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Research and Applications

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A mobile health app may improve maternal and child health knowledge and practices among rural women with limited education in Uganda: a pilot randomized controlled trial

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ABSTRACT

Objective: This article describes the impact of a mobile health app (*MatHealth App*) on maternal and child health knowledge and practices among women with limited education.

Materials and methods: Pregnant women initiating antenatal care (ANC) were randomized (1:1) to the *MatHealth App* versus routine care. Participants were followed until 6 weeks after delivery. Questionnaires for assessing knowledge and practices were administered to participants from both arms at baseline and endline. Using logistic regression, we estimated the difference in odds of having maternal health knowledge. We reviewed clinic records to capture maternal health practices.

Results: Of the 80 enrolled participants, 69 (86%) completed the study with a median follow-up of 6 months. Women in the *MatHealth* arm had 8.2 ($P = .19$), 3.6 ($P = .14$), and 6.4 ($P = .25$), respectively higher odds of knowing (1) the recommended gestation period for starting ANC, (2) the recommended number of ANC visits, and (3) the timing and frequency of recommended human immunodeficiency virus (HIV) testing, respectively, compared to those in the routine care arm. All women in the *MatHealth App* arm exclusively breastfed their babies, and brought them at 6 weeks for HIV testing, compared to the routine care arm. Just over half of the women attended at least 4 prenatal visits across the 2 arms. The main reason for noncompliance to ANC appointments was a lack of transport to the clinic.

Discussion and conclusion: The app increased knowledge and practices although not reaching statistical significance. Future efforts can focus on addressing social and economic issues and assessing clinical outcomes.

Key words: mobile phones, multimedia, prenatal care, low literacy

LAY SUMMARY

Over 17 women die daily from maternal health complications in Uganda. Mobile health tools may offer novel solutions to address maternal and child health challenges. This article describes the impact of a mobile health app on maternal and child health knowledge and practices among women with limited education in Uganda. Pregnant women initiating antenatal care (ANC) were randomized to the app versus routine care and followed (until 6 weeks after delivery) to assess the impact on knowledge and practices. Using logistic regression, we estimated the difference in odds of having maternal health knowledge. We reviewed clinic records to capture maternal health practices. Of the 80 enrolled participants, 69 (86%) completed the study with a median follow-up of 6 months.

Although not reaching statistical significance, the app increased knowledge about (1) the recommended gestation period for starting ANC, (2) the recommended number of ANC visits, and (3) the timing and frequency of recommended human immunodeficiency virus testing. Good practices adopted as a result of using the app include exclusive breastfeeding and early infant human immunodeficiency virus diagnosis. Attending prenatal appointment was the least affected, mainly due to lack of transport to the clinic.

INTRODUCTION

According to a 2021 World Health Organization (WHO) report, over 800 women die daily from preventable maternal deaths related to pregnancy and childbirth.[1] This report further indicates that 99% of all maternal deaths occur in low-resource settings (LRSs), particularly among rural and poor women. In Uganda, the maternal mortality rate stands at 343 maternal deaths per 100 000 live births[2] with over 17 women dying daily from maternal health complications.[3] The country is far from reaching the target specified in the WHO Sustainable Development Goals (SDGs) of reducing the global maternal mortality ratio to <70 per 100 000 live births.[1]

Antenatal care (ANC) provides a critical opportunity to reduce maternal and child mortality, for example, by providing avenues for testing for human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) and getting reliable information about best practices such as facility-based delivery and proper infant feeding. However, in Uganda, over 30% of women still deliver outside facilities with an unskilled birth attendant.[4] According to the most recent Uganda Demographic and Health Survey, only 29% of women in Uganda attend their first ANC during their first trimester and 40% of women do not attend at least 4 of the 8 antenatal visits recommended by the WHO.[4] This survey further indicates that 43% of mothers either do not have a postnatal check-up or do it more than 41 days after delivery, while only 61% of women are aware of the 3 modes of preventing mother-to-child HIV transmissions (PMTCT) (ie, through pregnancy, delivery, and breastfeeding). Additionally, in Uganda, only an estimated 33% of infants exposed to HIV receive early infant diagnosis (EID) at 6 weeks.[5]

Major constraints to maternal and child health include a lack of reliable information, long distances to healthcare centers, and poverty.[6,7] Compared to women with secondary or higher education, women with low levels of education are less likely to get reliable information about ANC, adhere to ANC visits, afford the cost of ANC, and deliver at the facility in Uganda.[7,8] Moreover, amidst the current coronavirus disease of 2019 (COVID-19) crisis, access to maternal and child services has worsened. Comparing March 2020 with January 2020, the Ugandan Ministry of Health (MoH) recorded a 29% reduction in facility-based infant deliveries and an 82% increase in maternal mortality.[9] Innovative interventions that specifically address the vulnerabilities of these socially marginalized women are lacking.

Mobile health (mHealth) tools may offer a solution to maternal and child health challenges. Rapidly expanding cellular networks across sub-Saharan Africa has greatly increased the capacity of cellular technology to serve as a novel solution to challenges in health service utilization. In Uganda specifically, over 75% of the population has access to mobile phones, and mobile phone reception is available across the vast majority of the country, including many rural areas and among economically disadvantaged populations.[10] Studies are lacking on the utilization of mHealth to support ANC service utilization in Uganda. The modest prevailing studies elsewhere have shown, for instance, that mobile phone-based educational videos and short message service (SMS) appointment reminders improved uptake of exclusive breastfeeding (adjusted odds ratio [aOR], 2.10) and EID at 6 weeks (aOR, 2.19) in India.[11] In Kenya, SMS for clinic appointment reminders and health education increased attendance to postpartum visits at 8 weeks among women living with HIV,[12] while delivering stigma-related counseling through phone calls improved maternal retention and EID at 6 weeks.[13] Despite this evidence base, there is a lack of specific application of mHealth technologies targeting rural women with limited education. This vulnerable population has unique needs, particularly regarding mHealth technology (eg, challenges with reading SMS texts). Importantly, in Uganda, only 33% of women aged 15–49 have attained at least some secondary level of education.[4]

In response to these needs, our group developed the *MatHealth App* that enables the automatic display of multimedia videos and audio files to rural women with limited education (primary/elementary level or no education at all), providing them with maternal and child health information, ANC appointment reminders, and remote connection to an obstetrician for questions. The initial qualitative assessment indicates that the app can provide tailored information that is easy to understand and recall, facilitate communication with healthcare workers, and enhance social support from spouses.[14,15] This article describes the impact of the app on maternal and child health knowledge and practices in this population.

MATERIALS AND METHODS

Study design and setting

This article reports a quantitative evaluation of a mixed-methods trial (NCT04089800) composed of pregnant women who were enrolled, randomized 1:1 to receive a maternal health app versus routine care, and followed until 6 weeks after delivery. The methodology for this study has been described previously.[15] Pregnant women were recruited from Mbarara Regional Referral Hospital

(MRRH), which is the largest hospital in rural southwestern Uganda. 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, a cesarean section rate of 30%, and a perinatal mortality rate of 56/1000. In routine care, 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 ANC card that contains her biographical data and the date of the next appointment. Women are expected to attend at least 8 ANC appointments with the first contact expected within the first 12 weeks of pregnancy, and they are advised to bring their ANC cards at every visit. The clinic verbally provides group-based maternal health talks to pregnant women scheduled according to the trimester—first-trimester talks are offered on Tuesdays, second-trimester talks are offered on Wednesdays, and third-trimester health talks are offered on Thursdays. Topics covered in these talks include nutrition and birth preparedness based on the MoH guidelines on maternal health.[16] There is currently no follow-up mechanism for pregnant women who miss ANC appointments and no provision for remote consultation of healthcare providers.

Study participants

Between January and December 2019, we recruited pregnant women receiving ANC from MRRH into the study. Inclusion criteria were as follows: (1) initiating ANC at MRRH with a first presentation in the first- or second trimester, (2) not having attended school or having limited education (ie, not having studied beyond primary 7 elementary education), (3) 18 years and above, (4) residents of Mbarara (within 20 km of MRRH), (5) ability to use mobile phones, (6) willing and able to give informed consent, and (7) able to speak Runyankole (the local language). We excluded women who were not able or willing to give informed consent.

Ethical approval

This study was approved by the Institutional Review Committee of Mbarara University of Science and Technology (No: 30/04-18) and the Uganda National Council for Science and Technology (No: SS4661). 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.

The MatHealth App

The maternal and child health application (or *MatHealth App*) was developed using the Java programming language, while the database that hosts multimedia messages was developed using SQLite. It is an offline (stand-alone) application that does not run on the internet. The video/audio contents are loaded in the app before it is installed on the participants' phones. On a monthly basis, the app displays notifications of new offline videos tailored to each woman's stage of pregnancy which is pre-set within the app. The development of the *MatHealth App* followed an iterative approach that involved engaging potential users (women and healthcare providers) in a series of focus group discussions (FGDs) to suggest and review the app designs.[17,18] These discussions included letting the prospective users suggest the content of messages, as well as practically logging in and navigating the app. Each FGD informed the further refinement of the app until users reported being comfortable and comfortable with the design. A pictorial password enabled access to the application. The app was installed on relatively low-cost smartphones (~60 US dollars) provided by the project at enrollment. The *MatHealth* was developed to run on android smartphones due to multimedia video and audio compatibility. Women were provided with solar electricity chargers given otherwise limited electricity access. The app has 3 major functionalities:

1. *Video and audio files*: This function provides 30 locally customized videos and audio files in Runyankole with personalized maternal and child health information displayed monthly to women based on their pregnancy stages and babies' growth. Content for the multimedia videos and audio files were developed by a senior obstetrician (GRM) and a nutritionist from MRRH drawing from the approved Ugandan MoH/WHO maternal and child health guidelines.[16] The contents covered by the video and audio files include the importance of ANC, nutrition, identifying danger signs, breastfeeding, HIV testing, spouse involvement, family planning, preparing for childbirth, and EID.
2. *Appointment reminder*: This function allows women to set the dates and reminders for their next ANC appointment.
3. *Obstetrician connection*: This function enables women to communicate with the maternal health specialist (obstetrician) who was a co-investigator in this study but not one of the participants' treating physicians.

Study procedures

A simple random number generator (https://www.random.org/) was used to determine the study arm assignments of the participants. After screening and consenting, participants were randomized 1:1 to the *MatHealth App* versus routine care. Each participant in the *MatHealth App* arm received a relatively low-cost smartphone with the app installed on it. Participants were informed that they could retain the phones after the study closure. A trained research assistant and the app developers explained and demonstrated how the app works including how to log in to access the app, view the multimedia videos and audios, set antenatal appointment reminders, call to talk to the obstetrician, and charge the phone. Participants were then asked to explain what the app does and practically demonstrate how it works.

Data collection

From a private space at a research office near the MRRH, research assistants (WT and ATM) administered a pre-tested structured questionnaire in Runyankole language, to assess maternal and child health-related knowledge and practices to both the *MatHealth App* arm and the routine care arm at baseline and study exit. Multiple-choice questions were used to assess maternal health knowledge, including (1) the recommended gestation period for starting ANC, (2) the number of ANC visits recommended, and (3) the timing and frequency of HIV testing. The questionnaires included some open-ended questions (such as questions about challenges to accessing ANC). Self-reported questions (expecting yes or no response) were used to ascertain whether women were escorted to the clinic for delivery. Also, we used surveys to collect information on sociodemographics, socioeconomic status, food security, and basic health. (See Supplementary Appendix for details of the questions used.) No metadata were available on app usage because it was used offline as a standalone app. Each survey lasted between 30 and 40 min. We reviewed clinic records from MRRH to capture practices, including ANC visit attendance, health facility-based delivery, and the baby's attendance at 6 weeks for HIV testing (for women living with HIV).

Table 1. Sociodemographic and basic health status characteristics of study participants at baseline

	MatHealth App arm $n=40$ (%)	Routine care arm $n=40$ (%)
Median age (years) IQR	27 (24–33)	24 (21.5–29)
Marital status		
Married/cohabiting	38 (95%)	33 (83%)
Separated	2 (5%)	4 (10%)
Single		3 (8%)
Education		
Primary (P1–P7)[a]	37 (93%)	39 (98%)
Ordinary level (Senior 1–4)	0 (0%)	0 (0%)
No education	3 (8%)	1 (3%)
Reading		
Unable to read basic English	27 (68%)	31 (78%)
Able to read Runyankole	37 (93%)	39 (98%)
Living with HIV	6 (15%)	3 (8%)
Tested for HIV at first ANC	20 (50%)	22 (55%)
Median (IQR) months of pregnancy at recruitment (first ANC visit)	3.5 (3–4)	3 (3–4)
Median (IQR) months of follow-up	6 (5–7)	6 (5–7)
Have no regular income (eg, salary, money from rentals, etc.)	40 (100%)	40 (100%)
Household food not enough	29 (73%)	30 (75%)
Median distance in kilometers from the health facility (IQR)	20 (5–22)	8 (4–11)
Spouses deciding when to seek ANC	25 (66%)	26 (79%)

Note: Values indicate *n* (%) unless otherwise noted.

ANC: antenatal care; IQR: interquartile range.

[a]In the Ugandan education system, primary (P1–P7) is often attended by 6- to 12-year-olds. Ordinary level is often attended by 13- to 16-year-olds.

Data analysis

Descriptive statistics were used to compare participants' sociobehavioral characteristics, basic health data, and maternal and child health-related practices of the study participants across the study arms. We estimated the difference in odds using logistic regression comparing the odds of having maternal and child health-related knowledge at baseline and study exit for both arms. A *P*-value of $<.05$ was considered to indicate a significant difference in the mean scores. We chose to carry out a protocol analysis (rather than an intention-to-treat analysis) to avoid making assumptions about knowledge. Open-ended questions were assigned numerical codes and analyzed quantitatively.[19] All analyses were done using STATA 13 (StataCorp, College Station, Texas, USA).

RESULTS

Participant characteristics

Participant characteristics are presented in Table 1. Of 113 screened pregnant women, 33 (29%) were excluded for the following reasons (individuals could have >1 criterion): third-trimester pregnancy ($n=13$; 12%), literate ($n=6$; 5%), living beyond the study catchment area ($n=11$; 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) enrolled in the study. Forty participants were assigned to receive the *MatHealth App* and 40 participants received routine care. Sixty-nine (86%) study participants completed the study with a median follow-up of 6 months (interquartile range 5–7). Five participants were lost to follow-up (4 in the *MatHealth App* arm and 1 in the routine care arm). Six participants had miscarriages (4 in the *MatHealth App* arm and 2 in the routine care arm).

The majority of women were in their mid-20s and had not studied beyond the primary level (which is often attended by 6- to 12-year-olds [$n=76$, 95%]), while the remaining women ($n=4$, 5%) had not gone to school at all. Also, the majority reported not having enough food in their households ($n=60$; 75%). All the women in both arms ($n=80$; 100%) had no regular income. Decisions about when to seek ANC among the married women were made by spouses only ($n=51$; 72%). All characteristics were similar between the 2 arms. Figure 1 below illustrates participant flow in this study.

As shown in Table 2, the odds of knowing the recommended gestation period were higher in the intervention arm than in the control arm at baseline. However, the difference in the odds ratio between the 2 groups increased after the receipt of the intervention. Using an interaction term to estimate the impact of the intervention, we found 3.1 higher odds of knowing the recommended gestation period for starting ANC ($P=.19$). We found similar patterns of increasing differences in the odds of knowing the recommended number of ANC visits and the recommended timing and frequency of HIV testing when comparing the *MatHealth App* arm to the routine care arm. The interaction terms showed 2.9 and 2.4 increased odds ($P=.14$ and $P=.25$), respectively for each outcome. Overall, knowledge increased in all aspects, although not reaching statistical significance (Table 3).

In the *MatHealth App* arm, 30 (94) were married/cohabiting intervention at study exit, while 30 (81%) were married/cohabiting in the routine arm. At the study exit, 16 (53%) of the women in the *MatHealth App* arm reported being escorted by their partners to the clinic for delivery, compared to 11 (36%) in the routine care arm.

All women in the *MatHealth App* arm were exclusively breastfeeding their babies 6 weeks after delivery compared to 30 (81%) in the routine care arm. All 4 women living with HIV in the *MatHealth App* arm brought their babies at 6 weeks for HIV testing, compared to 1 (33%) in the routine care arm. Twenty-seven (84%) of the women in the *MatHealth App* reported having delivered from a health facility, compared to 36 (97%) of the women in the routine care arm. Across the 2 arms, just over half of the women attended at least 4 prenatal visits. Women reported that lack of money for transport to the clinic constrained attendance to prenatal appointments ($n=50$; 72%). Other reasons for nonadherence to ANC included lack of permission from the spouse ($n=46$, 67%), and failure to set the appointment reminder for women in the *MatHealth App* arm ($n=18$; 56%).

DISCUSSION

When comparing the *MatHealth App* arm to the routine care arm, knowledge increased in all aspects, although not reaching statistical significance. After exposure to the intervention, we found higher odds of knowing (1) the recommended gestation period for starting ANC, (2) the recommended number of ANC visits, and (3) the recommended timing and frequency of HIV testing. Compared to the routine care arm, all women in the *MatHealth App* arm were exclusively breastfeeding their babies 6 weeks after delivery. All the women living with HIV in the *MatHealth App* arm brought their babies at 6 weeks for HIV testing, compared to those in the routine care arm. Just over half of the women attended at least 4 prenatal

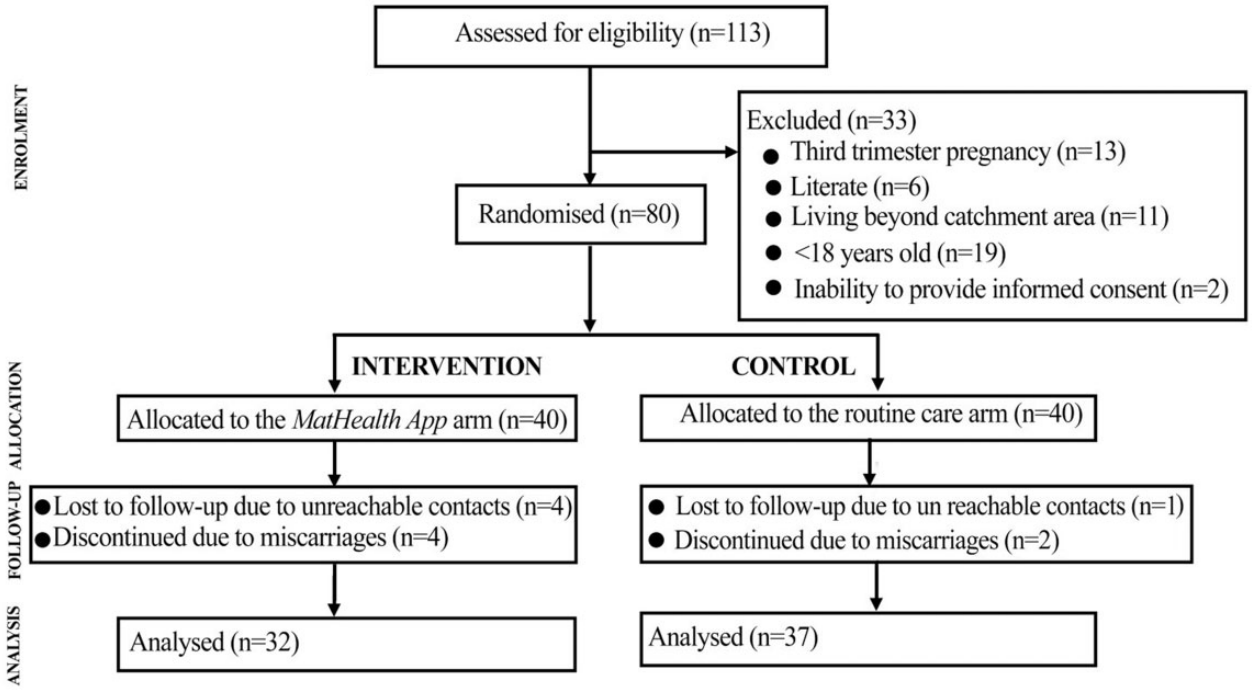

Figure 1. CONSORT diagram to illustrate participant flow in the study.

Table 2. Knowledge before and after receipt of *MatHealth App* intervention

	Before (OR)	After (OR)	Interaction (ratio of the ORs)	Interaction (*P*-value)
Gestation period for starting ANC	2.7 (1, 7.2)	8.2 (2.1, 31.8)	3.1 (0.6, 16.2)	.19
Number of ANC visits recommended	1.3 (0.46, 3.4)	3.6 (1.3, 9.8)	2.9 (0.7, 11.8)	.14
Timing and frequency of HIV testing	2.7 (1, 7.2)	6.4 (2.1, 19.2)	2.4 (0.5, 10.5)	.25

ANC: antenatal care; OR: odds ratio.

visits across the 2 arms. The main reason for noncompliance to ANC appointments was a lack of money. Few women were escorted by their spouses to the health facility for delivery. In offline apps where reminders have to be set by women themselves (rather than automatic ones), reminders could be set at the clinic with the aid of staff during antenatal visits.

Table 3. The impact of the intervention on maternal and child health-related practices

Assessment statements	*MatHealth App* arm	Routine care arm	*P*-value
Among all participants	($n = 32$)	($n = 37$)	
Married/cohabiting escorted by the spouse to the clinic for delivery	16 (53%)	11 (36%)	.23
Exclusively breastfeeding at 6 weeks after delivery	32 (100%)	30 (81%)	.01
Delivered at the health facility	27 (84%)	36 (97%)	.09
Attended at least 4 antenatal visits	18 (56%)	22 (60%)	.81
Among participants living with HIV[a]	($n = 4$)	($n = 3$)	
Brought baby at 6 weeks for HIV testing	4 (100%)	1 (33%)	

[a]We do not have enough participants living with HIV to run a statistical analysis.

Improving women's knowledge of maternal and child health in the study population is important given that participants had limited education and may not have had much familiarity with health issues. Moreover, healthcare settings in Uganda often give limited prenatal and postnatal information, leaving women inadequately prepared for childbirth and newborn care.[20] Consequently, many women, particularly those who are poor and live in rural areas, resort to prenatal and postnatal care practices (such as drinking local herbs during pregnancy or using the herbs for bathing the baby) that are deeply rooted in culture and may be harmful.[21] Because these women lack adequate formal education, our tailored maternal and child health intervention helped to fill their maternal and child health-related knowledge gaps. This improvement in knowledge is important given that maternal health-related knowledge has previously been reported to be positively related to birth preparedness in the same setting.[22] However, having knowledge alone is not sufficient to improve service utilization. For example, despite the reported improvements in knowledge, nearly only half of the women who used the app adhered to the recommendation to attend at least 4 ANC visits. Nonadherence to ANC can have detrimental effects including lack of prevention and treatment of complications, access to maternal health education, and identification of high-risk pregnancies.[23]

Most women reported that lack of money for transport to the health facility constrained their adherence to attending ANC visits—none of the women had a regular source of income. In a low-income country like Uganda where 2 in every 10 people (21% of the population) live on $1.25 a day or less,[4] saving for health amidst other immediate competing interests can be difficult. Moreover, pregnancy and breastfeeding periods are often associated with negative socioeconomic consequences (such as lack of energy to carry out routine work—in this case, farming, and job loss). Prior research has shown a positive influence of poverty alleviation approaches, including monetary incentives utilization[24] and transport vouchers[25] on maternal health service utilization (eg, facility-based delivery). Women's economic status has also been seen to positively influence attendance to ANC visits in another LRS (Bangladesh).[26] Access to financial resources enables women to afford transport to the clinic and pay for ANC where they are not provided free of charge. Unless this vulnerable population is economically empowered, attaining the SDGs 1–3 (ie, no poverty, zero hunger, and good health and well-being) will be next to impossible.

Innovative mHealth interventions could address financial and economic burdens among pregnant and breastfeeding women of low socioeconomic status. For instance, solutions could be provided through travel reimbursements delivered using mobile money (money delivered via mobile phones). The rapid evolution of mobile phones has enabled a mobile payment platform (often known as mobile money). Many people in Uganda are increasingly relying on mobile money due to a lack of access to formal banking services. More than 27.7 million people have mobile money subscriptions in Uganda.[27] These applications can potentially provide accessible and affordable means of providing economic incentives in form of mobile money that could reach even remotely located people in Uganda, given the high penetration of mobile network infrastructure in rural areas.[10] Although the literature about the application of mobile money to support maternal and child health is still limited, there is some promising evidence about the application of mobile money in facilitating incentivizing traditional birth attendants for timely and appropriate maternal healthcare, as well as facilitating pregnant women's transport to the health facility for delivery.[28]

Dependence on spouses' decision to seek ANC may have contributed to ANC visits—most women reported that nearly all decisions on when to attend ANC were made by their male partners. Women with limited education are more likely than educated women to adhere to the prevailing cultural norms that expect women to depend on men for any decision-making.[29] In Africa, males are the key decision-makers in most families including decisions for attending ANC, and they control household budgets where the money to facilitate women's transport to the clinic comes from.[30] Women who jointly make decisions with their partners are more likely to adhere to attending ANC compared to those whose partners make family decisions alone.[31,32]

Given the importance of male partner influence on ANC, the optimal design of the *MatHealth App* should also emphasize tailored functionalities and information for the male audience aimed at creating awareness about the importance of spouse involvement in maternal and child health. Exposure to multimedia entertainment education about birth preparedness exhibited new birth preparation and new knowledge gains among men in Indonesia.[33] It might be more helpful for couples to listen and watch the video and audio files contained in the *MatHealth App* together to promote shared learning and decision-making. Mobile phone messages on maternal and child health topics sent to husbands improved the adoption of maternal and child health behaviors (such as antenatal and postnatal checkups, and delayed bathing of the newborn) in India.[34] Gender-tailored SMS texts helped define men's role in PMTCT and triggered discussions between women and their husbands about ANC and postpartum visits in Kenya.[35] Because negative perceptions about males' involvement in maternal health are deeply rooted in societal norms in Africa,[32] effective gender-sensitive user-centered mHealth interventions should be accompanied by related interventions at the community and health facility level aimed at creating supportive environments for spouse involvement.

This study identifies important insights about the impacts of the *MatHealth App* on maternal health-related knowledge and practices among rural women with limited education in a sub-Saharan African setting. Findings may have implications for similar settings. However, they are based on responses from only 69 women who were followed up for an average of 6 months. Also, giving participants phones and solar chargers could have potentially influenced women's behaviors. Importantly, this study was not powered for differences in maternal and child health knowledge and practices. Larger studies with a longer-term follow-up that includes clinical outcomes should also be assessed. Additionally, rather than an intention-to-treat analysis, we carried out a per-protocol analysis (in order not to make assumptions about knowledge)—which could bias the findings. Also, since this study recruited pregnant women from the clinic, it may not have included the experiences of women who do not go to the clinic.

In summary, we found that the *MatHealth App* (composed of educational videos and audio files, appointment reminders, and calling function to speak with an obstetrician) was influential in improving maternal health-related knowledge and practices among rural women with limited education. The *MatHealth App* may have improved women's knowledge about the recommended period for starting ANC, the timing and frequency of ANC visits, and EID. The app also positively influenced some maternal health-related practices such as exclusive breastfeeding and EID. Future efforts should focus on optimized application design, incorporating economic support, and spouse involvement to potentially increase impact.

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AUTHOR CONTRIBUTIONS

AM participated in the acquisition and analysis of data, drafting, and revision of the article. WT, JA, AM, ATM, GRM, JK, and JEH participated in the acquisition and interpretation of data and revision of the article for important intellectual content. JEH contributed to the interpretation of data and critically revised the article. AM, ECA, NP, JEH, and RZ contributed to the conception and design of the study, analysis and interpretation of data, and drafting

and revision of the manuscript. All authors provided final approval of the version to be submitted and agree to be accountable for all aspects of the work.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *JAMIA Open* online.

CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILABILITY

Data are available on request. The data underlying this article will be shared upon reasonable request to the corresponding author.

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