Barriers and Facilitators Associated with Kenyan Caregiver's Engagement in a Child Nutritional Mobile Health Intervention

Jeanne Louise Goodman

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Committee:
Christine J. McGrath
Arianna Rubin Means

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Abstract

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Jeanne Louise Goodman

Chair of the Supervisory Committee:

Christine J. McGrath

Department of Global Health

mHealth shows high potential for nutrition interventions in low and middle-income countries. Mama Aweza, a mHealth intervention in Migori, Kenya, teaches caregivers of children aged 6-12 months to measure their child's mid-upper arm circumference (MUAC) and asks them to respond to a weekly short message system (SMS) message with the measurements. This mixed-methods study aims to determine the perceived facilitators and barriers to engaging in Mama Aweza using data from five formative focus groups discussions (FGDs) with caregivers and assess sociodemographic factors associated with engagement (response) to weekly system messages using enrollment and midpoint response data from Mama Aweza. On average, 71% of caregivers responded to weekly SMS messages. Shared phones and mobile illiteracy were barriers to engagement [Relative Risk (RR): 0.76 and RR: 0.44, respectively]. Other concerns including message timing and language were taken into account in Mama Aweza. Facilitators to engagement included higher education, ease of use of the MUAC tape, and higher frequency of SMS use prior to study. FGDs highlighted the importance of stigma, husband and community influence on nutritional health seeking behavior and engagement in the intervention. Future mHealth interventions should consider adapting the system to increase accessibility for those with shared phones and difficulty with using SMS. Including the community and spouses in the design and dissemination of mHealth interventions will also help promote engagement.

INTRODUCTION

mHealth or Mobile Health is defined as the use of wireless and mobile technologies to support medical and public health practices to improve health outcomes.[1] Mobile phones have become the primary mode of communication worldwide with over 97 cell phone subscriptions per 100 people.[2] Following the global trend in cell phone usage, public health programs implementing mobile phone technology increased by 31% between 2005 and 2011.[3] In 2011 alone, more than 500 projects were registered as mHealth interventions, of which the majority were in sub-Saharan Africa.[4] mHealth has been successfully used for health care delivery, data collection to patient communication, and medication counseling and adherence.[5] It is particularly useful in low and middle income countries (LMIC) where access to health care is limited but cell phone coverage is high.

Early evidence supports the role of mHealth interventions for improving health outcomes. However, in LMICs, the majority of mHealth interventions have been small pilot studies, where the impact of mobile technology on health outcomes is difficult to assess without a larger scale-up program.[3,6] A review of 31 mHealth studies on child nutrition surveillance programs reported overall poor results with little information on the barriers to implementation and uptake of the mobile technology.[7] Although the importance of Digital Health in achieving the Sustainable Development Goals has been recognized,[8] further research on the feasibility and acceptability of mHealth is necessary.[5,9]

According to a qualitative study by the World Health Organization (WHO), patient acceptability of mHealth interventions can be diminished by uncertainty regarding confidentiality of the technologies, poor access to a mobile device, poor access to electricity or network, and low literary or mobile literacy skills.[8] These barriers should be examined within the context of any mHealth intervention where the scale up and impact of health outcomes relies on patient engagement and acceptance of the intervention. A study investigating the use of mHealth for maternal and infant health and HIV counseling in Kenya observed that shared phones, higher depression scores, longer distance from home to clinic, and greater number of living children were associated with lower engagement with the mHealth platform.[10] Whereas higher education increased the number of messages sent per participant per period.[10]

mHealth is an increasingly promising strategy for nutrition programs to address caregiver specific barriers to seeking care for acutely malnourished children. Contributing factors to care seeking include lack of knowledge, confidence, distance, and fear of judgement were contributing factors in the decision to not seek healthcare for the child.[11] In a study in Kenya on the barriers to seeking care for child malnutrition, 23% of all participants' responses were considered "social and cultural barriers" and were the second most cited reason after temporal and geographical reasons.[12] The use of mHealth technologies, such as a short message service (SMS) system for communicating and monitoring a child's nutritional status, may mitigate issues such as distance to clinic. However, barriers such as embarrassment and fear of judgement are not as readily addressed through the use of SMS messages and may be less likely to encourage motivation and engagement with the system.

The Mama Aweza Study is a randomized controlled trial designed to test whether a mHealth intervention, the Maternal Administered Malnutrition Monitoring System (MAMMS), leads to earlier identification of childhood malnutrition in western Kenya. The study trains caregivers to measure their child's mid-upper arm circumference (MUAC) to detect acute malnutrition and uses a two-way SMS system to collect the measurements from caregivers in the MAMMS intervention arm on a weekly basis during 6-month follow up. The messaging system was adapted from Mobile

WACh, which was originally developed to connect Kenyan mothers to the health care system to promote maternal and infant health through counseling on adherence to antiretrovirals, breastfeeding, family planning and encouraging neonatal visits.[13] It was proven to be effective with 50% of mothers sending more than one message per week and 97% of mothers staying engaged throughout the 6-month follow up period.[13] In the context of the ongoing Mama Aweza study, responsiveness has yet to be analyzed. The objective of this study is to evaluate the acceptability of the SMS-supported nutrition monitoring program among caregivers randomized to the MAMMS arm and identify factors that contribute to caregiver's engagement during 6-month follow up.

The specific aims are to:

1. Determine the perceived facilitators and barriers to engaging in a SMS-supported pediatric nutrition monitoring program among caregivers of children aged 6-12 months in Migori County, Kenya.

2. Describe SMS engagement patterns (usage and attrition) among caregivers randomized to the MAMMS arm during 6-month follow up.

3. Determine sociodemographic factors associated with engaging with weekly SMS messages among caregivers in the MAMMS arm.

METHODS

This is a mixed methods study using formative focus group discussions (FGDs) and midpoint data from the MAMMS intervention arm of the Mama Aweza Study. This is an exploratory sequential design as qualitative data were collected to design quantitative data collection instruments and analyses. Qualitative and quantitative data were used to triangulate perceived and observed barriers and facilitators of engagement with the MAMMS mHealth platform.

Study Setting & Sampling

FGDs were conducted at the Migori Country Referral Hospital in May 2019, prior to initiation of the Mama Aweza study. Participant inclusion criteria for the FGDs were having a child between 6 and 12 months of age, access to a cell phone and attending the Maternal Child Health clinic.

The Mama Aweza study recruited caregiver-infant dyads attending 6-month and 9-month infant immunizations at Migori County Referral Hospital. Inclusion criteria were infants aged 6 to 12-months with MUAC between 12.5cm and 14.0cm (not currently on or needing treatment for malnutrition) that have not previously been enrolled in the Mama Aweza Study or have a sibling currently or previously enrolled in the study. Caregivers must be able to provide a mobile phone number, read or write or have someone to help them read or write, plan on living in Migori County for at least six months and able to complete MUAC measurement training.[14] This analysis excluded caregiver-infant dyads randomized to the standard of care (SOC) arm of the Mama Aweza study and those enrolled after March 19, 2020. Enrollment in the Mama Aweza Study was temporarily put on hold on March 19, 2020 due to COVID-19. Caregivers enrolled prior to this date continued to receive weekly system messages as planned.

Study Procedures

Focus Group Discussions (FGDs):

Caregivers attending Migori Country Referral Hospital for their child's 6-month and 9-month immunizations were approached to participate in FGDs. After the caregiver gave verbal consent to participate, study staff noted their age, number of children, age of youngest child, and whether or not they had an individual or shared phone. Five FGDs were conducted, each consisting of 5-8 participants in a private area of the hospital and took 88 minutes on average. FGDs were led by a skilled FGD facilitator using a semi-structured FGD interview guide to identify caregiver perceptions of malnutrition barriers and facilitators to measuring their child's MUAC, and barriers and facilitators to responding to a weekly SMS message. In addition, caregivers were asked to provide feedback on message topics, wording, and preferred timing (time of day or receipt). FGDs were conducted in Luo and Kiswahili, based on caregiver preference, and transcribed and translated to English by the FGD facilitator. FGD summary briefs were written immediately following each FGD and shared with study staff immediately. Transcriptions were shared within two weeks of the final FGD.

Mama Aweza Study:

Eligible caregivers were asked to provide written consent prior to enrollment in the Mama Aweza study. At enrollment, study staff administered a standardized questionnaire to capture data on social, demographic, medical, obstetric, nutritional and household information.[14] Caregivers were trained to measure their child's MUAC and asked a series of questions to assess their confidence in using the MUAC tape, responding to a weekly SMS, and seeking treatment if their child's MUAC measure was below 12.5 cm.[14] Caregivers were then randomized into either the MAMMS or SOC arm. One-third (33%) of the MAMMS arm were randomized to receive weekly SMS messages asking for both the color (green, orange, red) and number of the MUAC measure and the remaining 67% were asked to provide only the color. Caregivers in the MAMMS arm received two MUAC tapes and were enrolled in the mHealth platform.[14]

SMS Procedure

Caregivers in the MAMMS arm received a weekly SMS from the automated mHealth messaging system for six months following enrollment. The SMS included a health education message and a request to respond with their child's MUAC measure.

Message topics were adapted from previously validated messages from Mobile WACh Neo[15] and supplemented with topics based on UNICEF's Guidance on Childhood Development and the Integrated Management of Childhood Illness recommendations.[16] Messages were tailored by study staff following the formative FGDs to include the following topics: developmental milestones, malaria prevention, sanitation and hygiene practices, fever recognition, diarrhea management, ear infections recognition, vaccinations, the utility of a kitchen garden and respiratory infections.[14] Messages were sent in the caregivers preferred language (Kiswahili, Luo or English) and the cost of sending and receiving messages was covered by the study.

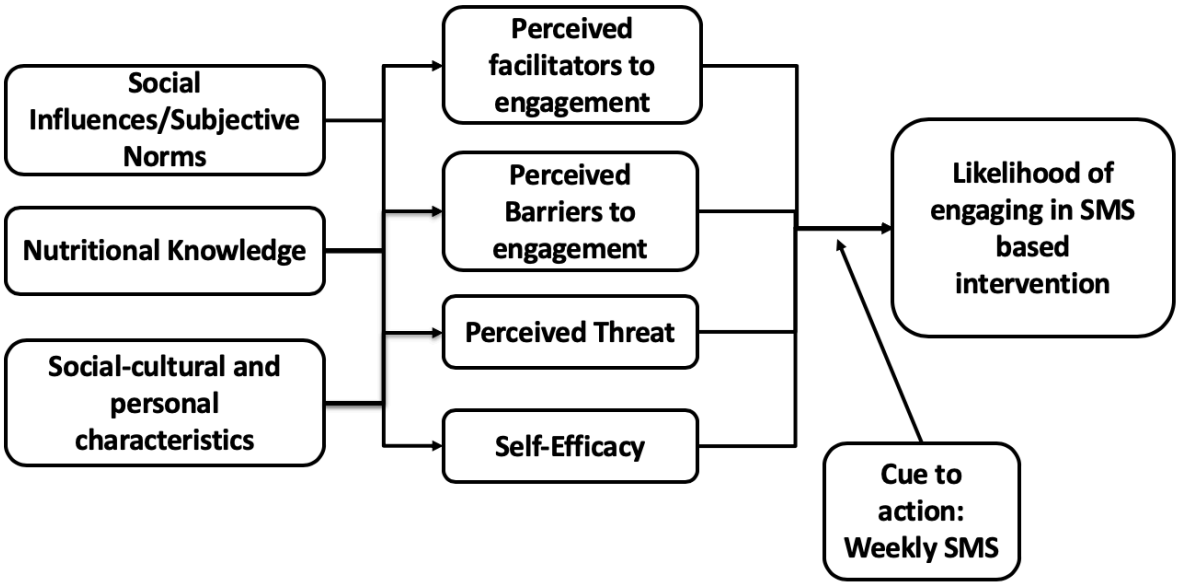
Analysis

Qualitative Analysis

The five FGD transcripts were coded using primarily a deductive approach and thematic coding were based on the adapted constructs of the Health Belief Model (HBM) until coding saturation was reached. The HBM (Figure 1) is used to help understand what influences individuals' adoption of a health behavior.[17] In this case, the health behavior is engagement in the SMS system by measuring their child's MUAC and sending in the results via SMS when asked. Coding was validated by a second coder and *in vivo* codes were incorporated when necessary. Coding

and data management was conducted in Atlas.ti and case memos were written throughout the process to synthesis the data. Findings were to describe the caregiver's perceived facilitators and barriers to using the MUAC tape on a weekly basis and to receiving and responding to a weekly SMS message about their child's MUAC.

Figure 1: Adapted Health Belief Model[17,18]



Quantitative Analysis

The analysis of engagement with the weekly SMS system included baseline sociodemographic and SMS data from caregiver's enrolled in the Mama Aweza study from August 2, 2019 to May 19, 2020. Engagement with the MAMMS mHealth system was defined as receipt of a SMS response from the caregiver within 7 days of the weekly SMS requesting the caregiver to send the child's MUAC measure. Univariate analysis was done using generalized estimating equations (GEE) with exchangeable correlation and a Poisson link as we assume the outcome of response to weekly message within 7 days is not rare in the MAMMS arm. The GEE model accounts for differences in the number of messages received per caregiver. Caregivers that had received less that 8 messages were excluded from the analysis. Key themes from the FGD analysis were triangulated with observed barriers and facilitators of engagement with weekly SMS messages.

RESULTS

Qualitative results

Twenty-nine caregivers participated in five FGDs. The average age of caregivers was 25 years [Standard Deviation (SD) 4.91]. Caregiver's reported having an average of 2.6 children and the mean age of their youngest child was 7.8 months (SD 1.47). Almost one-third (27%) of caregivers used a shared phone. Several key HBM constructs emerged as key themes when discussing participation in the SMS intervention included in Table 1 below.

Table 1: Focus Group Discussion Themes and Codes

Adapted HBM Constructs	Codes
Perceived Barriers	Receiving SMS Sending SMS MUAC Tape
Perceived Facilitators	Receiving SMS Sending SMS MUAC Tape
Social Influences	Husband/Partner Community Health care/nurses
Self-efficacy	SMS MUAC

Perceived barriers to engagement: receiving and sending SMS messages

The most commonly reported barrier to receiving an SMS was having a **shared phone** and the **timing of the incoming messages** (5/5 FGDs). Concerns included being away from the phone when the message was received, not being informed that a message has been received, having the message deleted, having the number blocked by the owner of the phone and someone answering for you without your consent. Most common concerns surrounded a husband deleting or not informing the caregiver of the message or becoming suspicious of the message and the fidelity of the caregiver.

> *"…**if you are sharing a phone with your husband** or he has received a message like that, he might think there is something going on between you and the person who has sent the message **so he will not tell you or it can cause conflicts in your family**" -R2, FGD 2*

Other perceived barriers to receiving and sending SMS included illiteracy, education level, and mobile illiteracy of women in their communities (4/5 FGDs). Caregivers shared examples of friends and family members who did not go to school or do not know how to send and receive SMS messages on their phone. This required relying on others such as husbands or neighbors to help read and send messages, affecting their ability to respond quickly and on their own. In addition, caregivers discussed language barriers if the message was not in their own language (4/5 FGDs) as well as not having enough airtime to respond to SMS (3/5 FGDs).

> *"Not all mothers know how to **read messages** and not all mothers can **compose a message**. It depends on someone's **level of education**. And then again there are some mothers in the community who don't even know **how to use a phone**" –R4, FGD 4*

Perceived barriers to engagement: MUAC tape

Common perceived barriers of measuring their child with the MUAC tape were being too busy, and the relative priority of MUAC measurements (5/5 FGDs). Caregivers mentioned being distracted by chores in the home, taking care of the children, and described that some mothers as "not being bothered with it". In addition, caregivers talked about having a job and forgetting to measure in the evenings after a long day. However, there was very little concern surrounding the difficulty with measuring their child's MUAC or fear of the MUAC results (1/5 FGDs).

Perceived facilitators to engagement: personal benefits

Most perceived facilitators to engagement are linked to personal benefits of the study. These included having **support with identifying their child's nutrition status** through the MUAC tape and the SMS messages and the **additional child health knowledge** that the messages would provide (5/5 FGDs).

> *"It can help me know my child's **nutritional status**, if I experience any problems I can be free with the nurse and send her text and she would answer me and she will also know how the baby is doing and if the baby is sick she will advise me to bring her to the hospital." –R,3 FGD 4*

> *"It is easy to understand because **when I measure my baby's arm it gives me the power to know that the food I give her is helping her to stay health**y so I can just continue to give her that kind of food so that she remains healthy." -R5, FGD 1*

Perceived facilitators to engagement: ease of system

Other perceived facilitators were connected to the **ease of the system**. All FGDs reported that responding to a weekly SMS would not be difficult and serve as a good reminder to measure their child's MUAC. In addition, all FGDs reported that the MUAC tape was easy to use and understand and would not take too much time to do on a weekly basis.

> *"I cannot forget because it is not difficult and it is not time consuming." –R2, FGD 2*

> *"I don't see anything hard even an old grandmother can use it."- R7, FGD 3*

Social influences and self-efficacy

Social influences or subjective norms are defined as the belief of caregivers that others such as community and family approve or disapprove of participating in a specific behavior.[18] The opinion of caregivers' husbands about the intervention, general community gossip about the intervention and rumors about the purpose of the MUAC tape were mentioned in all FGDs as potential barriers to participation (5/5 FGDs). Approval of the husband to access the phone for sending messages and measuring the child, as well as fears of the intervention causing issues of infidelity due to misunderstanding of the study were mentioned in every FGD.

In all FGDs, participants also mentioned gossip surrounding measuring the child's MUAC, specifically that others may perceive this to indicate that the child may be sick or have HIV/AIDS.

Less frequent gossip included that caregivers in the intervention have joined a cult or new religion that requires that they measure their child's arm.

> *"They can just think that the baby has been **infected with HIV** [baby crying] or **you joined a cult** and they gave you the MUAC tape to go and keep tying it on your child's arm."-R6, FGD 3*

The stigma of having a child with malnutrition was explicitly mentioned as a social influence or barrier to engagement of caregivers in the nutrition program (3/5 FGDs). The traditional causes and alternative treatment for malnutrition such as herbalists were also mentioned in 4 FGDs when discussing treatment of malnutrition or community and family members suggestions for malnutrition treatment.

> *"**People love a healthy child**…[when] you enter somewhere with him…everyone wants to carry him, **they move for you like a queen**, but if your child is not healthy even if you enter a vehicle when you are going somewhere and ask a fellow woman to hold the baby for you, **no one wants to hold her for you**,…." –R5, FGD 4*

Although the above social concerns were raised by caregivers when discussing barriers to participating in the intervention, every FGD reported that they would feel comfortable sharing the MUAC knowledge with their neighbors and husbands, as well as explaining the reason for the messages to their husbands. Most did not express personal fear of the judgement and were confident in their abilities to explain the purpose of the MUAC tape.

> *(Referring to gossiping woman) "I can educate her so that she can also know maybe her child is also suffering but because of ignorance she doesn't know, so those of us who have been educated when you hear someone talking badly just go and educate them, after that they will also know." -FGD 3, R7*

Quantitative results

From August 2, 2019 to May 18, 2020, 108 caregivers were randomized to the MAMMS arm and received at least 8 SMS messages. The mean age of caregivers at enrollment was 27 years (SD 6.4) and the mean infant age was 7.6 months (SD 1.8) (Table 2). Sixty-two percent of caregivers had secondary and above education and 39% reported being employed (self-employed, salaried or hourly). Three-quarters (77%) of caregivers were married and 23% shared a phone. All caregivers stated feeling very comfortable with MUAC tape directly after training and 98% expect very little to no effort measuring their child on a weekly basis.

Table 2: Caregiver-Infant Characteristics at Enrollment (n=108)

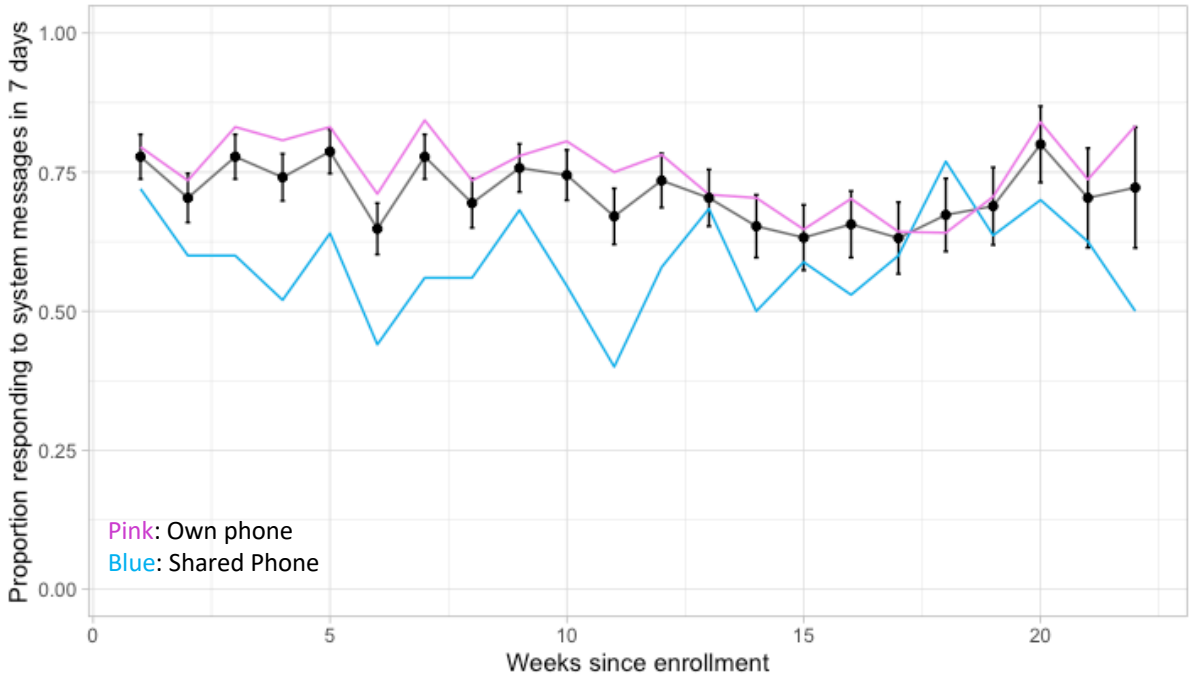
	Caregiver-Infant Pairs (n=108) n (%) or Mean (SD)
Caregiver Characteristics	
Relationship to child	
Biological mother	105 (97%)
Biological father	1 (1%)
Grandmother	5 (2%)
Age (years)	26.9 (6.38)

Categorical age (>25 years)	62 (57%)
Number of living children	2.41 (1.68)
Education	
Primary and below	41 (38%)
Secondary and above	67 (62%)
Marital Status	
Married	83 (77%)
Single	21 (19%)
Widowed	4 (4%)
Employment	
Unemployed	66 (61%)
Employed (self-employed, salaried, hourly)	42 (39%)
Monthly household income (Kenya Shillings)	10,710 (10,210)
Monthly income ≥30,000 Kenya Shillings	10 (9%)
Preferred language	
English	26 (24%)
Luo	53 (49%)
Kiswahili	29 (27%)
Literacy	
Able to read and write	107 (99%)
Someone to help read or write	1 (1%)
Depression Score (0-27pts) (PHQ-9 Score[1])	
No depression (0 pts)	35 (32%)
Minimal depression (1-4 pts)	37 (34%)
Mild depression (5-9 pts)	26 (24%)
Moderate depression (10-14 pts)	9 (8%)
SMS Track: color and number	38 (35%)
Shared Phone	25 (23%)
Primary use of mobile phone	
To make phone calls	74 (69%)
SMS messaging	39 (36%)
Need help sending a SMS	3 (3%)
Previously used SMS for pregnancy or medical advice	9 (8%)
Mean SMS *received* per week	28 (32)
Mean SMS *sent* per week	23 (28.6)
Expected effort to measure child's MUAC with tape	
No effort	100 (93%)
Very little effort	6 (6%)
Some effort	1 (1%)
Substantial effort	1 (1%)
Reported being very comfortable with MUAC tape	108 (100%)
Reported family and community would be very supportive	108 (100%)
Infant Characteristics	
Female	49 (45%)
Age (months)	7.6 (1.77)

[1] No caregivers scored above 14 out of 27 on the Patient Health Questionnaire-9 (PHQ-9) depression scale.

The proportion of caregivers responding to the MAMMS system within 7 days of receipt of a SMS requesting that they measure their child's MUAC was relatively consistent over time with 71% (SD 0.05) of caregivers responding to the system message within 7 days (Figure 2). Overall, 75% (SD 0.07) of caregivers with their own phone and 59% (SD 0.09) of caregivers with a shared phone responded to the weekly system message within 7 days.

Figure 2: Graph of proportion of caregivers responding to system message in 7 days by week after enrollment



In univariate analysis, caregivers who reported sending and receiving at least 20 messages per week were more likely to engage with the system (defined as the caregiver sending a SMS response with their child's MUAC within 7 days) [Relative risk (RR)=1.16, 95% Confidence Interval (CI) 1.01-1.33; p=0.03]. Conversely, caregivers reporting that they need help sending a message were 56% less likely to engage with the system within 7 days (RR=0.44, 95% CI: 0.30-0.64; p<0.01). Higher education and being employed were associated with higher response. Age of caregiver, number of living children, income and depression score were not associated with response.

Table 3: Univariate associations between caregiver characteristics and caregiver engagement with the SMS system within 7 days

	RR	95% CI	P-value
Shared Phone (ref: owned phone)	**0.76**	**0.64-0.90**	**<0.01**
MUAC track: number and color (ref: color only)	0.90	0.78-1.04	0.14
Education: Secondary and above (ref: less than secondary)	**1.36**	**1.14-1.63**	**<0.01**
SMS as primary mode of communication (ref: other than SMS)	1.09	0.96-1.25	0.19
Employed (ref: unemployed)	**1.16**	**1.00-1.35**	**0.05**
Mild and moderate depression (ref: minimal and none)	0.96	0.83-1.11	0.54
Caregiver age (continuous)	1.01	1.00-1.02	0.26
Caregiver age ≥ 25 years (ref: <25 years)	1.02	0.88 1.17	0.81
Number of living children	0.98	0.94 1.03	0.37
Married (ref: single)	1.02	0.88 1.18	0.82
Monthly Income (ref:<30'000 Kenyan Shillings)	1.12	0.94 1.34	0.21
Needs help sending a message (ref: no help)	**0.44**	**0.30 0.64**	**<0.01**
20+ messages sent per week (ref: <20 messages)	**1.16**	**1.01 1.33**	**0.03**
27+ messages received per week (ref; <27 messages)	**1.19**	**1.05 1.36**	**<0.01**

DISCUSSION

Engagement with the Mama Aweza messaging system was high and consistent during 6-month follow up, with 71% of caregivers sending their child's MUAC measure each week. Key constructs from the Health Belief Model (HBM) raised in the FGDs were perceived facilitators, perceived barriers, social influences and self-efficacy. The use of deductive coding based on the constructs of the HBM informed the key themes and focused the univariate analysis evaluating facilitators and barriers to engagement in Mama Aweza. Perceived facilitators to engaging with the messaging system indicated by the qualitative (FGDs) and quantitative (caregivers at enrollment in the Mama Aweza Study) data included ease of use of the MUAC tape and higher caregiver education (secondary and above). Support with the child's nutritional status and health education embedded in messages were significant perceived facilitators in the qualitative data. Employment was a significant facilitator of engagement with the messaging system among caregivers in Mama Aweza. Perceived barriers to engaging with the messaging system demonstrated by the qualitative and quantitative data included shared phones and low mobile literacy. Additionally, illiteracy, language, timing of the SMS, and the costs associated with sending and receiving a SMS were significant barriers raised in the FGDs. Finally, the qualitative analysis called attention to social influences as factors associated with engagement and self-efficacy in addressing these influences. Social influences included stigma of malnutrition, spousal and community influences on malnutrition causes and treatment decision and participation in the study.

Facilitators to engagement with the mHealth system such as ease of use of the MUAC tape and sending a weekly SMS are promising as FGD participants reported that measuring their child would not take too much time and was easy to understand. This was confirmed by caregivers at enrollment in the Mama Aweza study, where 100% of caregivers responded being very confident with the MUAC tape after undergoing brief training. Additionally, personal benefits of the study

such as empowering the caregiver to monitor their child's nutrition status, and health education messages embedded in the weekly SMS were significant facilitators in the qualitative data. Although this is promising and reflected in the overall high engagement in the study thus far, additional qualitative analysis will be conducted at the end of the study to assess if perceived ease of the system (message and MUAC) at enrollment and perceived benefits are indeed influencing caregiver engagement.

Higher education was also raised as a facilitator in engagement in the mHealth intervention in both FGDs and midline user data. Illiteracy was considered a barrier across all five FGDs. Although 94% of Kenyans are literate,[19] this concern is supported by previous mHealth studies as a determining factor in accessibility and engagement in mHealth services.[20–22] To assist with literacy concerns within Mama Aweza, illiterate participants who had someone that could help them read or write were included in addition to participant who could read or write increasing the reach of the study. However, literacy rates in the area of study should be taken into account when designing an mHealth intervention. Adaptations such as the use of phone calls or Multimedia Messaging Service (MMS) can mitigate literacy abilities.

Shared phones were identified as an important barrier to engagement in each of the five FGDs. Converging with and validating these findings, midpoint data from the Mama Aweza study indicate that caregivers with shared phones were 24% less likely to respond to the system message within 7 days compared to caregivers with their own phone. Our findings are similar to primary results in the Mobile WACh Neo study in which shared phones were associated with lower engagement among caregivers in Kenya.[10] Other mHealth studies have highlighted the importance of shared phones, particularly in relation to issues with confidentiality.[23,24] A study on phone ownership in Kenya demonstrated that male sex, literacy and higher education were predicators of phone ownership, underscoring accessibility barriers for caregivers in this study of whom 99% are female.[25] Future mHealth studies should consider the implications of a shared phone and develop strategies to facilitate engagement and maintain confidentiality. Communication with husbands/partners through targeted SMS at the start of the study or via handouts at enrollment are possible strategies to support engagement in the study.

Indicators of higher mobile literacy, such as receiving and sending more SMS messages per week, were associated with better engagement with the system and an important barrier among caregivers in the FGDs. Although 93% of Kenyans have cell phones,[19] mobile illiteracy remains a barrier to engaging in an mHealth intervention. This is a concern found in previous studies of barriers to mHealth interventions and is highlighted by the WHO in their mHealth intervention recommendations.[8,22] Strategies such as providing an illustrated handout or SMS-user training at study enrollment may reduce anxiety among participants uncomfortable with the system. Allowing alternative means of communication such as a phone call could also bridge the gap among those less comfortable with SMS as 69% of caregivers in the MAMMS intervention indicated that the primary use of their cell phone was for phone calls.[22]

The FGDs identified a number of perceived barriers to engagement that can be mitigated by the design of the SMS system prior to study initiation. For instance, caregivers identified language, timing of the SMS, and the costs associated with sending and receiving a SMS as perceived negative influences on program engagement. Based on this input, caregivers enrolled in the Mama Aweza study were given the choice of message language (English, Luo or Kiswahili) as well as time of message received (8am, 1pm or 8pm) and assured that there was no cost to sending or receiving the SMS as this was covered by the study. Language has been cited as a common barrier in other SMS mHealth interventions and is an important factor to consider for scale up in communities with different languages and dialects.[21,26,27] The provided languages for

Mama Aweza were sufficient for the study area and additional languages would be added for scale-up. Choice of message time and frequency of message have also been reported in other studies to be beneficial to participation in various mHealth intervention.[27–29] Adaptations such as these should always be considered in the design of future studies to facilitate higher engagement.

FGDs highlighted the importance of social influences and self-efficacy in engaging in the system including stigma surrounding malnutrition, factors highlighted in the WHO mHealth guidelines as well as other child nutrition studies.[8,12] The influence of husbands and other community members on engagement in the study, accessibility to a mobile phone as well as the decision making of caregivers on treatment for a malnourished child are not present in the univariate analysis but significant in the FGD findings. Caregivers in the FGDs spoke of self-efficacy and ability to explain the mHealth intervention to their husbands and neighbors. Engaging the community and providing more information on the mHealth study and health issues that the study addresses, as well as engaging husbands/partners in the conversation will support caregiver self-efficacy and assist in overcoming certain stigmas or misinformation.

Strengths and Limitations**:**
This study has several strengths and limitations. FGDs were conducted prior to initiation of the Mama Aweza study and thus, did not include information on the experience of the caregivers enrolled in the study. Additional FGDs will be conducted at the end of the Mama Aweza study to gain further insight and expand on these findings. Holding the FGDs prior to study initiation enabled adaptations to the system such as preferred timing of SMS delivery, preferred user language, and the addition of message topics which may facilitate better system engagement. In addition, caregivers in the FGDs were of similar age, with similar cell phone ownership and number of living children as those currently enrolled in the SMS arm of the Mama Aweza study. This study evaluated patterns and factors associated with SMS response collected at the midpoint of the Mama Aweza study and thus, power is limited due to a small sample size. However, the current patterns of responsiveness meet our anticipated trends and represent the variation in response patterns among participants with shared phones versus their own phones. Caregivers who cannot read/write or do not have someone who can help them read or write, as well as caregivers who cannot provide a phone number were excluded from the Mama Aweza study, limiting generalizability. Finally, caregivers in the FGDs and caregiver-infant dyads in Mama Aweza were enrolled at Maternal Child Health clinics, which may exclude a vulnerable group of caregivers who do not bring their child to clinic. However with high cell phone coverage (93%) and high literacy in Kenya (94%),[19,30] this mHealth model is promising for scale-up in similar settings.

Conclusion:
This study highlights the importance of using mixed methods to inform the design and adaptation of an mHealth intervention and facilitate increased engagement with the target population. Future studies should evaluate strategies to increase accessibility through system design and community engagement, particularly among the most vulnerable populations. Stigma, cultural norms and social influences play a significant role in engagement and supporting caregivers' self-efficacy in addressing these influences is an essential component that should be included in every mHealth intervention.

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