

A mobile phone-based multimedia intervention to support maternal health is acceptable and feasible among illiterate pregnant women in Uganda: Qualitative findings from a pilot randomized controlled trial

Digital Health
Volume 7: 1–10
© The Author(s) 2021
Article reuse guidelines:
sagepub.com/journals-
permissions
DOI: 10.1177/2055207620986296
journals.sagepub.com/home/dhj



Angella Musiimenta^{1,2} , Wilson Tumuhimbise¹, Niels Pinkwart³,
Jane Katusiime¹, Godfrey Mugenyi¹ and Esther C Atukunda¹

Abstract

Background: Uganda's maternal mortality rate remains unacceptably high. Mobile phones can potentially provide affordable means of accessing maternal health services even among the otherwise hard-to-reach populations. Evidence about the acceptability and feasibility of mobile phone-based interventions targeting illiterate women, however, is limited.

Objective: To assess the acceptability and feasibility of a mobile phone-based multimedia application (MatHealth app) to support maternal health amongst illiterate pregnant women in rural southwestern Uganda.

Methods: 80 pregnant women initiating antenatal care from Mbarara regional referral hospital were enrolled in a pilot randomized controlled trial and followed until six weeks after delivery. The 40 women in the intervention group received a MatHealth app composed of educational videos/audios, clinic appointment reminders, and the calling function. Qualitative interviews on acceptability of this technology were carried out with 30 of the intervention participants. An inductive, content analytic approach was used to analyze qualitative data. Quantitative feasibility data were recorded and summarized descriptively.

Results: Participants reported that the intervention is acceptable as it enabled them adopt good maternal health practices, enhanced social support from spouses, provided clinic appointment reminders, and facilitated communication with health-care providers. Challenges included: phone sharing (74%), accidental deletion of the application 15 (43%), lack of electricity 15 (43%), and inability to set up a reminder function 20 (57%).

Conclusion: The MatHealth app is an acceptable and feasible intervention among illiterate women, in a resource limited setting. Future efforts should focus on optimized application design, spouse orientation, and incorporating economic support to overcome the challenges we encountered.

Keywords

Mobile phones, multimedia videos/audio, maternal health, acceptability, feasibility, illiterate pregnant women

Submission date: 17 January 2020; Acceptance date: 11 December 2020

¹Department of Information Technology, Mbarara, Mbarara University of Science and Technology, Uganda

²Angels Compassion Organisation, Mbarara, Uganda

³Computer Science Department, Humboldt-Universität zu Berlin, Berlin, Germany

Corresponding author:

Angella Musiimenta, Department of Information Technology, Mbarara University of Science and Technology, P.O. Box 653, Mbarara, Uganda.
Email: amusiimenta@must.ac.ug
Twitter: @Dr_Angella_M



Background

Maternal health issues

Compared to high income countries, maternal and child mortality rates remain unacceptably high in many low and middle income countries (LMICs). Globally, 300,000 women die annually from avoidable maternal health-related complications, 99% of which happen in LMICs with Sub-Saharan Africa alone accounting for 66%.¹ Uganda's maternal mortality rate is estimated at 343 maternal deaths per 100,000 live births, which is one of the highest rates in the world.² Over 17 women and 106 children die every day from maternal and child health issues in Uganda.³ Many of these deaths happen in rural areas especially among poor and illiterate women, who compared to educated women are less likely to receive antenatal care and deliver at the clinic.⁴ The World Health Organization (WHO) envisions a world where every pregnant woman and new born baby receives quality care through pregnancy, child birth and postnatal periods.⁵ The health and well-being of pregnant women has far-reaching impacts—it does not only ensure the health of mothers, but also warrants the health of their babies, and the rest of their family members.^{6,7} Many of the maternal and child deaths could be avoided given timely access to the right care and resources during pregnancy, at a time of delivery, and after delivery.⁸ Illiteracy, lack of reliable information, poverty, distance to health care centers, and cultural practices are some of the barriers that limit access to quality maternal health care.^{9,10} In Uganda, only 58% of pregnant mothers attend at least four antenatal visits previously recommended by WHO¹¹ (WHO currently recommends eight visits) while over 30% of women deliver outside the facility without a skilled birth attendant.¹²

Mobile health technologies for maternal health

Given widespread telephone adoption and mobile network coverage in sub-Saharan Africa,¹³ mobile technologies (such as mobile phones) can provide affordable means of providing maternal health services to women including those that would otherwise find it challenging to access the services. This approach is reported to be acceptable and feasible in extending other health services such as HIV,¹⁴ tuberculosis,¹⁵ and sexual health¹⁶ care to rural poor populations in the same setting—Uganda. However, in low resource settings (LRSs), studies reporting about the application of mobile technologies in maternal health are limited. The modest existing studies report some promising results e.g. mobile tools enabled access to

pregnant-related information,¹⁷ and increased service utilization.¹⁸ Besides, the prevailing studies mainly utilize Short Messaging Services (SMS) which are not appropriate for illiterate women since they are unable to read.^{19,20} This approach leaves out a significant number of women since 41.2% of women in Uganda only completed some primary level education.¹² Overall, there is need for more research documenting the application of mobile health technologies to support maternal health among illiterate women especially in low resource setting. This paper documents how illiterate women (not having studied at all or not having studied beyond primary seven or elementary education) perceive a mobile application composed of maternal health-related tailored video and audio messages, appointment reminders and calling function. This application is known as the MatHealth app for the purpose of this paper.

Methods

Study design and setting

The study utilized a mixed methods study design. Participants (pregnant mothers) were recruited from mbarara regional referral hospital (MRRH), which is the largest hospital in rural southwestern Uganda. According to the hospital records, the MRRH employs 11 obstetricians and 22 midwives and performs over 10,000 deliveries annually with a maternal mortality rate of 270/100,000 live birth, caesarean section rate of 30% and a perinatal mortality rate of 56/1000.²¹ Sociodemographic and basic health data are captured from pregnant women during their first visit, and stored in paper-based antenatal registers. Each woman is given an antenatal card that contains her biodata as well as the date of the next appointment. Women are expected to attend at least eight antenatal appointments, and they are supposed to bring their antenatal cards on every visit. The clinic verbally provides group-based maternal health talks to pregnant women scheduled according to the trimesters—first trimester talks are offered on Tuesdays, second trimester talks are offered on Wednesdays, while third trimester health talks are offered on Thursdays. Topics covered in these talks include nutrition and birth preparedness. There are currently no follow-up mechanism for pregnant women who miss their antenatal appointments.

Selection of study participants

Between Jan 2019 and Dec 2019, we purposively selected pregnant women receiving antenatal care from MRRH. Inclusion criteria were as follows: a) initiating antenatal care at MRRH at the earliest presentation in

the first or second trimester, b) being illiterate (not having studied beyond primary seven or elementary education), c) 18 years and above, d) residents of Mbarara (within 20 km of MRRH), e) ability to use mobile phones, f) willing and able to give informed consent, g) able to speak Runyankole (local language). We excluded women who did not qualify per the inclusion criteria or who were not able or willing to give informed consent.

The MatHealth app

The MatHealth app was developed using Java programming language, while the database that hosts multimedia messages was developed using SQLite. It is an offline (stand-alone) application which does not run on the internet. The development of the MatHealth app followed an iterative and approach that involved engaging potential users (women and healthcare providers) in series of focus group discussions (FGDs) to suggest and review the app designs.^{20,30} These discussions included letting the prospective users suggest contents of messages, as well as practically logging in and navigating the app. Each FGD informed further refinement of the app until users reported being comfortable satisfied and comfortable with the design. A pictorial password enabled access to the application. The app was installed on low-cost smart phones provided by the project at enrollment. MatHealth app was developed to entirely run on android smart phones due to multimedia videos/audios compatibility. Women were provided with solar chargers to supplement electricity charging. The app has three major functionalities;

- a. The video/audio function; which provides 30 locally customized videos and audios (in the local language—Runyankole) with personalized maternal health information sent monthly to the women based on their pregnancy stages and babies' growth. Content for multimedia videos/audios were developed by a senior obstetrician and gynecologist and a nutritionist from MRRH drawing from the approved Ugandan Ministry of health/WHO maternal health guidelines. Contents of the videos/audio messages include; nutrition, breast feeding, HIV testing, spouse involvement, family planning, danger signs, preparing for child birth, care during pregnancy, care during delivery and postnatal care.
- b. The appointment reminder function that allows the women to set the dates and reminders for their next antenatal care appointment.
- c. The calling function through which the women can communicate with the maternal health specialist (gynecologist) who was a co-investigator on this study.

There is also a login module which uses pictorial password to allow access to the app.

Study procedures

This paper reports a qualitative evaluation of a randomized trial (results of which are being analyzed) composed of a total of 80 study participants (pregnant women) who were enrolled and followed until six weeks after delivery. A simple random number generator (<https://www.random.org/>) was used to determine study arm assignments of the participants. After screening and consenting, participants were randomized 1:1 (NCT04089800) as follows:

1. Maternal health application arm – Study participants received a mobile phone-based MatHealth app that enabled them to receive tailored monthly maternal and child health-related video and audio messages, set clinic attendance appointment reminders, and talk to an obstetrician and gynecologist.
2. The routine care only arm (control arm) – Study participants in this arm did not receive the MatHealth app. This group didn't participate in interviews for assessing the acceptability and feasibility since the investigators were interested in assessing the user experiences of the application.

Each participant in the MatHealth app arm was trained at enrollment about the mobile app and received a relatively low cost smartphone (about USD 60 per phone) with the MatHealth app installed on it. Participants were informed that they could retain the phones after the study closure. The research assistant (whose has an MSc in health informatics) and the app developers (researchers) explained and demonstrated how the app works including how to login to access the app, view the multimedia videos, audios, set antenatal appointment reminders, and call in to talk to the obstetrician and gynecologist. Participants were then given the app and asked to explain what it does and to practically demonstrate how it works to the RAs.

Data collection

This is a qualitative inquiry within a pilot randomized trial. From a private space at a research office near the MRRH (recruitment site), the research assistant WT carried out semi-structured face to face interviews with pregnant mothers from the intervention arm (those that used MatHealth app) until reaching thematic saturation (at the 30th participant) when no new information arose from the interviews." Each interview lasted between 40 and 50 minutes. All questions in the

interview guide were translated into the local language (Runyankole) and back-translated to English by a different translator, after which the two versions were compared for accuracy. The interviews were carried out in Runyankole (local language), digitally recorded, transcribed, and translated to English. Interviews mainly elicited information about participants' understandings and experiences of the key components of the app (videos/audios, appointment reminder function, and the calling function). Following each interview, researchers AM and GM reviewed transcripts for quality, clarity, and detail. WT administered surveys to pregnant women to collect information on socio-demographics, socio economic status, food security, and basic health. Quantitative feasibility data were recorded.

Analysis

We used inductive content analysis²² to derive categories describing and summarizing how participants perceived the intervention. Initially, AM, and WT, and GM reviewed and discussed 20% of transcripts for content relevant to participants' experiences of the intervention. AM and WT then assembled a codebook from the identified concepts, using an iterative process, which included developing codes to represent content, writing operational definitions, and selecting illustrative quotes. Researchers NP, JK, and ACE reviewed and discussed the codebook. Following completion of the codebook, AM and WT applied codes using NVIVO 11. Differences in coding were harmonized through discussion. WT used STATA 13 to describe study participants' characteristic, their socio economic status, food security, basic health, and feasibility data.

Results

Survey results: Participant characteristics

Of 113 screened pregnant women, 33 (29%) were excluded. Participants were excluded for (individuals could have >1 criterion): not initiating antenatal care at the earliest presentation in the first or second trimester; i.e. women in the third trimester ($n = 13$; 12%), literate (studied beyond primary seven) ($n = 6$; 5%), living beyond the study catchment area; 20 km from the MRRH ($n = 11$; 10%), being <18 years old ($n = 1$; 1%), and/or inability to provide informed consent ($n = 2$; 2%). A total of 80 (71%) pregnant women, of whom 9(11%) were persons living with HIV/AIDS, enrolled in the study as shown in Table 1 below. The majority of participants were in their mid-20s, had no source of income, and did not have enough food in their households.

Table 1. Socio-demographic and basic health status characteristics of all study participants.

	Pregnant women ($n = 80$ (%))
Median age (years) include IQR	25 (IQR = 10)
Marital status	Married (70, 88%)
Education	
-Lower primary up to P3*	11 (14%)
-Upper primary (P4 to P7)*	65 (81%)
-No education	4 (5%)
Reading	
-Able to read basic English	21 (27%)
-Able to read Runyankole	74 (95%)
-Living with HIV	9 (11%)
Mean (SD) months of pregnancy	3.4 (1.1)
Mean (SD) months of follow-up	6.1 (6.0)
No regular income	65 (81%)
Household food not enough	60 (75%)

*In the Ugandan education system, P3 is often attended by 6 to 8 year olds. P4 to P7 is often attended by 9 to 12 year olds.

As indicated in Table 2, the majority of the women shared their mobile phones, and used the app to consult the gynecologist.

Interview results

As explained below, participants (pregnant women) reported that the MatHealth app was beneficial in various ways including: 1) enabling the adoption of good maternal and child health practices e.g. adherence to antenatal/postnatal care, and exclusive breast feeding, 2) enhancing spouse support and involvement e.g. being escorted to the clinic for antenatal care, 3) reminding them attend antenatal/postnatal appointments, and 4) facilitating communication with health-care providers. Additionally, participants reported that the app was easy to use, and that the multimedia information contained in the app was easy to understand and recall. Participants reported that the functionality of the app was limited by socioeconomic issues, and technological challenges.

Table 2. Technical feasibility of the maternal health application.

Issues	Comment (n = 35 (%))
Phone charging	15 (43%) of participants reported not having electricity for charging phones in their homes.
Phone sharing	26 (74%) of the participants reported sharing their phones with other people especially spouses. Two of these participants' study phones were in possession of their spouses at time collecting this study, who were not staying with the participants during the study time.
Phone selling	3 (9%) reported having sold their phones to raise some money for basic needs.
Setting of reminding	20 (57%) reported having not used the application to set antenatal/postnatal reminders. The study team set the first reminders, but all participants had to set subsequent reminders. Although participants were oriented in setting reminders, they later confessed having failed to set the reminders. Some of them resorted to coming to the study office monthly for assistance with setting appointment dates.
Calling function	23 (66%) of the women used the app to call the maternal health specialist (gynecologist)
Re-installing the application	15 (43%) of the participants had their applications re-installed by the study team due to accidental deletion by either the participants themselves or the ones they shared the phones with.
Lost follow-up	5 (13%) of participants were lost to follow up due to non-functioning phone numbers.

Benefits of using the MatHealth app. Enables adoption of maternal and child health practices: Participants reported that watching the videos contained in the MatHealth app enabled them adopt good maternal and child health practices such as saving money to prepare for delivery, adoption of malaria prevention strategies (e.g. use of mosquito nets, cutting bushes), attending antenatal and postnatal appointments, preparing for facility-based delivery, exclusive breastfeeding, as well as proper nutritional habits.

I increased on the number of times I breastfeed my baby. The baby that follows this one used to fall sick many times, but this one has not fallen sick may be because I followed the videos to exclusively breast him (Breast feeding mother, 30yrs)

I have learnt that I am supposed to go for antenatal because with my first pregnancy I could do only one antenatal checkup throughout the nine months but with this one I have been able to do antenatal checkups on a monthly basis. ~ (Breast-feeding mother, 40yrs).

Women described adopting good maternal health practices compared to their previous pregnancies.

Enhances spouse support and involvement: Some participants reported watching the videos from the app with their spouses which enabled them obtain various social support. This included being escorted to the clinic for a maternal and child health-related appointments, providing nutritional and feeding support,

purchasing essentials required for delivery, as well as providing transport/permission to the clinic for antenatal services and delivery.

I shared with him the video that tells us to go with our husbands for check-up. After watching the video, he was convinced, and we agreed and went together, carried out check-up together including for HIV and we produced a healthy baby. ~ (Breast feeding mother, 30yrs).

The video that specifically demonstrates the need for spouses to take an active role in maternal and child health encouraged spouses to support their wives.

Reminds attending clinic appointment: Participants reported being reminded to attend their clinic appointment by the app's reminder function. Consequently, some participants never missed any clinic appointment.

R: The app has been beneficial to me because it reminds me to attend my clinic appointments. Because of the reminder messages, I did not miss attending any of my appointments. ~ (Breast feeding mother, 30yrs).

Participants reported feeling obliged to comply with these reminders in order not to disappoint the study team and healthcare providers who minded about their health by giving them the app.

Facilitates communication with healthcare workers: Participants reported using the calling function of the application to consult healthcare providers about maternal and child health-related issues such as

inquiries about potential danger signs, confirmation of labor signs, as well as organizing for facility-based delivery.

I used the call function to call a doctor when I started feeling some pain in my lower stomach, I suspected something, so I called the doctor and he told me to come to the hospital and they worked on me, so if I didn't have this phone I wouldn't have been helped. I really thank you people for giving me this phone and its contents. ~ (Breast feeding mother, 34yrs).

Some participants reported that mobile phone-based consultations saved them the cost of having to come to the clinic for inquiries that can easily be done on phone.

Challenging issues. Socioeconomic issues: Some participants reported lacking money to cover maternal and child health-related costs such as transport to the clinic, buying the required foods and drinks, purchasing requirements for delivery as well as meeting the cost of delivery especially in case of delivery by operation which involves extra costs. These constraints limited the adaptation of good maternal and child health practices advocated by the mobile health application.

The contents on the phone are good, but sometimes I don't have money to buy the foods/drinks recommended. Also sometimes even if I am reminded to go the clinic, I don't have transport to take me there. Although I sometimes I walk to clinic, it is a long distance. My husband has no job, he just makes ropes and the little he gets is for buying basic food for the family. ~ (Breast feeding mother, 33 years).

A few participants sold their phones before study closure. Others reported being mocked for having smart phones yet they cannot afford basic costs such as transport to the clinic, and purchasing requirements for delivery.

Technological challenges: Some participants that lacked electricity in their homes found it challenging to charge their phones. Before the study provided supplementary solar chargers, these participants who resorted to taking their phones for charging at public charging points reported unauthorized utilization of their phones resulting in accidental uninstallation of the maternal health application, as well as exchange of their phone batteries.

When I took my phone to the center for charging, they opened it, deleted your videos and audios, and they also exchanged my battery and gave me a dead one. ~ (Breastfeeding mother, 28yrs).

The challenge of phone sharing was highlighted by some participants who reported sharing the phones especially with the spouses. A participant narrated how phone sharing resulted in accidental deletion of the app (despite being password protected), and also limited her access to, and usability of the app particularly when the phone was with her spouse.

I use it [phone] with my husband. He used to disturb me [by using the phone] but when I came to your offices your colleague talked to him and he no longer disturbs me like before. He used to take it away from me, but now days he put his line in my phone, so I give it to him when someone calls him but the challenge is that sometimes I cannot find my videos when he gives me back the phone. ~ (Breastfeeding mother, 34yrs).

Some participants changed their sim cards (telephone lines) attached to the phones that contained the app. Attempts to reach them through the telephone numbers of the contacts persons they had provided at enrollment failed—the numbers of their contact people could also not go through, while those that went through claimed that they are no longer in contact with the participants, resulting in lost to follow ups.

Discussion

In this study, participants (illiterate pregnant women) reported that the MatHealth app composed of videos and audio, appointment reminders, and the calling function was acceptable. They reported that the application enabled them to adopt good maternal and child health practices (such as adherence to antenatal/postnatal care, exclusive breast feeding, preparing for facility-based delivery, malaria prevention strategies, proper nutritional habits) that they would otherwise find challenging to adopt without the app. Additionally, some women reported intentionally sharing the contents of the app with their spouses, which triggered their spouses' support and involvement in their prenatal and postnatal care. For instance, some spouses started escorting their wives to clinic for antenatal care for the first time in their lives, while others bought foods they had never bought before as a result of watching educative contents provided by app. Through the reminding function of the app, participants were reminded to attend antenatal appointments. Also, through the app's calling function, women reported being able to make pregnancy and child-related inquiries to healthcare providers in cases of. They found the app easy to use, and its contents easy to understand and recall. However, socioeconomic challenges, and technological issues (e.g. charging the phones, phone sharing, and changing

phone numbers) limited the feasibility of the application.

After watching video and audio messages about breastfeeding contained in the MatHealth app, participants gained knowledge about proper breastfeeding practices and exclusively breastfed their babies for the first 6 months, which improved the health of their babies. They enjoyed watching the videos while at the same time learning from them. Information recall was enhanced by the opportunity to replay the videos/audios several times at their own convenient times. Adopting exclusive breastfeeding is an important milestone in these illiterate population, since, compared to educated women, women of low literate levels are not likely to exclusively breast feed their babies.²³ This could be attributed by the possible lack of accurate information such as information about the benefits of exclusive breastfeeding. Having accurate information is key to adoption of sound breastfeeding practices.²⁴ Breastfeeding is an optimum source of nutrition for children, which can ensure child health and survival, and lead to life-long health and well-being. Despite the benefits, worldwide, only 40% of infants are exclusively breastfed within their first six months.¹ Educational interventions especially those targeting illiterate women are needed to create awareness about the benefits of exclusive breastfeeding. As reported in the current study, these interventions can be successfully delivered via mobile phones in video/audio formats that illiterate women can easily understand.

Women used the MatHealth app to share maternal health-related videos and audios with their spouses. In particular, the app's video that demonstrates the need for spouses to take an active role in maternal and child health motivated spouses to provide pregnancy-related support such as escorting women to the clinic, providing nutritional and feeding support, purchasing essentials required for delivery, as well as providing transport and permission to the clinic for antenatal services, delivery, and postnatal services. Although not necessarily mobile phone-assisted, evidence suggests that spouse involvement can improve maternal health outcomes in developing countries,²⁵ where most men are key decision makers and providers in their families.²⁶ Mobile phone-based SMS texting is associated with utilization of maternal health services in Uganda.²⁷ Since the majority of women could read Runyankole (local language), SMS texts in local language could potentially be used as alternative approaches to disseminate maternal and child health information to these women. Although they are not as interactive as videos and audios, their compatibility with feature phones makes them more affordable in this low resource setting. However, studies utilizing SMS texts to support maternal and child health

among rural, poor, and illiterate women are generally lacking. Such studies can potentially reach populations that would otherwise be hard to reach by traditional face-to-face approaches which often involve huge transport costs and significant time commitments.

Through the reminder function of the MatHealth app, participants got reminded of their clinic appointment dates, which resulted in adherence to antenatal and postnatal appointments. This could potentially improve maternal and child health.²⁸ The utility of adhering to clinic appointment as a result of using the app could address the current gaps between the number of antenatal visits recommended by WHO, and the current practices in Uganda. Only 58% of women from rural areas attend the four antenatal visits previously recommended by WHO.¹² (currently recommends eight visits). Associating the use of the app with adherence to antenatal appointment is particularly important given the evidence that compared to educated women (72%), few illiterate women (53%) attend the recommended four antenatal visits.¹²

The calling function enabled women call a maternal health specialist (gynecologist) whose number was included in the application. This helped women make important inquiries about their pregnancies including asking for more information in case they needed more clarifications in the video/audio contents, as well as inquiring about suspected pregnancy danger signs. Rather than physical meetings, mobile telephone-based communication is time and cost saving since there are no physical movements involved. This approach could also give women confidence to inquire about sensitive issues that they would otherwise not be confident to talk about face-to-face at the facility. Information communication technologies are reported to facilitate confidential sharing of sexual health information in the same setting.¹⁶ Using mobile telephone-based communication approaches could supplement the existing face-to-face approaches that have long been criticized for being unfriendly²⁹—subject to unkind words, refusing to attend to pregnant women when they reach late at health facilities¹⁰ in low resource settings.

Despite the identified benefits of using the MatHealth app to support maternal and child health, the reported financial challenges limited the functionality of the application. Providing educational videos/audios, appointment reminders, and the calling function is not sufficient if there is no money to purchase nutritional supplements required by pregnant/breast feeding women, transport women to the clinic for antenatal/postnatal appointments, buy air time to call and consult a maternal health specialist, or/and afford potential out of pocket medical expenses. Selling study phones by some women in order to meet the

basic needs of life suggest the need to incorporate economic interventions to enable women overcome the identified financial challenges while addressing poverty as the root cause poor maternal and child health outcomes. Although studies utilizing economic interventions to support maternal and child health, especially in low resource settings are rare, the modest existing ones demonstrate promising results in improving access to maternal and child health services in Uganda.^{30,31} Despite the promising results, the impact of these studies is limited by providing incentives face-to-face; they are thus restricted by geographical boundaries, are time consuming, and involve transport costs. Alternatively, mobile services could be used to provide financial support. Indeed, use of “mobile money” (money accessed through mobile phones) services is nearly ubiquitous in Uganda, and has provided access to financial transactions to people that were otherwise unreachable by conventional banks.

A few technological issues limited the feasibility of the application. Some participants lacked electricity to charge their phones, others shared their phones especially with their spouses, while others changed their phone numbers. In Uganda, many people in rural areas still lack access to electricity.³² Providing compatible solar chargers could address this challenge. To make it more affordable, a few solar charges could be put to designated charging stations where participants could charge their phones. Sharing mobile phones in this population is not uncommon.¹⁴ Women’s practice of giving spouses control over their phones might be a reflection of the prevailing gender imbalances in this setting. Phone sharing could be minimized if spouses are oriented about the need for their wives to have full time access to the study phones. For participants whose phone numbers were unreachable, it is not clear whether they changed the phone numbers deliberately—even after being assured that they will remain with the mobile phones after study, some of these participants could not imagine being given free smart phones in this low resource setting, so they could have changed their telephone numbers so that the study team could not reach them. This could have been minimized by incorporating a run-in period for a couple of weeks prior to randomization. The run-in period could contain particular study-related activities that prospective participants must adhere to before randomization. The compulsory run-in activities could include brainstorming sessions to discuss appropriate contents for the video/audio messages, as well as issues of application usability. This approach minimizes dropouts after randomization by identifying participants who are likely to honestly take up the intervention.³³

The main strength of this study is that it identifies important insights about the experiences of illiterate

rural women in using a mobile multimedia application to support maternal health in a sub-Saharan African setting. Findings has implications for similar settings. However, results may have limited generalizability since they are based on responses of 30 participants that used the MatHealth app and were followed-up for six months. It is not clear how they manifest in larger, diverse contexts, and with longer-term follow-up.

In conclusion, we found that the mobile multimedia application (composed of educational video/audio messages, appointment reminders and calling function) to support maternal health in rural illiterate women was largely acceptable and feasible in a research context within a low resourced setting. The application was beneficial in enhancing the adoption good maternal and child health practices such as exclusive breastfeeding and adherence to antenatal appointments. It also enhanced spouse support and involvement, and facilitated communication with healthcare providers. The analysis of data to assess the impact of the app on maternal health outcomes (e.g. adherence to prenatal and postnatal clinic appointments) is on-going and will be reported in a separate paper. Future efforts should focus on optimized application design (e.g. making the appointment setting function more user-friendly, including a functionality that detects application usage), spouse orientation/gender considerations, incorporating economic support, as well as organizing pre-randomization run-in sessions to overcome the challenges we encountered.

Acknowledgment: The authors would like to acknowledge the contributions of Richard Glander, Phionah Kobutungi, Elly Bangumya, Sandrah Aye baza, Aaron Mugaba, Ezra h Muhindo, Davis Byamugisha, and Richard Ninsiima.

Contributorship: AM and WT collected and analyzed data. ECA, NP, JK, GM reviewed the transcripts and code book. AM wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

Declaration of conflicting interests: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval: This study was approved by the Institutional Review Committee of Mbarara University of Science and Technology (No: 30/04-18), the Uganda National Council for Science and Technology (no: SS 4661). All participants provided signed informed consent before study participation and were informed at enrollment about their right to refuse/withdraw from the study at any time without any penalty or losing the benefits they were entitled to at the hospital.

Funding: The study was funded by a grant from the German Ministry of Education and Research, under the German-African Innovation Incentive Award (01DG18004). AM is also supported by Fogarty International Center of the National Institutes of Health (K43TW010388). The study was registered with ClinicalTrials.gov (NCT04089800).

Guarantor: AM.

Peer review: Bronwyn Harris, University of Warwick, Warwick Medical School has reviewed this manuscript.

ORCID iD: Angella Musiimenta  <https://orcid.org/0000-0003-1983-696X>

References

1. WHO. *Maternal mortality: key facts*. Geneva: World Health Organization, 2017.
2. World Health Organization. *World health statistics overview 2019: monitoring health for the SDGs, sustainable development goals (No. WHO/DAD/2019.1)*. Geneva: World Health Organization, 2019.
3. WRA. White ribbon alliance for safe motherhood, [www.whiteribbonalliance.org/uganda/](http://whiteribbonalliance.org/uganda/) (2017, accessed 23 December 2020).
4. Rutaremwa G, Wandera SO, Jhamba T, et al. Determinants of maternal health services utilization in Uganda. *BMC Health Serv Res* 2015; 5: 271.
5. WHO. *WHO recommendations on antenatal care for a positive pregnancy experience: summary: highlights and key messages from the World Health Organization's 2016 global recommendations for routine antenatal care*. Geneva: World Health Organization, 2018.
6. World Health Organization. *WHO recommendations on antenatal care for a positive pregnancy experience*. Geneva: World Health Organization, 2016.
7. UNICEF. Healthy mothers, healthy babies: taking stock of maternal health, <https://data.unicef.org/resources/healthy-mothers-healthy-babies/#> (2019, accessed 23 December 2020).
8. World Health Organization. *Maternal mortality*. Geneva: World Health Organization, 2019.
9. Musiimenta A, Tumuhimbise W, Mugenyi G, et al. Mobile phone-based multimedia application could improve maternal health in rural southwestern Uganda: mixed methods study. *Online J Public Health Inform* 2020; 12.
10. Tumuhimbise W, Atukunda EC, Ayebaza S, et al. Maternal health-related barriers and the potentials of mobile health technologies: qualitative findings from a pilot randomized controlled trial in rural southwestern Uganda. *J Family Med Prim Care* 2020; 9: 3657.
11. Kawungezi PC, AkiiBua D, Aleni C, et al. Attendance and utilization of antenatal care (ANC) services: multicenter study in upcountry areas of Uganda. *Open J Prev Med* 2015; 5: 132–142.
12. Uganda Bureau of Statistics (UBOS) and ICF. *Uganda Demographic and Health Survey 2016*. Kampala, Uganda and Rockville, Maryland, USA: UBOS and ICF, <https://dhsprogram.com/pubs/pdf/FR333/FR333.pdf> (2018).
13. ITU. *Key global Telecom indicators for the world telecommunication service sector*. Geneva: International Telecommunication Union, 2016.
14. Musiimenta A, Atukunda EC, Tumuhimbise W, et al. Acceptability and feasibility of real-time antiretroviral therapy adherence interventions in rural Uganda: mixed-method pilot randomized controlled trial. *JMIR mHealth Uhealth* 2018; 6: e122.
15. Musiimenta A, Tumuhimbise W, Mugaba AT, et al. Digital monitoring technologies could enhance tuberculosis medication adherence in Uganda: mixed methods study. *J Clin Tuberc Other Mycobact Dis* 2019; 17: 100119.
16. Musiimenta A. Information technology-mediated issues in sexual health and HIV/AIDS education. *EJISDC* 2012; 53: 1–12.
17. Deloitte & Touche. *Maternal messaging mHealth programmes Empowering and enabling decision makers to include mHealth services into their budgets*. London: Deloitte & Touche, 2014.
18. Sondaal SFV, Browne JL, Amoakoh-Coleman M, et al. Assessing the effect of mHealth interventions in improving maternal and neonatal care in low-and middle-income countries: a systematic review. *PloS One* 2016; 11: e0154664.
19. Thompson S, Harrison M and Mercer MA. Mobile-Ligalnan: improving quality and access to maternal care in Timor-Leste. Health Alliance International. Health Alliance International in action 2013 ANNUAL REPORT, 2013.
20. Pillay Y, Peter J and Barron P. Using mobile technology to improve maternal, child and youth health and treatment of HIV patients: guest editorial. *Afr J Health Prof Educ* 2016; 106: 3–4.
21. Mugenyi GR, Atukunda EC, Ngonzi J, et al. Functionality and acceptability of a wireless fetal heart rate monitoring device in term pregnant women in rural southwestern Uganda. *BMC Pregnancy Childbirth* 2017; 17: 178.
22. Hsieh H-F and Shannon SE. Three approaches to qualitative content analysis. *Qual Health Res* 2005; 15: 1277–1288.
23. Poorman E, Gazmararian J, Elon L, et al. Is health literacy related to health behaviors and cell phone usage patterns among the text4baby target population? *Arch Public Health* 2014; 72: 13.
24. Victora CG, Bahl R, Barros AJ, et al. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. *Lancet* 2016; 387: 475–490.
25. Yargawa J and Leonardi-Bee J. Male involvement and maternal health outcomes: systematic review and meta-analysis. *J Epidemiol Community Health* 2015; 69: 604–612.
26. Schuler SR, Rottach E and Mukiri P. Gender norms and family planning decision-making in Tanzania: a qualitative study. *J Public Health Afr* 2011; 2: e25.

27. Ilozumba O, Dieleman M, Van Belle S, et al. Multistakeholder perspectives on maternal text messaging intervention in Uganda: Qualitative study. *JMIR mHealth Uhealth* 2018; 6: e119.
 28. Serbanescu F, Goodwin MM, Binzen S, et al. Addressing the first delay in saving mothers, giving life districts in Uganda and Zambia: approaches and results for increasing demand for facility delivery services. *Glob Health Sci Pract* 2019; 7: S48–S67.
 29. Shahabuddin A, Delvaux T, Nöstlinger C, et al. Maternal health care-seeking behaviour of married adolescent girls: a prospective qualitative study in Banke district, Nepal. *PloS One* 2019; 14: e0217968.
 30. Alfonso YN, Bishai D, Bua J, et al. Cost-effectiveness analysis of a voucher scheme combined with obstetrical quality improvements: quasi experimental results from Uganda. *Health Policy Plan* 2015; 30: 88–99.
 31. Hunter BM, Harrison S, Portela A, et al. The effects of cash transfers and vouchers on the use and quality of maternity care services: a systematic review. *PLoS One* 2017; 12: e0173068.
 32. Ministry of Energy and Minerals. Ugandan Ministry of Energy and mineral development (2014). Statistical Abstract 2014, www.energyandminerals.go.ug/index.php?id=28 (2014, accessed 23 December 2020).
 33. Fukuoka Y, Gay C, Haskell W, et al. Identifying factors associated with dropout during prerandomization run-in period from an mHealth physical activity education study: the mPED trial. *JMIR mHealth Uhealth* 2015; 3: e34.
-