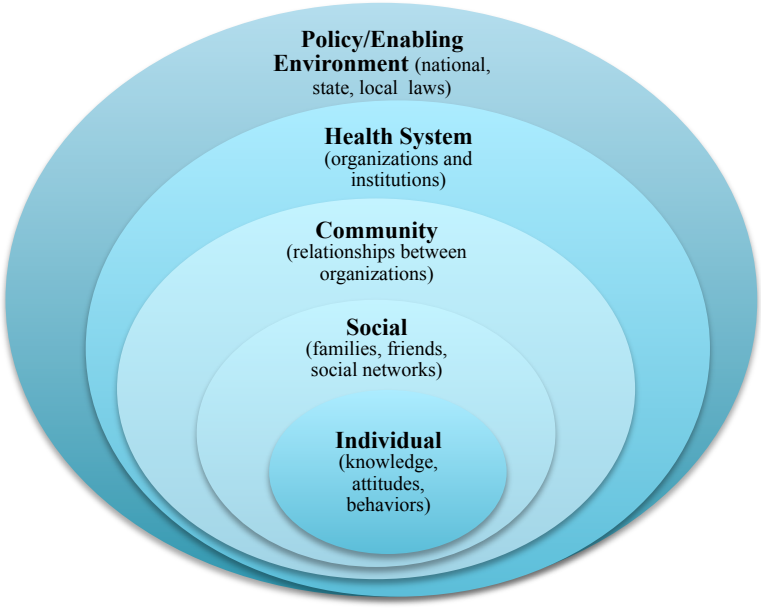

FIGURE 1: THE SOCIAL ECOLOGICAL MODEL

Source: Adapted from Health Behavior Theory for Public Health.[27]

Secondly, we use the Health Belief Model (HBM) as a framework for analysis in order to address individual level factors (Figure 2).[28] The HBM states that modifying variables, cues to action, and self-efficacy affect one's perceptions of susceptibility, seriousness, benefits, barriers and consequently, behavior. Modifying variables can include culture, education level, past experiences, skill, and motivation. Cues to action, such as events, people, or things that move people to change their behavior also influence behavior. Self-efficacy, or an individual's perception of her own effectiveness with respect to a task, can typically be a predictor, mediator, or moderator of behavior change. Together or in isolation, these affect one's perceptions, which include perceived susceptibility to and severity of a disease or condition as well as perceived benefits and barriers to taking preventative actions.

The purpose of this qualitative study is to identify and describe the factors that influence behavior regarding maternal health that are targeted with the Liga Inan mHealth program for women in Manufahi District, Timor-Leste.

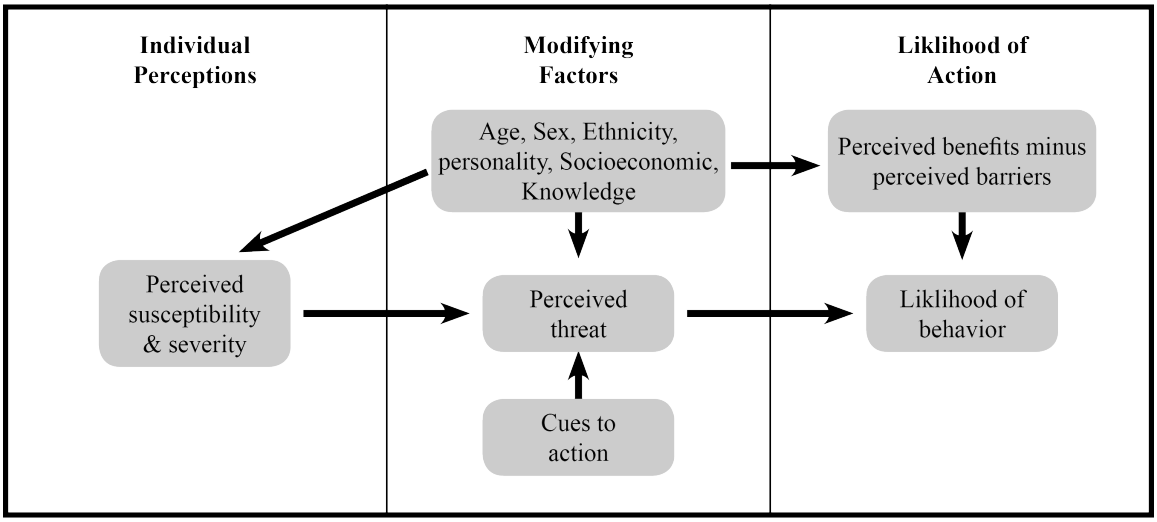

FIGURE 2: THE HEALTH BELIEF MODEL
Source Glanz et al[29]

Methods

This cross-sectional qualitative study was conducted in the rural district of Manufahi, Timor-Leste, which is home to approximately 49,000 people, an estimated 10,000 of whom are women of reproductive age. The study population consisted of all women who were past participants in the LI mHealth program. A total of twenty-seven in-depth, semi-structured interviews were conducted either in the participant's home or another location of her choosing. Data collection took place over ten weeks in Manufahi District, Timor-Leste from July to September 2014.

To be eligible for participation in this research, women had to meet several criteria. First, to minimize recall bias, researchers recruited women who had completed LI no longer than 6 months prior to the initiation of this research in Timor-Leste. Second, to eliminate the possibility of recruiting women who had participated in the program less than the average "dose" or exposure to LI which was found to be ten weeks, we recruited women who had participated in LI for at least ten weeks. Third, because researchers were interested in understanding differences between the pregnancies enrolled and not enrolled in LI, only women with a minimum of two children (one born while enrolled in the program and one born prior to enrolling in the program) were recruited. Lastly, because women in Timor-Leste have varying access to maternal health services and because several of the key text messages encourage participants to seek maternal health care (ANC 2-4, use of SBA), researchers aimed to sample for diversity of access to healthcare. To accomplish this, villages, locally referred to as sucos, in Manufahi district were grouped according to the main source of health care and randomly selected using Microsoft Excel. Main sources of health care include the Maternity Clinic in Same, Community Health Center (CHC), Health Post (HP) or no health facility. Nine villages were selected: two urban areas where the main source of maternity care is a Maternity Clinic, two villages with a CHC as the main source of health care, two villages with a HP as the main source of health care, and due to the high percentage of rural residents in Timor-Leste, three villages with no access to a health facility in their village were selected. Next, due to the large number of possible study participants, a list of participants meeting inclusion criteria was generated from LI enrollment data. Ten women were randomly selected from each previously selected village with the intention to interview three women from each village. Unfortunately, participant enrollment data does not include surnames, addresses or parity (one of the study's inclusion criteria), making

women difficult to identify as eligible and difficult to locate. Furthermore, women were often difficult to reach by telephone and fearing bias, researchers did not want to limit participation in this research only to women who answered the telephone to pre-arrange an interview time. Therefore, to locate and speak with eligible women, researchers traveled to the selected village and located the Chefe Suco (Village Chief) who assisted researchers in systematically locating the first three available, consenting, eligible participants. For example, if the first woman on the list was not available, did not want to participate, or had only one child, researchers would locate the second woman on the list and so on. This was continued until 3 women were interviewed from each village. A total of 27 women were interviewed and researchers reached data saturation. Researchers believe that while the sample size is small, the women interviewed are a suitable group that can reveal a lot about the experiences that others in the sampling frame share.

Data Analysis

A combination of inductive and deductive data analysis techniques were used applying the HBM and the SEM frameworks.[30] An a priori code list related to behavior change theory was developed and expanded upon inductively as relevant themes emerged after three coding passes. Data were managed and analyzed using Atlas.ti (Version 1.0.24, Scientific Software Development, 2015). English portions of the interviews (questions from the investigator and real-time English interpretation of women's responses) and field notes were transcribed in full. Data were analyzed by the investigator who also conducted the interviews.

Ethical Considerations

Ethics approval was obtained through both the University of Washington, Seattle, Washington, United States and through the Ministry of Health of Timor-Leste. In a standard form that was read aloud to participants by the translator in the local Tetun language, participants were informed about the research, about confidentiality, and told that they had the choice to participate or not, and could withdraw at any point. Upon agreeing to participate, women provided written consent by signing the consent form.

Findings

In this study we draw on the SEM, HBM and techniques used by LI to target behavioral determinants to identify and describe the ways in which LI mediates behavior change in program

participants. Borrowing from both the SEM and HBM, major themes are organized into individual, social, and health-system categories.

Individual factors:

Increased access to high-quality health information

Women overwhelmingly described their participation in LI as positive. They described as paramount the increase in access to larger volumes of high-quality health information leading to their (self-described) ability to adopt healthier choices for themselves and their babies during and immediately after pregnancy. As one woman explained:

> *"Based on my experience, this program can help all pregnant women. Sometimes we don't have a lot of knowledge about healthy behaviors. Before (LI), we only learned information when we went to the hospital, but through this program, we receive many messages from the (LI) so we know all that information."*

Another woman described access to high-quality health information as follows:

> *"I think that this program is good. It helps people. Because it gives me suggestions based on information. They say that if you feel pain or headache, then you need to come to the hospital. But the first child, when I went to the hospital I didn't get any suggestion from the midwife saying that if you feel pain, just come to the hospital. That's why I think this program is good, because I know more information about health related to the baby."*

Access to knowledge is a key internal determinant in behavior change communication and LI is a simple means to access this knowledge. As a result of access to high-quality health information, women described the adoption of health behaviors that they did not previously espouse. As one woman explained:

> *"The messages talk about politics, but not really politics, it's the politics of the family. They advise to the husband and wife to make a plan…The advice is for the mother and father that it's good [after] your baby is born wait for two years and then you can have another baby."*

This woman, never having attended school, went on to report discussing family planning with her husband and making a decision to seek family planning services in order to space their children based on LI recommendations. Similarly, another woman states:

> *"As I mentioned, I followed a lot of the messages. I also received a message about family planning. Before the program, I had not heard that information. I agreed with the*

message and now I am participating in family planning. I got the injection in Same."

Most respondents noted access to high-quality health information as important and invaluable. While many stated that health professionals had conveyed the information they received through the messages during previous pregnancies, women described the delivery of the information as novel and useful. They commented on the consistency and synergy between the midwives' advice during routine visits and the information received through LI. Women also linked access to information with improving both ante- and post-natal experiences in comparison to prior pregnancies. Having information limited to face-to-face contact with the midwife assumes adequate time during ANC visits to discuss important health information related to pregnancy, delivery and the postpartum period, which is often not the case. One woman described the program as useful because it *"does the same thing as what was done at the health facilities or hospital."* Access to accurate and high-quality information may in that way effectively strengthen the formal health system.

Active role in caring for one's health

Women's responses suggest that LI may improve service utilization or improved healthy behaviors by influencing the modifying factor, motivation. Women described LI as helping them to take an active role in their health both during and immediately after pregnancy. As one woman states: "*It was useful because it helped me to care about my health."* While motivation for health behavior is dynamic and complex, women reported being more motivated to move to action as a result of receiving LI messages. As one woman eloquently states: *"The messages always reminded me to do things related to my health. Don't just sit there. Do something."* Echoing this, other women reported similar benefits in terms of seeking care based on the messages from the LI program.

"I received one message that said, "If your baby is overdue, then you need to go to the hospital immediately." When I received that message, I realized that my baby was overdue, so I went to the hospital immediately. The advice came from the messages."

Individual Beliefs—Severity

Women's responses suggest that their beliefs about the seriousness and severity associated with giving birth in Timor-Leste are a reflection of the real dangers, an important foundation to encourage behavior change. As one woman shared: "…*because in general we see that most*

pregnant women [in Timor-Leste], when they give birth, they die." Women interviewed show signs of appreciating the dangers of giving birth in Timor-Leste. However, because enrollment in LI typically occurs during the first ANC visit, women interviewed for this research could be women that, prior to enrolling in LI, appreciated the dangers of giving birth in Timor-Leste and were therefore more likely to have positive health seeking behaviors. For example, one woman expressed the following:

> *"I became involved in this program at the hospital. I was at the hospital because I know many women die giving birth. And sometimes it can be very difficult if you deliver at home. That's why I decided to go to the hospital and that's where I enrolled in LI."*

Individual Beliefs—Labor Pains

While message recall varied across participants, women most frequently recalled the recommendation to contact the midwife when they feel labor pain, nutrition information, danger signs both during and immediately after pregnancy, and information regarding breastfeeding. However, despite recalling the relevant messages, when labor pain began, women expressed delays in contacting the midwife. For example, one woman, a teacher, explained:

> *I first felt pain in the morning. I went to school and then I went back home at three in the afternoon and I continued to feel pain and I thought maybe it was because of the hard work and maybe that's why I was feeling pain. Then at around 4 or 5 I still felt pain but I didn't know if it was labor pain or if it was because of the hard work or because of the walk from school to home. At around 7 at night then I felt labor pain. Then my family told me I should just deliver at home and then I told my husband that 'no, we need to contact the ambulance so we can go to the hospital'. So my husband called the ambulance and when it came to pick me up to go to the hospital while we were in the ambulance the baby was born. We went directly to the hospital and the midwife attended to the placenta. In the morning we came back home.*

While this woman had a safe delivery, the initial delay in contacting a midwife due to not recognizing labor pain could have resulted in danger for mother or baby. Many woman were able to explain the LI recommendation to contact the midwife when labor pain occurs and their subsequent lack of follow through reveals an important disconnect between receiving and understanding important information from the LI program and health seeking behavior.

Individual Beliefs—Intention to deliver with assistance from an SBA

Women were asked to narrate the story of their most recent delivery, which took place while enrolled in the LI program. This question was designed to understand and document two things: 1) is LI helping to promote the presence of an SBA at delivery and 2) why or why not?

Many women who delivered with an SBA described their intention to do so and a relatively smooth labor and delivery process. They noted feeling labor pain and contacting the midwife through the emergency number provided by LI in a timely manner, and then being transported by ambulance or another means to the hospital, or, alternatively, having a midwife attend the birth at the woman's home. One woman explains her experience:

> *"I was at home, and at four o'clock in the afternoon, I felt pain. My husband called the ambulance by the emergency number given to us by LI. At six or seven o'clock, I was at the hospital. … At 9 o'clock in the evening, they checked me again and at eleven o'clock my baby was born."*

This same woman expressed a strong intention to have a facility delivery stating: *"I had planned to deliver at the hospital because I thought that if I had any problem they can help me. But if I deliver at home, if there is a problem, I can't do anything."* Intention is commonly included in behavior change theory and some cite intention as one of the most important determinants of behavior. By providing women with an emergency phone number to call that is connected to the government ambulance system, LI strengthened women's abilities to act on their intentions. LI did this by eliminating the communication barrier that previously existed, thereby strengthening communication infrastructure between women, midwives, and emergency transportation services.

A majority of women interviewed did not have a birth attended by an SBA while enrolled in LI. Many of these women were capable of articulating the dangers of a birth with no assistance from a skilled attendant, recalled LI messages and midwife rhetoric about contacting a midwife when labor pain begins, and in some cases expressed a strong intention to deliver with an SBA; however, they continued the practice of giving birth without a skilled birth attendant. The analysis that follows describes potential mechanisms to understand this paradox as it relates to LI and behavior change.

The point in time when a woman is in labor and decides to contact or not to contact the midwife or ambulance for help is a critical moment. Women described four reasons for failure to contact

the midwife or ambulance for delivery that all hinge around this point in time. These reasons include: 1) trust in traditional practices, 2) the belief she was having a normal delivery, 3) speed of the progress of labor, and 4) time and conditions when labor began.

Trust

Women overwhelmingly described trusting relatives and traditional birth attendants (TBAs) as a reason for failure to contact the midwife or ambulance after labor began. They described trust in family members and TBAs to help deliver and trust in previous birth experiences and how those experiences guided them to make decisions about where and with whom to give birth for their most recent delivery. As one woman describes: *"…because my first child was delivered at home, something makes me feel confident with my mother so I trust her. That's why I chose to deliver at home."* When asked if she trusted her midwife, this same woman responded: *"I trust my midwife, it's just like a behavior, or something like that, because I have always delivered at home I would always just do the same thing."*

Consistent with previous research, younger women giving birth for the first time tended to seek the assistance of an SBA because of lack of experience and lack of confidence in their ability to birth.

> *"For my first child, I chose to give birth at the hospital because it was new for me, so I gave birth at the hospital. But then for the second, third, and fourth, because I trust the TBAs and all the family that can help you give birth, I felt everything was normal so I decided to give birth at home. I prefer to give birth at home because based on my experience, I've seen people like TBA's helping to give birth and I felt that it was good. So I decided to give birth at home. But, if I had felt there was an emergency, I would need to contact the midwife."*

Belief the delivery was 'normal'

Women also described failure to contact the midwife as due to the pregnancy being 'normal' and therefore the midwife or ambulance did not need to be called. For example, *"I had planned to deliver at the hospital but then I felt normal and I delivered at home." "I felt my pregnancy was normal, so I wanted to give birth at home."* For these women, contacting and engaging the help of a skilled attendant for what was deemed a "normal" birth seemed unsound.

Speed

Women frequently explained that there was not enough time to contact the midwife after labor pain began and before the baby was born. For example:

> *"There were none of the messages that I couldn't do. I could do them all. The messages that said, "don't work too hard, and don't wash clothes too much" I did those. Except for giving birth. They advised me through the messages and at the Health Post to give birth at the hospital, but all of my 5 children, I've only given birth at home because it happens so fast. When I feel pain, it's not even 1 or 2 hours. When I feel pain, my baby is immediately born. All 5 children were the same. That's why I didn't go to the health facility to give birth."*

Echoing this, another woman expressed the following: *"It was only one hour from when labor pain started to when my baby was born, so I didn't feel like I needed to contact the midwife."*

These descriptions reveal two things. First, they reveal a lack of urgency in terms of the need to contact a health provider or other emergency services when labor pain begins. Women are postponing consideration of calling for assistance until later stages of labor. Second, these comments reveal inadequate planning for labor and delivery. While many women intended to have a facility delivery and could recite messages from LI related to planning for the birth of their baby, "planning" was most commonly interpreted as preparing various items such as clothing and soap for the baby, not as making a plan for how to reach a facility or contact a health provider when labor began. As one woman explained:

> *"And when they knew that my baby was nearly born, they sent a message saying that you need to prepare. They informed us to prepare all of the things needed for the baby like a thermos to put the hot water, clothes, soap, and everything that is needed for the baby and mother as well."*

In a country where a large majority of the population lives in rural areas that are geographically complex coupled with emergency transportation systems that are often slow to respond, a thoughtful and relevant plan for actions to take at the onset of labor is important preparation. Messages about making preparations and contacting a midwife when labor began were not adequate in many cases to catalyze behavior change.

Time and conditions when labor begins

Finally, several women mentioned time of day and conditions such as rain as barriers to calling the midwife or emergency services when labor pain began. As one woman states:

> *I got information that said when you feel pain please contact us as soon as possible so we can send someone to help you. But when I felt pain it was 6pm and at that time there was also very heavy rain so I felt pain and later on, it's not long, my baby was born and at that time I was at home and my husband helped me to give birth.*

This particular individual lived approximately half a mile from the Health Post in a village recently staffed with a midwife. Further, despite her close proximity to the health post, this woman did not receive a postpartum check for two weeks after her baby was born. The WHO guidelines state that if birth is at home, the first postnatal contact should be as early as possible within 24 hours of birth.

Individual Beliefs—Other Information

In addition to the recommendations related to labor and delivery, LI messages the women recalled included: nutrition information, danger signs both during and immediately after pregnancy, and information regarding breastfeeding. Their descriptions of acting on those messages were mixed. Some messages that were described as particularly difficult to act on were messages about taking rest and eating more nutritious foods. For example, one woman stated: *"It seems that I did most of the messages. But "eat more nutritious food", I can't say if the food is nutritious or not, it depends on what kind of food that we have, we just eat the food that is available."* This example highlights important structural barriers to acting on the messages received. Without access to nutritious foods and an understanding of which foods possess optimal nutritional content, it is impossible for women to follow such messages. Additionally, several women expressed not following advice due to conflicting advice from sources outside of the health system. As one woman explained:

> *"One piece of advice from the messages says that when you get the vitamins you need to take all the vitamins it's good for you and your baby. But also I am listening to information from someone else, someone not from the hospital, someone from the local community, and they advised me that those vitamins, if you take all of them, it will make your baby bigger in your stomach and it will be difficult for you when you are giving birth. So during that time I only took the vitamins one time. The rest I didn't take."*

This highlights an important point that people are exposed to powerful influencers within the family and/or community that deliver different health information. These women might make decisions contrary to LI recommendations depending on the sway of social influencers.

Social factors

Health choices are not dictated solely by the individual, but also have a complex social component. In Timor-Leste, family and social support in terms of decision-making are important determinants of behavior change. The LI program theory of change describes the text messages being shared among family members, influencing these important decision-makers such as husbands and mother-in-laws. Additionally, the theory of change describes pregnant women disseminating this information to other women, thus influencing the perceived social acceptability of adopting new behaviors.

Women overwhelmingly described sharing the text messages among family members in the home, with the most cited family member being her husband. This is important because in Timor-Leste a woman and her husband are the most important decision-makers regarding maternal health, specifically in deciding where the birth should take place and with whom.[6] Birth plans are often flexible and are highly dependent on the progress of the labor, degree of pain experienced, access to transport, and other individual and household circumstances.[6] Therefore, including a woman's husband in promoting behavior change for maternal health is important.

Women described engaging their husbands in LI in three ways. First, women described the importance of informing their husbands of their initial enrollment in the LI program and the subsequent messages that they will receive about their health and the health of their baby. Second, women reported sharing the messages with their husbands as they receive the bi-weekly messages, ensuring that husbands also received the health information delivered via SMS. Third, women then described using this information to make maternal health decisions jointly with their husbands. As one woman explained: *"When my husband read the messages and we had a conversation, he asked me, 'What do you think of this information?' He said he thought it was good information and he said if you feel this is happening to you, you need to let me know so we can go to the hospital together."*

In addition to husbands, women also discussed sharing the messages with other members of the

household. For example, one woman reported:

> *"After I finished reading the messages I spoke with people in my house about the messages. They thought the messages were good and they said that you should remember that information because that information will help you in your health and to have a healthy pregnancy."*

While sharing of the information contained in LI frequently occurred within households, women were less prone to sharing LI messages with people living outside of the home. As one woman explained: *"I didn't talk to anyone outside my husband because you know, for most people if we are just talking, maybe some people trust and some people don't, so for me I didn't discuss the information with anyone."*

Health System factors

Women reported that because LI is integrated into the health system it facilitated their ability to take action on messages. Specifically, women described three important ways in which LI's integration with the national health system facilitated behavior change: 1) reverence for midwives, 2) emergency and non-emergency phone numbers provided, and 3) interface with local emergency system.

Among the women interviewed, reverence and trust for midwives emerged as major themes. As one woman explained: *"The midwife who helped me deliver at the hospital for my first child, I'm very thankful for her. They are like second Gods because they help me deliver."* Women also described consistent messaging between midwives and LI as beneficial. One enrollee's sister explained:

> *"For the previous three children, my sister always used a TBA to deliver her baby. For the fourth child, when she was enrolled in [LI] and both the midwife and the messages from LI explained and kept reminding us that you must give birth at the hospital. If you give birth at home and the TBA helps you to deliver, if you start to bleed a lot it will be trouble because they can't help you with the bleeding."*

Women's trust in midwives in Timor-Leste likely helped to facilitate behavior change through supplying consistent messaging between LI and midwives and capitalizing on women's potential willingness to contact trusted health professionals. However, trust in the midwife was described as dependent on the outcome of the birth. *"The midwife did a good job and I trust the midwife. Why wouldn't I trust her? She has helped me to deliver a child in good condition, so I trust her."*

This suggests that trust would be lost if a poor birth outcome occurred in the presence of a midwife.

Second, the facilitation of communication between women and the health system was one of the biggest benefits described by women improving access to the health system as a result. The provision of emergency and non-emergency phone numbers specifically, was described as beneficial. For example:

> *"If I compare the two, the second birth is better. Because the second birth, I was given the contact number and they always sent me messages telling me information. But the first one, there is no number in our books and we [pregnant women], when we feel sick, we have to figure out the best way to contact the hospital. But they didn't give us a number to call."*

This quote illustrates nicely the barriers removed as a result of LI. Strengthening communication — a critical link to accessing care — allows women the opportunity to follow messages delivered by LI.

Closely related to the improvement in communication described above, the LI program interfaces with the local health facility ambulance and this was also described as one of the benefits of LI. For example, about an hour outside of the town of Same, a neighbor to a woman being interviewed for this research went into labor. The neighbor was not enrolled in LI and, knowing that the interview team was in the area, she requested help. Fortunately, the interviewee had the emergency contact number for the ambulance in both her Livrado Saúde Inanfante hoet Onan (LISIO or Mother and Child Health Book) and programmed into her phone. The research team was able to successfully summon transportation for the woman in labor through connecting with the on-call person at the District Health Facility. The ambulance arrived 40 minutes later to take the laboring woman to the health facility in Same. While many roads are still in an ongoing state of disrepair and often become impassable during the wet season among other challenges, this story illustrates a reduction in barriers to birthing with a health provider facilitated by a stronger communication system linked to a transportation system, which were bolstered by LI.

Discussion

This research demonstrates that LI influences important determinants of behavior among participants through the use of behavior change techniques at the individual, social, and health

system levels. However, influencing behavior of the target population is complex and there are several factors hindering the adoption of healthier maternal behaviors. These factors could be addressed more effectively through LI as discussed below.

At the individual level, several techniques target important behavioral determinants such as knowledge and motivation, which can lead to action: receiving information and reminders of healthy actions, facilitating women taking an active role in their health, and interactions with personal beliefs. This research shows that LI improved the process whereby women receive high quality, reliable health information, both supplementing and supporting health information articulated by midwives during scheduled appointments and at community health events. This improved access to information likely improved individual behaviors by making accurate health information available outside of routine ANC appointments, and also by improving knowledge, an important behavioral determinant.

Access to knowledge is not an adequate model by which to attribute all behavior change. Many complex factors impact behavior, including individual beliefs and motivation. For example, people with beliefs contrary to health information delivered through LI will make different decisions depending on the importance of those beliefs. Additionally, motivation and behavior vary at different times, and changes may occur over short time periods in the same individual.[31] To this end, LI also promotes behavior change through the use of cues to action, which the HBM describes as an important influence on personal beliefs and, as a result, behavior.[28]

At the individual level, our analysis highlighted several, interconnected key factors that moderate the influence LI has on behavior change, specifically having a birth attended by an SBA. All of these factors appear to be connected to women's beliefs about their susceptibility to emergencies. These moderating factors include: 1) individual beliefs of "normal" pregnancy, 2) trust in home birth process, 3) delay in contacting the health facility, and 4) time and conditions when labor begins.

While women described their perceptions of severity, such as the dangers of giving birth without a skilled birth attendant, LI is not effectively targeting women's perceptions of susceptibility. It was not uncommon for women to articulate the dangers of a home birth with no assistance from a skilled attendant, to recite messages about contacting a midwife when labor pain begins, as well as express awareness of the health benefits that midwives and hospitals provide. This

knowledge coexisted with the continued practice of giving birth without a professional birth attendant, particularly if she believed that her pregnancy was "normal." Personal risk or susceptibility is one of the more powerful perceptions in prompting people to adopt new health behaviors. The greater the perceived risk, the greater the likelihood of engaging in behaviors to decrease the risk.[28] Ensuring that messaging uses persuasive techniques to target individual perceptions of susceptibility might improve the likelihood that women will use a skilled attendant at delivery. For example, addressing the commonly held belief that a midwife should be called only if there is a problem, could be addressed with a message that every birth needs skilled care. Additionally, more complex messaging might address commonly held practices and beliefs such as delaying contact with the midwife until long after contractions begin, trust in relatives and TBAs, the predictability of a "normal" delivery, and time and conditions when labor begins. This coupled with persuasive techniques used by midwives to reinforce these messages during an ANC visit could increase the use of skilled birth attendants.

Women also described their trust in the home birth process largely as a result of previous successful home births that were not attended by an SBA. Targeting messages from LI and midwives to help ensure that first time mothers give birth with an SBA to normalize this behavior might improve the likelihood of women utilizing an SBA for all births. Additionally, ensuring that messaging explicitly addresses popularly held myths, such as the fear that taking prenatal vitamins will produce an overly large baby, might improve the likelihood that women will adopt healthier behaviors.

More complex moderating factors are the time and conditions when labor begins and delay women described in recognizing labor and subsequently contacting the midwife. In rural areas, many midwives do not reside in the same village as their assigned Health Post, but commute Monday through Friday from larger towns of varying distances away from the village. Women's perceptions that the midwife is not easily accessible might explain why some women, when going into labor at night or when heavy rains persisted, decided against contacting the midwife. Additionally, women's difficulty recognizing active stages of labor, which results in delays in contacting the midwife or emergency services, might be an important moderating factor that LI can address. To address both of these factors, LI might tailor messages that are also reinforced by midwives.

At the social level, our findings support theories that suggest the opinion of significant others is vital in decision-making and in supporting behavior change.[25] Importantly, the social processes of encouragement, pressure, and support have been shown to be effective techniques for influencing beliefs about capabilities and motivation. Women described including their husbands in the LI program. This inclusion likely encouraged behavior change by shaping women's environments and facilitating the support of husband's and other important family stakeholders. It may be worthwhile for LI to explore ways of more explicitly targeting the husbands of pregnant women in messaging, such as messages developed for and sent directly to husbands, parents or in-laws.

Lastly, like many LMIC's, problems exist with communication and transport for women in Timor-Leste. These problems contribute to significant delays for women in emergency situations. To this end, LI was designed to address health system barriers and regulations for operations that affect how, or how well, MNCH services are provided to an individual or group. To enhance communication between women and midwives and facilitate emergency transportation, enrollees are given phone numbers for the LI phone, which stays at the health facility and is assigned to rotating midwives twenty-four hours per day and the number for emergency transportation provided by the government at each Sub-District Health Office. To facilitate communication between women and the emergency transport a phone was provided to the sub-district health facility, and in cooperation with staff, a clear system was designed to ensure the phone remains charged, turned on, and staffed 24 hours a day.

Respondents identify the design feature that linked LI enrollees with health facility transportation as a huge benefit. This study found that LI's unique integration into the health system of Timor-Leste and the strengthening of emergency response units, proved to be one of the program's most useful components for participants. LI's facilitation of access to care in emergency and non-emergency situations likely influenced women's perceived barriers to change, or their own assessment of the obstacles in the way of adopting a new behavior. Of all the constructs detailed in the HBM, perceived barriers have been shown to be highly significant in determining behavior change. This facilitation also allowed women living in different settings more ability to act on their intentions to deliver with an SBA.

It is challenging to evaluate mechanisms of behavior change in a complex intervention such as

LI. However, given the popularity of mHealth programs to change behavior in LMICs, it is important to begin to understand the mechanisms of behavior change within these programs. The use of qualitative methods in this study provided an opportunity for in-depth exploration of women's experiences interacting with LI and offers more understanding of the ways in which LI targets important behavioral determinants.

This study has a number of limitations. While data saturation was reached, the study population is small and limits the ability to generalize from these findings. The language barrier, combined with the limited amount of time spent with women, meant that conversations were limited to behavior related to LI. There are likely to be deeper and more complex explanations of behavior that were not captured by this research. Additionally, some women were very shy, leaving more confident women to speak at greater length with us. This meant that sometimes other family members spoke on behalf of women. Additionally, all behavior was self-reported and not cross-referenced with a more reliable and objective source of data. Lastly, this study only examines mechanisms of behavior change through the lens of one mHealth program. Despite these limitations, which may limit generalizability, lessons from this work may be applicable to other mHealth programs. Further research is needed to understand the most effective ways to change behavior using mobile-mediated program design to influence important behavioral determinants at the individual, social, and health systems levels.

As mhealth programs continue to gain popularity among program planners and policy makers, it is important to remember that mHealth can be an effective tool, but is not a stand-alone solution to changing behavior. When designing mHealth programs, taking individual, social, and health system behavioral determinants into consideration is crucial to developing locally appropriate and effective programs. Also, extreme poverty, heavy workloads, position in society, and position in the household are all part of the complex picture of determinants of women's behavior and should be thoroughly examined and understood when any behavior change intervention is implemented. Importantly, this research demonstrates that interventions using mobile technology will be strengthened if they work within rather than in isolation to established health systems. Further research is required to evaluate specific programs and how mHealth interventions interact with behavioral determinants in complex systems.

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