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Modeling and testing maternal and newborn care mHealth interventions: a pilot impact evaluation and follow-up qualitative study in Guatemala

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ABSTRACT

Objective: To develop a descriptive model of structural characteristics of mHealth in the context of newborn nutrition, and to assess the effects of illustrative interventions through a mixed-methods study consisting of an impact evaluation and a qualitative assessment.

Materials and Methods: We conducted a 23-week intervention with 100 mothers in rural Guatemala in 2013 and 2014. In group 1 ($n = 24$), participants received health-promoting text messages. In group 2 ($n = 32$), peer-to-peer groups were formed. In group 3 ($n = 30$), peer-to-peer groups were formed, a health professional participated in the discussions, and participants received health-promoting messages. In the control group ($n = 14$), participants were simply given a mobile phone. We measured changes in knowledge and self-reported behavior. Four focus groups in 2015 showed the perceptions of 44 additional women and the potential of the previously tested interventions in other marginalized areas.

Results: Significant relationships were found between group membership and changes in knowledge ($P < .001$), and between changes in knowledge and self-reported behavior ($P = .010$). Within peer-to-peer groups, 3665 text messages were shared; discussions covered topics such as breastfeeding practices, health concerns, and emotional issues. Focus groups revealed a deficit of support for mothers, a precariousness of public services, different cultural barriers affecting access to care, and the potential for scaling up.

Discussion: The complementarity of structural arrangements of mHealth interventions can play an important role in helping to encourage recommended breastfeeding attitudes along with providing rich information about challenges in rural areas.

Conclusion: A mixed-methods study was appropriate to compare the effects and assess the potential of mHealth strategies in a complex rural setting.

Key words: mobile, mixed methods, self-reported behavior, breastfeeding, knowledge, comparison

BACKGROUND AND SIGNIFICANCE

Mobile technology is increasingly used to extend the reach of health care in low-income countries, but recent work[1,2] has shown that projects yield equivocal results. Mobile-health interventions – referring to the use of mobile devices such as smartphones in health contexts – can support coordinated and evidence-based care, facilitate community-based health services, and enable patients to access more efficient and personalized services.[3–5] There is evidence to show that interventions might lead to short-term adoption of provider-suggested behaviors[6,7]; simple text messages have the

potential to modify health attitudes.[8,9] Yet, interventions might produce limited effects,[10–13] and mobile phone support might not be cost-effective.[14]

Mobile-health (mHealth) pilots abound in size, scope, and shape, but only a few are based on theoretical grounds.[15–17] In fact, projects are often driven by the implementers' trust in technology,[16,18,19] and solid evidence is needed to affect policy investment.[20] Implementation and health care process improvements are common mHealth topics in the scientific literature, but less well understood is how the mechanisms of adoption and appropriation of technology at the individual and sociocultural levels can produce useful health outcomes.[1] To overcome imprecision of results, it has been suggested that new studies should aim for establishing theoretical and measurement standards in multidisciplinary contexts, fostering collaboration between information technology and public health researchers.[1,21] Studies need to highlight the types of interventions that are most effective to help public deciders make better informed decisions and refine health programs.

To contribute to this effort, we present a mixed-methods study whose main goal was to compare the effects of current mHealth approaches. We concentrated on the maternal and newborn care context, because mHealth programs are increasingly recognized as an important tool in helping to improve services in marginalized areas,[22–28] but more evidence on the business, impact, and behavioral values of mHealth is needed.[23] The study was conducted in Guatemala, where economic and health inequities among the population of 16 million are substantial. Nearly three-fifths of all Guatemalan children and adolescents live in poverty and 19% are extremely poor; close to 76% of the indigenous population live below the poverty line and 28% below the extreme poverty line.[29] Guatemala has one of the worst indicators in the world of chronic malnutrition or stunting: it affects 1 in 2 children under 5 years of age.[30] The prevalence of malnutrition is 66% among indigenous children vs 36% among non-indigenous children, and 58% among children living in rural areas vs 34% in urban areas.[30] Mobile penetration rates reached 110% in 2014.[31]

OBJECTIVES

The primary objectives of the study were to develop a descriptive model of structural characteristics of mobile-health pilots in the context of newborn nutrition, and to assess the effects of illustrative interventions through a mixed-methods, 2-phase study consisting of a pilot impact evaluation in 2014 and a follow-up qualitative evaluation in 2015 in low-resource settings. The goal of the evaluation was to compare the effects of simultaneous interventions in knowledge and self-reported health behavior in newborn nutrition among new mothers living in rural Guatemala. The goal of the follow-up qualitative study was to gather information on how appropriate the tested interventions might be in other marginalized regions of Guatemala.

Additional objectives were to identify insightful data about the challenges that new mothers face when it comes to newborn and maternal health, and to describe lessons learned that could be of use for future studies.

MATERIALS AND METHODS

Descriptive model of structural arrangements in maternal and newborn care mHealth pilots

To construct a descriptive model in 2013, we first gathered information about mobile health projects that involved patients or health care workers in the context of maternal and newborn care in low-resource areas. We did not conduct a thorough review of the literature. Instead, we used a published review[28] to identify studies. We included pilot studies, interventions, and evaluations that were published before September 2013. We excluded theoretical and qualitative studies that were not directly related to interventions in developing countries and that relied on interviews and surveys only. To confirm the completeness of the empirical basis of the constructed model, we also considered one recent thorough review[1] in the write-up of this manuscript; all studies in the review were published before 2013 and had been previously identified.

A subset of 14 studies[32–45] found in the published reviews met the inclusion criteria. We extracted the target population of the described interventions – women, health workers, or others, such as information systems – and the communication channels enabled by the described projects. Interventions fell into 1 of 3 possible categories, vertical, horizontal, or hybrid interaction channels, depending on their structural characteristics; 11 studies[32–42] described interventions that applied vertical communication channels mainly to collect data and to promote maternal and newborn health through mobile phones. The mobile-based services were based on diffusion of information in 1-way streams. The pilots tended to focus on the diffusion of previously constructed messages in order to educate mothers or improve the skills of health professionals. One study[43] described interventions that introduced horizontal communication channels with the intention of improving communication and sharing knowledge among health workers. Communication channels were bidirectional and allowed interactions between medical experts and midwives. The pilot tried to address the potential of health care worker communities in building social capital, enhancing collaboration, and improving communication. Two studies[44,45] described pilots with multidirectional communication channels that allowed communication between mothers, medical experts, and other stakeholders. These studies presented hybrid interventions aimed at improving the production and delivery of health services by establishing coproduction dynamics that might alleviate the burden of congested and precarious health systems (see Supplementary Material 1 for details about the considered studies). We summarize the characteristics of the pilots in a descriptive model in Figure 1.

Pilot impact evaluation design
Experiment design
Recent generations of field experiments have been reported to set ambitious goals because they were designed to test theory, collect facts useful for constructing a theory, and organize data to make measurements of key parameters.[46] The main purpose of current impact evaluations is to determine whether a program has a meaningful effect and to quantify the size of the effect.[47] Patojitos (meaning "little ones" in Guatemalan affectionate slang) was an interventional field experiment with a parallel assignment of participants into 4 groups. It was designed to test illustrative mHealth approaches derived from the descriptive model presented in the previous section and was conducted in rural Guatemala. It sought to promote exclusive breastfeeding, an intervention intended to reduce the high prevalence of chronic malnutrition.[30]

Participants in group 1 received text messages twice a week related to newborn nutrition, on mobile phones they were given when they enrolled in the project. The messages, developed by experts in maternal and newborn care, were provided by the Mobile Alliance for Maternal Action (http://mobilemamaalliance.org/mobile-messages). They were specifically designed to promote rec-

	Service production dynamics	Interaction forms	Technology added value
Vertical Platforms [31-41]	Centralization of information	One-way streams of information	Data collection and low-cost health promotion
Horizontal Platforms [42]	Adjusted production of services	Virtual communities	Sharing of knowledge and experience; social bonding
Hybrid Platforms [43,44]	Co-production of services	Multidirectional streams of information	Interactions between health care stakeholders

Figure 1. Descriptive model of structural arrangements in maternal and newborn care mHealth pilots

ommended breastfeeding attitudes. Messages encouraged bonding with babies during feeds and covered topics such as women's well-being and how to overcome difficulties with breastfeeding.

In group 2, participants were assigned to 1 of 3 peer-to-peer groups of 10 individuals each. Women in these groups could send text messages to a short-code number. When 1 participant sent a text message to this number, all the women in the virtual community received the message, on mobiles phones they were given at the beginning of the project. At enrollment, participants were were asked to use their group to freely discuss any issues and doubts they may have in relation to their infant's health and well-being. One researcher supervised conversations on a daily basis to ensure that no harmful information was being shared among groups.

In group 3, participants were assigned to 1 of 3 peer-to-peer groups (as in group 2); in addition, they received information regarding breastfeeding practices (as in group 1), and could communicate with a health professional. Two health professionals took part in the groups, bringing up topics for discussion and helping to answer any questions or concerns the participants might have. The health professionals also had the role of intervening in their group if any misleading or wrong information was sent among the group.

Participants in group 4 were simply given a mobile phone and were instructed to use it for matters related to their babies. Participant women and health professionals were unaware of group assignment at enrollment.

Recruitment of participants

Recruitment took place in Centro de Salud Barbara, a health center attached to the School of Medicine of Universidad Francisco Marroquín and located in the rural area of San Juan Sacatepéquez. The eligibility criteria for the study were a compromise among 3 restrictions: the intervention had to last 23 weeks (due to funding restrictions); the women's exposure to a relevant health program had to be maximized (we were trying to promote exclusive breastfeeding in the first 6 months); and the number of potential participants in a rural clinic with a low influx of patients had to maximized. Therefore, eligible women had to be not less than 8 months pregnant or had to have a baby not older than 4 months. They also needed to understand written Spanish and be willing to participate in a mobile technology program. Recruitment interviews started in November 2013 and ended in December 2013. Recruitment selection did not take into account ethnicity, baby gender, or income.

Participants were to be assigned to the groups according to a predefined list of random numbers. However, investigators considered that assignment on a first come, first served basis would be more appropriate due to the limited time for recruitment and a potential deficit in the number of recruited participants. Two investigators (J.T.P.

and C.Z.) assigned individuals into groups. Informed consent from all participants was obtained. One week after the interviews were conducted, participants were asked to come back to the recruitment center to pick up an inexpensive, basic mobile phone for free. Phones were credited with postpaid credit and participants received a simple handout and a brief instructional session on how to use the phone.

Assessment

Women were interviewed and asked about their breastfeeding habits at recruitment and at the end of the study. Questions were based on a 2008 national survey.[48] Changes in levels of knowledge were assessed by counting the number of participants who did not know about exclusive breastfeeding at enrollment but did at the end (learned the message); the number of participants who knew about exclusive breastfeeding at enrollment but did not at the end (forgot the message); the number who did not know about exclusive breastfeeding either at the enrollment stage or at the end (continued to be unaware); and the number who knew about exclusive breastfeeding at enrollment and at the end (remembered the message).

Participants were also asked questions about their behavioral practices when it came to breastfeeding. If during initial face-to-face interviews participants answered "yes" to the question "are you giving foods other than breastmilk to your baby, like water, baby formula, soups, and solids?" their self-reported behavior was marked as insufficient to be able to exclusively breastfeed. Changes in self-reported breastfeeding behavior were assessed by counting the number of participants who reported that they did not exclusively breastfeed at enrollment but did afterward; the number who reported they exclusively breastfed at enrollment but did not afterward; the number who reported that they did not exclusively breastfeed either at enrollment or afterward; and the number who reported that they exclusively breastfed at enrollment and afterward.

Text-message analysis

Text messages exchanged in groups 2 and 3 during the pilot were manually coded according to a framework that was informed by previous work.[49] One investigator (J.T.P.) made a first, rapid round of review of text messages and defined 3 possible coding categories and associated topics. The Social Support category included topics such as sharing of identities and personal information, life updates, and relationship problems (the complete list can be seen in Table 3). The Medical and Health Information category included topics such as baby's health and development, family planning, mother's health, and sex life. The third category, Other Information, included program-related information and general complaints about public health services. In a second round of review, 2 investigators (J.T.P. and C.Z.) worked independently to assign categories and topics to individual text messages. At the end of this round, investigators compared assignments and solved disagreements through discussion until a consensus was reached.

Qualitative follow-up assessment: focus groups in other regions of Guatemala

In 2015 we organized 4 2-hour focus groups with mothers in rural areas in order to assess the potential of Patojitos's interventions in other regions of Guatemala. These women had not participated in the previous pilot. The chosen locations to conduct the groups were in the departments with the highest poverty rates in Guatemala.[50] The only requirements to participate were to live in a rural area and have maternal experience. Focus group 1 was organized with 15

mothers in Joya de las Flores, San Juan Sacatepéquez, on February 16. Focus group 2 was done with 15 mothers in San Antonio I, Alta Verapaz, on March 3. Focus group 3 was done with 7 mothers in Santa Lucía la Reforma, Totonicapán, on March 4. Focus group 4 was conducted with 7 mothers in Huehuetenango on March 11. Collaborators from 2 nongovernmental organizations, TulaSalud[51] and Health Poverty Action, helped to recruit participants.

A common set of discussion points was used across the focus groups. These were led by a moderator who used a standardized guide developed by study investigators (see Supplementary material 2 for details). Focus group 1 was conducted in Spanish. Focus groups 2, 3, and 4 were conducted in indigenous languages; the help of a local moderator was needed to translate questions and women's answers into Spanish. Women were initially asked some general demographic questions, and investigators recorded the data on paper. The moderator then initiated group discussions around 2 components: the public health experience and the potential benefits and obstacles of vertical, horizontal, and hybrid mHealth platforms. Investigators took notes during the sessions, which were also recorded. Qualitative techniques were then used to extract common themes. Informed consent was obtained from participating mothers.

RESULTS

Pilot impact evaluation

Demographic data and participant flow during the experiment

Of 111 indigenous women who were assessed for eligibility, 100 were eligible. Data from 78 individuals was used for analysis, as 7 women did not attend the mobile phone handout meeting and 15 were lost to follow-up (Figure 2).

Almost all participants (96%, $n = 75/78$) used public health services as their primary health care for treatment and diagnosis, and over two-thirds (68%, $n = 53/78$) reported having encountered problems to get basic medical services in the past year. Common complaints were: a shortage of doctors to meet the demand for health services, a lack of punctuality in terms of appointments, a lack of medicine and vaccines, and disrespectful behavior from workers at public health clinics. Participant demographics are presented in Table 1.

Changes in knowledge and self-reported health behavior

Groups yielded a significant difference ($P < .001$) in changes of knowledge (Table 2). The most effective intervention in terms of increase of knowledge was the one used in group 1, followed by those used in groups 3, 4, and 2. Most participants in group 1 (60%, $n = 12/20$) experienced a knowledge increase, and the rest (40%, $n = 8/20$) remembered the message at the end of the experiment. Half of the participants in group 3 (50%, $n = 11/22$) learned the exclusive breastfeeding message, and 45% ($n = 10/22$) remembered it at the end. All individuals in group 1 ($n = 20/20$) and 95% in group 3 ($n = 21/22$) were aware of the exclusive breastfeeding message at the end, either because they learned it during the experiment or because they remembered it. In contrast, only half of participants in group 2 ($n = 12/24$) and two-thirds in group 4 ($n = 8/12$) were aware of the exclusive breastfeeding message at the end of the experiment. The only setups where participants experienced a knowledge decrease were group 2 (peer-to-peer groups without health professional participation) and group 4 (control). No individuals in group 1 or 3 forgot the exclusive breastfeeding message during the experiment.

Although groups did not show a significant difference in self-reported behavior, a significant relation ($P = .010$) between changes

in knowledge and changes in self-reported behavior was found (Supplementary material 3). Of participants who learned the exclusive breastfeeding message, 89% ($n = 15/28$) reported exclusively breastfeeding at the end of the experiment; 85% ($n = 29/33$) who remembered the message reported exclusively breastfeeding at the end. In total, 89% ($n = 54/61$) of those participants who were aware of the exclusive breastfeeding message at the end of the experiment reported exclusively breastfeeding their babies.

Text message analysis

Among the participants of groups 2 and 3, 3665 text messages were sent. Close to two-thirds (62.00%, $n = 2272/3665$) were in relation to social support and psychosocial dialogue, and approximately one-third (34.69%, $n = 1271/3665$) were in relation to medical or health information such as family planning, sex life after pregnancy, mother's health following a caesarean operation, and newborn's well-being outside the scope of nutrition (Table 3).

Qualitative follow-up assessment: focus groups in other regions of Guatemala

In all, 44 mothers took part in the focus groups. Most participants (64%, $n = 28/44$) were between 16 and 30 years old. The majority (64%, $n = 28/44$) did not finish primary school, and 25% ($n = 11/44$) had no education. Two-thirds (66%, $n = 29/44$) had between 1 and 3 children. The rest (34%, $n = 15/44$) had between 4 and 14 children. Approximately three-fifths (57%, $n = 25/44$) traveled between half an hour to an hour to get to the nearest health center. Nearly one-fifth ($n = 8/44$) took more than an hour. All participants reported breastfeeding their babies, but close to half (48%, $n = 21/44$) started giving food other than breastmilk to their babies before 6 months. Just over half of participants (53%, $n = 23/44$) had access to a mobile phone. Discussion points revolved around 3 main topics: availability of and access to health services, support structures, and interaction and trust with workers at rural health systems. We summarize the most important discussion points in Table 4.

DISCUSSION

Based on behavioral change literature,[52] previous work has attempted to characterize mHealth interventions as passive and active.[53] Other studies have classified interventions by themes, such education and awareness or data access.[54] These categorizations fail to depict complex arrangements in which a variety of stakeholders might adopt different roles leading to different outcomes. Instead, we focused on the structural characteristics of communication channels in mHealth pilots to construct a descriptive model of interventions.

The resulting model inspired a pilot impact evaluation of different illustrative, simultaneous interventions. The impact evaluation revealed that the most effective intervention in terms of improved levels of knowledge was the vertical, unidirectional structure in which the exclusive breastfeeding message was transmitted via one-way communication. This was followed by peer-to-peer groups with a medical professional in the group. Simple access to mobile technology and unsupervised virtual communities were the settings in which participants seemed to have forgotten the health knowledge they already had. It appears that the guiding hand of a health professional was an important component to spread reliable information and counteract inaccurate recommendations. Future work should continue to apply impact evaluation methodologies to explore the potential benefits of the presence of health professionals in larger virtual communities.
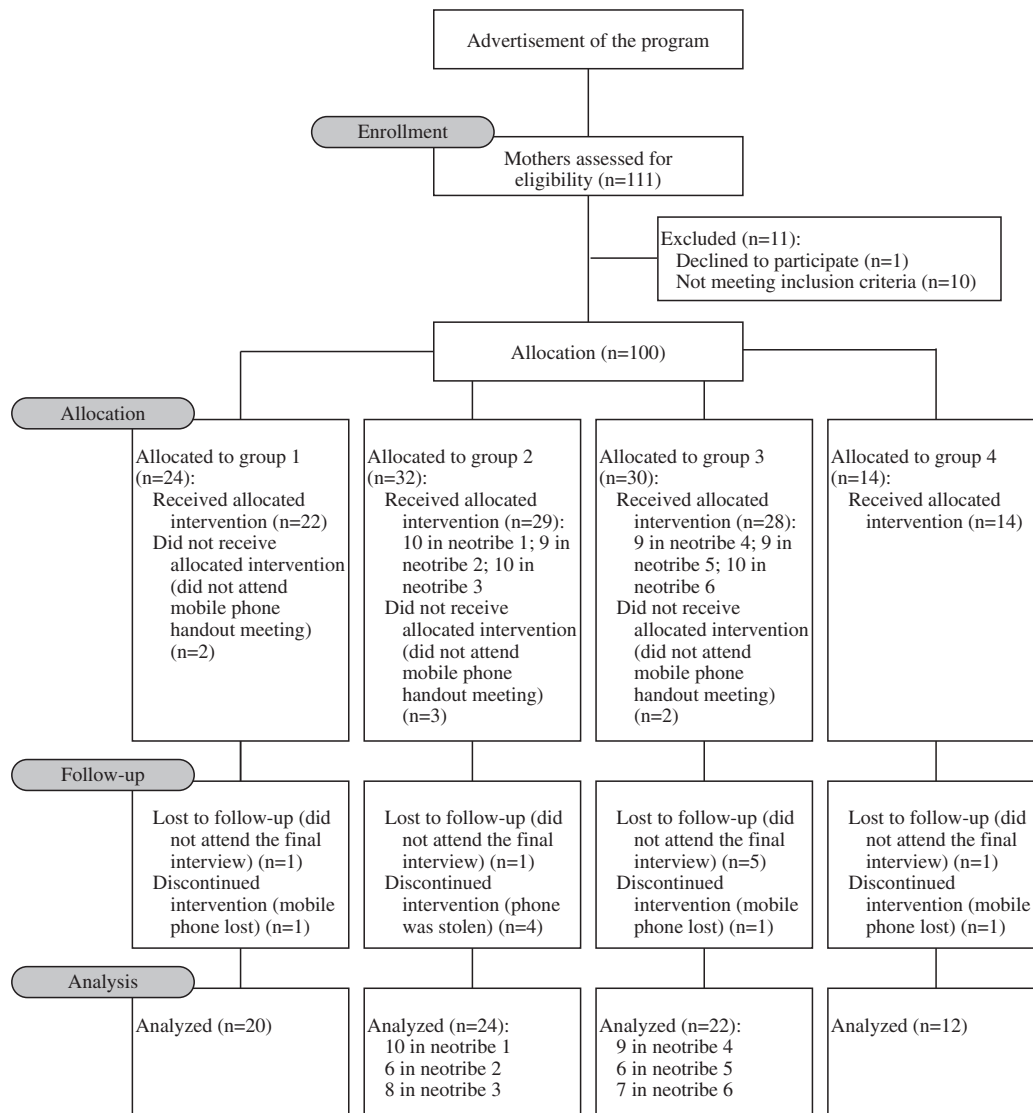
Figure 2. CONSORT flow diagram

Results from the experiment might prove useful in the maternal and newborn care context. Being aware of the practice at the beginning of the project seemed to be enough for women to report remembering a recommended behavior at the end of the study. This finding, in harmony with recent work,[55] supports the idea that health-promoting text messages can raise awareness among mothers in countries where health service resources are stretched. Human behavior is complex, however, and exclusive breastfeeding is both a natural act and a learned behavior.[56] Although we highlight the relationship between knowledge and self-reported behavior, the answer to only 1 question, at enrollment and at the end of the experiment, was used to analyze participants' breastfeeding behavior. Future work could examine complementary instruments to ensure consistency between answers during interviews and in daily behavior. For example, text message exchange in virtual communities could be further analyzed to perceive longitudinal changes in nutrition and other maternal and newborn health factors. The majority of babies in group 3 were male, but the majority in groups 1 and 2 were female. One recent study in Guatemala confirmed a prediction of healthier growth in indigenous girls than in boys throughout the first

year of life.[57] Cultural perceptions in indigenous populations might in fact influence breastfeeding habits. We did not find significant associations between infants' gender and mothers' changes in knowledge ($P = .897$) or self-reported behavior ($P = .829$), but researchers should take into account the potential impact of gender effects when designing future large-scale mHealth experiments.

The analysis of the qualitative information we collected during the experiment and in the follow-up study based on focus groups showed the challenges that marginalized mothers were, and likely are, facing. This information puts into context the lives that many of these mothers are facing day-to-day and partially explains the obstacles that are leading to poor health outcomes for them and their babies. Women's complaints about the unavailability of health clinics and the rudeness of some public health workers showed that the health service experience is often discouraging. Plus, the context of sexual discrimination, sometimes leading to domestic violence, demonstrates that maternal and newborn care extends beyond mothers' access to health clinics, and should in fact be part of a more integrated community and family care program. Regular exchanges among women gave them support structures. Advice

Table 1. Participant demographics

Participant demographics	Total sample n = 78 (%)	P-value	Group 1 n = 20 (%)	Group 2 n = 24 (%)	Group 3 n = 22 (%)	Group 4 n = 12 (%)
Mother's age in years		.659				
16–22	32 (41)		9 (45)	11 (46)	10 (45)	2 (17)
23–30	35 (45)		9 (45)	10 (42)	9 (41)	7 (58)
>30	11 (14)		2 (10)	3 (12)	3 (14)	3 (25)
Maternal experience		.814				
First baby	34 (44)		9 (45)	12 (50)	9 (41)	4 (33)
Not first baby	44 (56)		11 (55)	12 (50)	13 (59)	8 (67)
Baby's age in days		.684				
0–50	42 (54)		11 (55)	13 (54)	12 (55)	6 (50)
51–100	27 (35)		5 (25)	9 (38)	7 (32)	6 (50)
>100	9 (11)		4 (20)	2 (8)	3 (13)	0 (0)
Baby's gender		.047				
Male	41 (53)		8 (40)	10 (42)	17 (77)	6 (50)
Female	37 (47)		12 (60)	14 (58)	5 (23)	6 (50)
Familiarity with text messages		.932				
Familiar	64 (82)		16 (80)	19 (79)	19 (86)	10 (83)
Not familiar	14 (18)		4 (20)	5 (21)	3 (14)	2 (17)
Education		.695				
None	7 (9)		2 (10)	3 (13)	1 (5)	1 (8)
Primary school	59 (76)		16 (80)	18 (75)	18 (82)	7 (58)
High school	11 (14)		2 (10)	3 (12)	3 (13)	3 (26)
> High school	1 (1)		0 (0)	0 (0)	0 (0)	1 (8)
Exclusive breastfeeding		.041				
Aware	45 (58)		8 (40)	18 (75)	10 (45)	9 (75)
Not aware	33 (42)		12 (60)	6 (25)	12 (55)	3 (25)

Table 2. Groups and changes in exclusive breastfeeding knowledge of participants

Groups and changes in knowledge	Total sample n = 78 (%)	P-value	Group 1 n = 20 (%)	Group 2 n = 24 (%)	Group 3 n = 22 (%)	Group 4 n = 12 (%)
Exclusive breastfeeding message		.000				
Learned	28 (36)		12 (60)	2 (8)	11 (50)	3 (25)
Forgot	12 (15)		0 (0)	8 (33)	0 (0)	4 (33)
Remembered	33 (42)		8 (40)	10 (42)	10 (45)	5 (42)
Still unaware	5 (7)		0 (0)	4 (17)	1 (5)	0 (0)

from peers appeared to be an effective way to comfort worrying mothers. Women in group 2 organized several face-to-face meetings to support each other. The text analysis of conversations in group 3, where it was possible to communicate with peers and a health professional, revealed general conversations about maternal and child health that could lead to positive behavior change among the participants, as they had the opportunity to discuss topics and receive advice from a health professional and their peers. Results support the idea that Information and Communication Technologies (ICTs) might be regarded as tools that offer new potential for combining information embedded in systems with the creative potential and knowledge embodied in people.[58]

The study sheds new lights on scaling-up possibilities. With minimal software development efforts, open-source platforms[59] can mimic the technical setup that we created. With regard to the target population, all participating mothers in the field experiment expressed that the mHealth intervention they were part of was helpful. Reasons were many, including because they felt their voice was being heard and because they could use the mobile phone as an alternative to request help when their husbands were not available or clinics were closed. Where literacy levels were a source of con-

cern, the mothers asked family members for help. Participants were given free credit; however, they expressed a willingness to pay for the services they had access to if the project were to be extended. Future projects could consider finding financial equilibrium by asking for a subscription fee to cover the cost of text message transmission. Results from focus groups in 2015 proved the suitability of the tested mHealth approaches and the validity of the experiment's results in other marginalized areas of Guatemala.

CONCLUSION

The study makes the case that the complementarity of different forms of mHealth can support valuable interactions among indigenous women and health providers. From a public health policy perspective, findings from the experiment and focus groups suggest that simple technology coupled with appropriate virtual organizational arrangements might enable rich, beneficial interactions in underserved areas.

New mHealth studies should explore the potential of mixed methodologies in the analysis of low-resource health environments. They should also exploit the possibilities of innovative data collection mechanisms.

Table 3. The nature of text messages and examples

Category	Topic	Sample text message[a]
Social support (62.00%[b])	Check-ins and greetings (48.36%)	"Hi good afternoon to all of you I hope you are feeling great Have a happy afternoon"
	Physical meet-ups (4.33%)	"Hello I am from Pachali we live close. We should meet; maybe you can come here or maybe I can go to your place"
	Identities, addresses, and personal information (3.13%)	"Hello, my name is XX and I live in XX"
	Life updates (1.58%)	"Hello babies my daddy already working he's baking bread"
	Encouragement and empathy (1.42%)	"God bless you all, take care of your little ones"
	Relationship problems (1.36%)	"I had problems with the father of my children. He hit me and wants to take my kids. What can I do thank you for listening"[c]
	Virtual community health (0.96%)	"Hello mothers. One of the mothers in our group got her phone stolen last week"[d]
	Friendship and affection (0.86%)	"We like you very much I hope our friendship will last long"
Medical and health information (34.69%)	Baby's well-being, health and development (23.93%)	"My baby cries too much what should I do?"
	Baby nutrition and breastfeeding (4.60%)	"My baby weights 12 pounds and she is 2 months old" "Why doesn't my baby drink my breast-milk?"
	Family planning, pregnancy, and sex life (2.66%)	"My baby will be soon be 4 months old and I still haven't had my period I'm worried that I'm pregnant, what should I do?"
	Mother's well-being and health (2.62%)	"I have sore nipples what could I do?"
	Family's well-being and health (0.56%)	"Good evening excuse me what can I give my two kids? They have had fever for the past two days and the fever won't go"
	Mother's nutrition (0.43%)	"What should I eat to produce white and thick breastmilk?"
Other information (3.31%)	Program-related information (3.05%)	"Hello at what time is the program's meeting tomorrow?"
	Access to and quality of health services (0.26%)	"In which health centre did you get the vaccines for your baby?" "I request more nurses in the health clinic they are always out"

[a]Originally in Spanish; some examples of text messages have been translated into English. We tried to preserve grammatical errors in the translations.
[b]Proportion of text messages ($n = 3665$).
[c]A health professional called the mother who sent this message to provide special support and advice.
[d]Researchers called the mobile phone operator to block the stolen number.

Table 4. Common discussion points across focus groups: obstacles, opportunities, and potential for mHealth services in other regions of Guatemala

Main discussion topics	Obstacles	Opportunities	Potential for mobile services
Availability of and access to health services	Lack of resources – Lack of medical experts in clinics – Lack of medicines and vaccines – Lack of access to accurate, current information – Discontinuity in provision of service	– Provide access to alternative sources of accurate information coming from midwives and health professionals – Increase cultural sensibility of health workers – Catalyze professional education of midwives	– Unidirectional mHealth channels to raise prevention awareness in families – Hybrid mHealth channels to create discussion groups among doctors, midwives, and families – Call centers to resolve immediate doubts
Support structures for mothers	Babies entail economic and psychological burden – Lack of support for families – Lack of support in rural communities – Lack of support in health centers	– Share experiences among mothers – Provide education for family members – Facilitate discussions between NGOs and rural health workers	– Unidirectional channels based on text messages to target husbands and children, to encourage family support. – Hybrid channels to create discussion groups among doctors, midwives, and families to decrease anxiety and stress
Relationships and trust with workers at rural health systems	Barriers between rural communities and services at health centers – Language and cultural barriers between mothers and doctors – Lack of trust between professional health workers and midwives – Geographic barriers between communities and health centers	– Strengthen relationships among institutional and traditional caregivers through discussion groups and workshops	– Horizontal channels to allow peer discussions and sharing of experiences – Hybrid channels to reveal attitudes that have been ignored and that might affect interactions between mothers and professional and traditional caregivers

ETHICS

The Ethics Board of the School of Medicine of Universidad Francisco Marroquín approved the study protocol on October 25, 2013 (CE/FM UFM0062-13). The experiment was registered in clinical-trials.gov with ID NCT02263118 in October 2014. Centro de Salud Barbara, the health center attached to the School of Medicine of Universidad Francisco Marroquín, where recruitment and interviews took place, provided ethical oversight.

SUPPLEMENTARY MATERIAL

Supplementary material are available at *Journal of the American Medical Informatics Association* online.

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