



Development of a customized m-Health-based intervention to reduce loss to follow-up among patients undergoing treatment for cervical lesions at a rural referral Hospital, South Western Uganda

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ARTICLE INFO

Keywords:

Mobile health
SMS messaging
Cervical cancer treatment
Loss-to-follow-up
Cancer adherence
Uganda

ABSTRACT

Background: Loss to follow-up (LTFU) in individuals undergoing cervical cancer treatment is a major challenge in many low resource settings. We describe development of a customized and tailored mHealth intervention for reducing LTFU among patients undergoing cervical cancer treatment at Mbarara Regional Referral Hospital (MRRH).

Methods: We interviewed all health care providers (HCPs) at the cervical cancer clinic of MRRH, between April and May 2023. Transcripts were subsequently derived, reviewed and coded to generate themes and categories using inductive content analytic approach. Four medical experts used this data to develop relevant SMS content, which was incorporated into an app.

Results: HCPs had owned a phone for $13.8 \leq$ years, had worked at the clinic for $5 \leq$ years, and used text messages regularly. Qualitative data revealed that the main challenge to re-engagement was absence of a reminder mechanism between HCPs and patients. HCPs preferred text and or audio mode of messaging to improve health care responsiveness to LTFUs, awareness, continuity of care, and health service uptake among the majority illiterate population; though with potential constraints of costs and workload. Identified key messaging content included; the importance of attending scheduled follow-ups, follow up visit date and clinic customization and tailoring the message to the intended recipient. SMS content was uploaded onto the *cc-follow-up* app platform and customized according to preferred language, day, frequency and time of delivery.

Conclusion: Tailoring an mHealth messaging intervention could help re-engage and reduce LTFU through improved information sharing, awareness, responsiveness, care engagement and medical compliance. A pilot study is required for our intervention in South Western Uganda.

Abbreviations and acronyms: LTFU, Loss to follow up; SMS, Short Message Services; mhealth, Mobile health; MRRH, Mbarara regional referral hospital; VIA, Visual inspection under acetic acid; WHO, World Health Organisation; HIV, Human Immunodeficiency Virus; TB, Tuberculosis.

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<https://doi.org/10.1016/j.gore.2024.101338>

Received 20 December 2023; Received in revised form 31 January 2024; Accepted 9 February 2024

Available online 24 February 2024

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1. Background

There is a total of 770,828 incident cervical cancer cases registered globally (Sung et al., 2020). Cervical cancer is thus ranked second commonest cancer especially in women aged 15–44 years worldwide (Sung et al., 2020; Bruni et al., 2019). It accounts for at least 270,000 deaths annually, and 85 % of these occur in developing countries (Ronco et al., 1996; WHO, 2020), particularly in sub-Saharan Africa (Anorlu, 2008; Denny et al., 2006). Cervical Cancer incidence stands at 43/100,000 cancer cases in East Africa (Sankaranarayanan, 2014). Uganda's age-standardized cervical cancer incidence rate is said to be higher compared to the global average of 56.2 per 100,000 women (WHO, 2021).

Uganda's cervical cancer screening program employs a "screen and treat" approach, in which the main screening tests include Pap smear cytology and visual inspection with acetic acid (VIA) (Nakisige et al., 2017). For women who test negative on visual inspections with acetic acid (VIA) or Pap smear cytology, the World Health Organisation (WHO) (WHO, 2014) recommends that the interval for re-screening be three to five years. The guidelines further specify that with women who test negative for Human Papilloma Virus (HPV), re-screening should be done after five years. After a subsequent screening with negative test results, and also for older women, the screening interval can be prolonged to more than five years. Women who have undergone treatment for cervical pre-cancerous lesions should receive post-treatment follow-up testing after 12 months as guided by WHO (WHO, 2014). At Mbarara Regional Referral Hospital (MRRH), patients who receive treatment for pre-cancerous lesions or cancer of cervix are required to return for a review visit after 6 weeks, and also return for a follow-up visit at one year post treatment. In low and middle income countries like Uganda, the proportion of loss to follow up (LTFU) among cervical cancer patients is estimated to be very high, ranging between 41 and 69 % (Jedy-Agba et al., 2020; Maranga et al., 2013). Recent data suggests an increasing proportion of loss to follow up among women undergoing cervical cancer treatment in Uganda. Wabinga and colleagues (Wabinga et al., 2003) estimated a LTFU rate of 28.4 % at Uganda National Referral Hospital, Mulago in 2000, while recent data at MRRH (a regional hospital in Uganda) indicate that LTFU among cervical cancer patients was as high as 76 % at the cervical cancer clinic in 2022 (cervical cancer clinic records, 2022, unpublished data). This means that out of 10 women who get treatment after a positive screening test at MRRH, less than three come back for scheduled routine follow up review. Loss to follow up may lead to progression of treatable premalignant lesions to cancerous lesions, thus contributing to poorer patient outcomes.

Although digital interventions including phone calls, text messaging and recorded audios have been successfully implemented to improve adherence to follow up in other disease conditions like Human Immunodeficiency Virus (HIV), Tuberculosis (TB) and other conditions (Getachew et al., 2022; Getachew et al., 2022; Atukunda et al., 2021; Musiimenta et al., 2019; Cattamanichi et al., 2021; Manyazewal et al., 2022), such interventions have not been tried in management of cervical cancer. Text messaging has been shown to be acceptable and feasible in low resource settings to support treatment adherence among people living with HIV (Musiimenta et al., 2018). In this study, we develop a customised user-centered text messaging app that could help in improving information sharing, awareness, responsiveness, care engagement, medical compliance, and reducing loss to follow up among women undergoing treatment for cervical lesions at the cervical cancer clinic of MRRH in rural South Western Uganda.

2. Materials and methods

2.1. Study design

We conducted key informant interviews among cervical cancer clinic health care providers (HCPs) to identify challenges, facilitators of LTFU,

identify key mHealth intervention appropriate to re-engage patients at the facility. We then developed the SMS content with the input of 4 medical experts (one obstetrician, one nurse and two midwives), one community health specialist and one community psychologist. We developed an app prototype that would deliver SMS text message reminders, in partnership with Ucatch Technologies Limited, a local mHealth development company.

2.2. Study setting

Participant recruitment took place at the cervical cancer clinic of MRRH, a referral hospital located in rural South Western Uganda. The referral hospital has a catchment area of approximately four million people (Uganda Ministry of Health, 2016) whose overall literacy rate is reported to be 72 % and slightly lower (68 %) in females (Statistics UBO, 2016). The clinic is open five days a week and receives over 250 women in a month (medical records). The clinic is run by several nursing staff, senior residents and a gynaecologist. The team is supervised by a gynecologist. Visual inspection with or without acetic acid, colposcopy, conventional cytology and HPV DNA are the screening tests routinely done at the clinic. Women with pre-malignant lesions are treated with cryotherapy and thermocoagulation; those with confirmed cervical cancer are referred to higher level health facilities for radiotherapy and chemotherapy. Following treatment, the patients at the cervical cancer clinic of MRRH are advised to return for a review visit at 6 weeks and one year as follow up intervals.

2.3. Sampling and recruitment of health care providers at the clinic

We used a purposeful qualitative sampling strategy to construct a sample of HCPs at the existing cancer clinic with vital and diverse experience and knowledge about cervical cancer LTFU, mobile technology and intervention development and use in a health setting. Contact with HCPs was initiated by a trained research assistant, who scheduled them for interviews at an appropriate/agreed upon date after obtaining their informed consent. All eligible HCPs contacted at the clinic were willing to participate in the study. A total of 10 HCPs were selected, recruited and interviewed, bringing a wide range of experiences, and suggestions. All interviews were conducted in a private location as agreed between the interviewer and the participant. All interviews lasted between 40 and 60 min and were conducted in the local language (Runyankole), and digitally recorded with the participant's permission and transcribed. A member of the team (research assistant) transcribed and back translated the interviews.

2.4. Data collection

2.4.1. Key informant interviews

All HCPs working at the cervical cancer clinic of MRRH for at least one month who were willing to provide written informed consent were screened and enrolled. Ten key informant HCP interviews were conducted using an interview guide (supplementary file 1) developed basing on the constructs of the Multiphase Optimisation Strategy (MOST) framework as previously reported (MacPherson et al., 2022). The MOST framework is suited for development of mhealth interventions that target behaviour change. The framework considers potential effectiveness of the intervention, affordability of the intervention, scalability of the intervention and the efficiency of the intervention within the intended population and setting (Collins and Kugler, 2018). The MOST framework includes three phases; preparation; optimization, and evaluation. In this study, the preparation phase involved key informant interviews with topics covering information on common challenges experienced by targeted LTFU patients as per the MOST framework namely; (1) Identifying/selecting the appropriate mHealth technology to re-engage LTFUs, (2) Explore the potential impact of the intervention use within the target setting to improve patient perceived

ease of use, usefulness, and returns/engagement, (3) Selecting potential/preferred intervention components and or medium of delivery, (4) identifying potential constraints on the technology/intervention to be developed, (5) Develop the context-specific messaging and content able to educate, support, prepare and motivate recipients to return for scheduled reviews, and 6) Develop a conceptually sound intervention/information/system tailored, personalized and customized for the targeted end-users.

Key informant interview data on commonest type of phones used, network connection, messaging content/components, user-friendly delivery medium, frequency, language, length, and timing of the SMS was collected. We used probes to elicit details corresponding to each of the highlighted topics, and field notes collected and included in each of the individual debrief notes by research assistants. We continuously reviewed emerging content together to refine the interview questions and add new potential probes. Demographic information; age, phone ownership/access, and phone use was collected to describe our study sample.

Additional information about the affordability, potential costs constraints and compatibility of the possible messaging interventions, workload, scalability and efficiency of the SMS text or audio messages was collected from the interviewed HCPs.

2.4.2. Messaging content development

Messaging content development was done to educate, support, prepare and motivate recipients to reengage in care, and eventually return for scheduled follow up review visits. We engaged seven independent panellists (not previously interviewed) including three (Ronco et al., 1996) HCP (one gynaecologist, one nurse and one social worker), a computer scientist, a community health expert and a community psychologist in a group discussion to develop relevant content for the intended SMS text messages around the HCP-identified categories/themes. The type of intervention, medium of delivery to suit the type of phone mostly available/used in this setting, available network connections, and potential cost of intervention were the key guiding principles to ensure the intervention being developed was affordable, practical, safe, useful, acceptable and accessible to many individuals being targeted in the long term as per the Behaviour Change Wheel (BCW) framework (Michie et al., 2014).

2.4.3. Application prototype design and development

We worked with a local mHealth app developer (Ucatch) with vast experience in building customised, tailored user-centered applications, with individualised/preferred language, service provider, type of phone, delivery medium, frequency and time of delivery of text messages and or reminders. We developed the first draft of a tailored messaging application aimed at increasing participant usability, and supports, motivates, prepares women to re-engage in care. The app has features that allow customisation in terms of preferred language (English or Runyankore), preferred time of the day, preferred day of the week, name of the recipient, preferred phone number, the exact date of the review visit and the preferred frequency for receiving SMS reminders. HCPs can be able to enrol participants on the app and schedule text messages, depending on the predetermined follow up visits, specifying their exact dates for any given patient. Additionally, this app can perform analytics, whereby the user can know the number of text messages sent and delivered and those that were not delivered. All messages for this project were developed in the Ugandan official language, English, and then translated into the local language, Runyankole, by an experienced translator to maintain context. Participants have the liberty to select either to receive English or Runyankore messages. This prototype was developed in Java as a *cc-follow-up app* or platform for SMS text messaging as preferred by most interviewed HCPs. The app was developed in android, connects to the Ubuntu Linux server and is hosted at [Linode.com](https://www.linode.com).

2.4.4. Data management and analysis

Our aim of the qualitative data analysis was to inductively construct categories that describe possible challenges/facilitators that contribute to individuals failing to return for follow up care/ review appointments, identify and developing preferred technology and content tailored for the available phone types and network to engage, educate, support, prepare and motivate recipients to return for scheduled review visits.

We constructed categories through repeated review of transcripts by two members of the research team (FS, ECA) to identify relevant content, which served as the basis for developing a code book. The rest of the transcripts were coded by research assistants using the developed code book, aided by the qualitative data management software, Nvivo 12. We iteratively reviewed, sorted and analysed data using inductive content analysis approach (Bronfenbrenner, 1977). Descriptive labels and elaborating verbatim text to define and specify each category's meaning, plus illustrative quotes from the key informant interview data was included.

3. Results

We conducted a total of 10 key informant interviews among HCPs involved in cervical cancer care at MRRH. Their average age was 35.3 (+/-6.4) years and all of them had worked in this public health care facility for an average of 10.5 (+/-6.3) years. Two (2/10) participants had attained a bachelor's degree, three (3/10) were certificate holders while five (5/10) were diploma holders from tertiary institutions. All our study participants were able to read, write and speak both English and the local language (Runyankore). All our participants were active phone users and had owned a phone for an average of 13.8 years (+/-6.1). Specifically, most of our participants reported to be active and regular phone users, including text messaging as presented in [Table 1](#).

3.1. Qualitative results

Despite the various reasons for individual LTFU, all HCPs showed optimism towards mhealth interventions and observed that any mobile-based intervention to improve patient follow up and compliance at this clinic would have to take consideration of the commonest type of phones used or accessible by the target population, the most available network connection, contain appropriate and tailored messaging content/components, delivered in a user-friendly medium, frequency, language, length, and timing to the rural populace. Our qualitative data revealed the main challenge to re-engagement as a lack of a follow up mechanism to actively engage and follow up patients under care regardless of the stage of cancer or mode of treatment. HCPs observed that a tailored text and or audio mode of message delivery could improve health care responsiveness, awareness, continuity of care, and health service uptake among the targeted mostly illiterate population. Our qualitative data

Table 1
Demographic characteristics of study participants.

Variable	Category	Frequency (N = 10)	Proportion (%)
Age		35.3 (+/-6.4)	
Experience in service		10.5 (+/-6.3)	
Highest qualification	Bachelor's degree	2	20
	Certificate	3	30
	Diploma	5	50
Access and use a cell phone	Every day	10	100
Ability to speak Runyankore	Yes	10	100
Ability to read/write Runyankore	Yes	10	100
Ability to read/write English	Yes	10	100

further revealed six key and repetitive categories that informed the application/intervention development namely; (1) Preferred/appropriate mHealth technology to re-engage women lost to follow up, (2) perceived potential impact of the identified intervention use within the target setting to improve patient perceived usefulness, and compliance, (3) Potential/preferred intervention components and or medium of delivery that would increase uptake and engagement, (4) perceived potential constraints on the proposed technology/intervention needing close consideration to improve access and or ease of use, (5) Design and dissemination of context-specific messaging and content able to educate, support, prepare and motivate recipients to return for scheduled review visits, and (6) Tailoring, personalizing and customizing the intervention for the targeted end-users.

3.2. Preferred/appropriate mHealth technology to re-engage LTFUs

HCPs believed that many of the patients that came to the clinic owned or accessed non-android phones for personal use and these would be used to build an appropriate intervention that can easily and widely reach the targeted audience, using a preferred or reliable network at one's residence. All HCPs further suggested that a suitable mobile health intervention originating from the clinic would make patients "feel connected" and part of the "care/facility family" that cares for their well-being, and that this continuity and perceived follow up care would quickly encourage, alert, remind and or motivate the receivers to take action and return for the scheduled visits. This engagement was also thought to possibly erase existing fears of loss, abandonment, helplessness or hopelessness that would make some patients stay away and opt for alternative and ineffective care within their communities, only to return when it's too late. According to a 38-year-old HCP who has worked at the clinic for over ten years:

"You see here, we do the screening and treat as much as we can. We give our patients a return date but we lack a good and reliable mechanism that reaches everyone to follow up our patients and retain them in care. I have seen other clinics like the HIV, TB with such strategies using mobile phones and their patients are happy with it and always come for their reviews and medicines every time they are needed back to the clinics. I think cervical cancer patients here loose hope when we don't keep in touch. They go to witch doctors, when in any case they would benefit greatly from our encouraging messages and reminders sent on their mobile phones. You see, they can keep connected and come back in time because they can be convinced that we, as their carers think about them and wish them well"

Another 39-year old HCP added,

"Most of our patients have phones, or at least they can access a phone at home but their phones are small non android phones. One needs to look at that and see the most appropriate intervention that fits in what is available among our people for it to be useful because they may not afford to buy and use big phones. Secondly, our network issues are many but most people here have double sim phones so a mobile phone app should be able to accommodate either line or reliable network at their home"

3.3. Perceived potential impact of the identified intervention

HCPs advised that a suitable intervention would help to actively mobilise close and hard to reach individuals to timely return for care. HCPs noted that a good intervention would help relay information about upcoming review visits, help patients understand their health status, the benefit of timely review visits, the risk of non-adherence that would directly or indirectly influence their decisions to return and comply with their scheduled review visits. This ongoing awareness towards one's health status, progress and risks associated with non-compliance was perceived to be influenced by regular and continuous HCP interaction during follow up visits or virtually through available mobile technologies. Such long-term relationships would further support these patients

as they navigate through new and existing challenges, misconceptions and or concerns that come alongside cervical cancer diagnosis and treatment. According to one of the 38-year-old HCP who has worked at the clinic for seven years:

"You see; we don't have means of calling back our patients. I can't use my airtime [all the time]. If a patient forgets their review date, no one calls them to remind them. For us we only write in their books and document in our register. Patients are even many that we can't follow every one. You see that register; we get a new one every month so we lose track. I would appreciate any mobile intervention that comes to not only help us trace our patients but also remain in touch with them, help them understand how they are doing health wise, how they are progressing, remind and encourage them to always come on time".

A 32-year-old HCP that has worked at the clinic for 5 years also added:

"The interventions that use mobile phones can reach many of our people especially in the villages down there. People have used these phones for long and they are convenient for them as they sit at home and get the information they want...our interactions as their carers can help patients as they go through a lot trying to understand their new situation without being confused by those around them to think they were bewitched and then resign to fate, be depressed or disappear and get deceived to look for alternative herbal medicine and return when its so late"

"I think they are good and timely, since we don't have any way of calling back those women. When we treat these women, we either write in their books or tell them by mouth their return date. This is so far the first time someone comes up with something to remind our patients to return for review. A good number of our patients never return. We only see them when its late. I think these messages will also be good in keeping our patients informed about their exact return dates." (participant 1, age range 30–40)

3.4. Potential/preferred intervention components and or medium of delivery

HCPs observed that a good intervention for the clinic would include text messaging, since it seemed cheaper and affordable long-term. HCPs alternatively suggested audio messages for the audience that is illiterate and can't read text. However, HCPs noted that these would need to be financed by the senders, and not the receivers in order to increase uptake and engagement by the targeted patients. The receivers should be able to identify of the sender, the reason for the reminder/ message and the date for the follow up visit. HCPs also noted the importance of making these messaging regular and or automated to avoid a lot of added work load to an already strained clinic with low human resource capacity. HCPs should therefore be able to enrol everyone and schedule messages, depending on the predetermined follow up visit date of any given patient. Consideration of such components would increase app usability and acceptability, and support patient tracking and improve compliance to care. The messages would need to be sent at a preferred frequency, timing, date, using a preferred medium, to improve engagement, avoid messaging fatigue and burdensomeness. HCPs noted that these messages would be developed universally in English language, and later back translated into the local language, Runyankore, by experienced translators to ensure consistency and context are maintained. A 29-year-old HCP with five years of experience said:

"I think if a message has something like "Mbarara hospital, cervical cancer clinic", a patient will feel at home, and feel like she is being remembered. The message should be intentional, regular and encouraging so that patients remain enthusiastic and expectant, something like; We are reminding you to come back on such and such a day for follow up on your treatment, thank you...I think if it was me, I would be able to remember exactly what the nurse told me while at the clinic and come quickly".

“It would be a lot of work if we were to type and send a separate message to different patients every day in different languages, different times of the day or week and so scheduled messages are better so there’s also consistency as we reach many people in a short time... although fewer patients don’t read texts but can pick up phone calls and obtain the same message and all if possible but these texts or calls would need to be paid for by us in order to work and not burden our patients further”, added a 47 year-old HCP with over 20 years of work experience in the same hospital.

3.5. Perceived constraints and considerations on the proposed technology/intervention to improve access and or ease of use

HCPs identified potential constraints about mobile interventions that would need consideration in order to work well within a rural setting. Some of these constraints included; additional costs needed by the facility or individual users to access and use this app, possible compatibility of the possible messaging interventions with their existing phones or existing network infrastructure, frequency of phone theft, dead batteries, consistent network connectivity to ensure messages are delivered as scheduled, and potential workload. These factors that were said to be key in future feasibility, scalability and efficiency of the messaging intervention. One of 34-year-old HCPs who has worked at the clinic for six years said;

“Most of our patients are poor, use simple phones, and some of them come from very far where network connection is poor...some of their phones get off for days due to dead batteries and so messages may not be delivered it time so you may need to think about all these and provide the whole thing, including finances to run it”

“We may also need to consider what is needed to do this extra work so it does not go to waste because we are already overwhelmed with more clinical work so you need to think about that too” added another 31-year-old HCP working at the facility for over 10 years.

3.6. Designing and dissemination of context-specific messaging

Interviewed HCPs observed that a good intervention would require context-specific content, that would be disseminated to educate, support, prepare and motivate recipients to return for scheduled reviews. HCPs also suggested key messaging content to include; the importance of attending scheduled follow-up visits and also having it customized to the intended recipient to encourage re-engagement. The message content developed and disseminated to individuals would intend to create awareness, ownership, offer support, engage, prepare and generally motivate the targeted recipients (patients) to return for scheduled reviews and visits.

“Most of our patients need to know why we are reminding them to return for review. They also need to know that we know them. I think if we write there her name, the woman will feel encouraged to come back. She will feel like we know her. That way, she will remember her return dates.”

“What is contained in that message really matters. We should have a message that is not going to anger the patient. It should instead motivate her to respect appointment dates for follow up visits. After telling the patient the importance of respecting follow up review visits, the patient should feel ashamed if they don’t return” added another 35-year-old HCP working at the facility for over 6 years.

3.7. Tailoring, personalizing and customizing intervention for the targeted end-users

All HCPs observed that many mobile technology interventions don’t work long-term because of excessive spams, alongside privacy and anxiety issues that goes along with using shared phones. HCPs noted that building a customised intervention that contains cervical cancer-tailored information customized to each individual needs and language would be

ideal to improve enthusiasm and control technology fatigue long term. Interviewed HCPs further suggested that tailoring information and or reminders would improve patient usability, ultimately support, motivate and prepare patients to re-engage in care. The messaging content incorporating these tailored themes would then be uploaded onto the app platform that is customized according to preferred language, day of the week, frequency, service provider and time of delivery. The HCPs would also be able to enrol participants on the app at a convenient time and schedule text or audio messages, depending on the predetermined follow up visit date of any given patient. This kind of prototype would give flexibility to both HCPs and the intended recipients (patients). One of the 44-year-old HCPs said:

“Like when I receive a birthday message from my bank or NSSF, showing my full name, I usually read the message to the end because I feel they know me very well and care a lot about me. Of course, the messages come when they are coded so they know where they are coming from and can’t ignore it as spam...of course you would not like reveal a lot of personal information like HIV status of the patient since some of these phones are shared but clear information about their upcoming clinic visit can remind and encourage people to come back in time. Let’s include these things and see”.

“If this app can upload messages at once, I mean the messages that have been developed to reach out to the patients and for us we only log in and add more patients against their preferred dates, network of choice, times of the day or week that they request to receive their messages, then it would be so fast and doesn’t need a lot of our extra time to do it alongside other clinic work. That way, we are able to enrol these patients easily and at any time on the app for them to all benefit”, added another 32-year-old HCP who has worked in the screening area for close to five years.

3.8. The app prototype design and development

The developed SMS text messages were uploaded onto the *cc-follow-up* app platform, with customisation features including preferred language (English or Runyankore), preferred time of the day, preferred day of the week, name of the recipient and preferred phone number. SMS text messages were designed such that they were to be sent as automated one way messages. This was aimed at reducing the financial burden on end users. Messages were utmost 150 characters long to ensure compatibility with all types of mobile phones. The App was also designed to schedule and queue messages and align them to set dates of appointments (review dates), allow variable timing, allow language preference and frequency of scheduled messages. The App has a module that provides quick analytics or reports for example status of any message (messages sent, messages delivered or messages undelivered). The tailored content, automated dispatch, frequency, timing and length of these SMS text messages were based on the type of feature phone (non-Android) owned by majority patients to improve message delivery, engagement and usefulness. We worked with a local mhealth app developer (Ucatch) with vast experience to capture targeted users’ flexibility in terms of language, service provider, delivery medium, frequency and time of delivery of SMS text messages and or reminders. This prototype was presented as a *cc-follow-up app* or platform for SMS text messages and this app was hosted at Lindone.com. The home page of the *cc-follow-up* app is shown in [Fig. 1](#).

4. Discussion

4.1. Principal findings

In this study, key informant interviews among HCPs revealed general optimism towards SMS text messaging as the preferred/appropriate mHealth technology with the potential to be used within a rural setting to improve patient compliance to cervical cancer care, re-engage and

Fig. 1. The *cc-follow-up* app home page interface.

increase cervical cancer care uptake among women lost to follow up. The main challenge to reengage patients was lack of a reminder mechanism to actively engage and follow patients. We also observed that costs and workload as the potential constraints on SMS text messaging and the need for close consideration in order to improve access and or ease of use of our intervention. Qualitative data further revealed six key and repetitive categories namely; Preferred/appropriate mHealth technology to re-engage women lost to follow up, perceived potential impact of the identified intervention use within the target setting, potential/preferred intervention components and or medium of delivery, perceived potential constraints on the proposed technology/intervention needing close consideration, design and dissemination of context-specific messaging and content, and Tailoring, personalizing and customizing the intervention for the targeted end-users. These informed the application/intervention development.

Using context-specific content that is able to educate, support, prepare and motivate recipients to return for scheduled review visits, we developed the *cc-follow-up* application, a novel health worker centred mhealth text messaging intervention that is tailored, personalized and customized for the targeted end-users, to be used by health workers at the cervical cancer clinic of MRRH. This app could reduce loss to follow up of women undergoing treatment for cervical lesions.

Text messaging was the most preferred mhealth technology that HCPs identified that would likely reengage those women lost to follow up. This feeds into the existing widespread adoption of mobile phone technologies (Mothobi and Grzybowski, 2017). Mobile phone subscription among Ugandans is reported to be 70 per 100 people (World Bank, 2022). This could have provided prior knowledge or exposure to mhealth technologies which in turn determines the probability of uptake of SMS text message mhealth interventions as indicated previously (Gagnon et al., 2016; Townsend et al., 2015). In our study, there was

vast optimism accorded to SMS text messages. Previous studies have demonstrated that text messaging as an intervention has the potential to improve clinical outcomes in many disease conditions (Musiimenta et al., 2018; Musiimenta et al., 2020; Yin et al., 2018; Mohammed et al., 2016; Sabin et al., 2018; Haberer et al., 2016). Previous work by Musiimenta et al. (2020) also showed that participants feel obliged to return for follow up visits once they receive SMS text reminders. The choice of SMS text messaging as the most preferred mhealth technology could also be attributed to trust in such interventions. Trust has been said to have a positive impact on one's intention to use a given mhealth intervention Akter et al. (2013); Deng et al. (2014); Vedder et al. (2014).

Considering SMS text message as an intervention with components and medium of delivery that would be educative, increase care uptake and engagement, text messages bear an advantage of allowing app developers and HCPs to incorporate unique customisation features including language, time and frequency preference; as well as scheduling according to the patient's review visit dates. These features in one way or another increase care uptake and engagement, and address the educative aspect as they emphasise the relevance of patient reviews as highlighted by Koshy et al (Koshy et al., 2008). At the MRRH cervical cancer clinic, patients are normally given many appointment dates numbered according to different review times. Each review is intended to serve a given purpose. For instance, an initial review, which is normally close to the treatment date, is given to check for reactions to treatment. Other review appointments are tailored to ascertaining clearance, persistence or progression of lesions.

There are inherent challenges that come along with SMS text messages as an intervention and need close consideration to improve access and or ease of use. Challenges like cost, especially for two way messages, and compatibility with existing network or information technology infrastructure or phone types have been earlier indicated as challenges associated with mhealth interventions (Musiimenta et al., 2020; Tamrat and Kachnowski, 2012; Kumar et al., 2012; Silva et al., 2015). Many areas in low resource settings have inconsistent phone network and poor coverage (Gupta and Jha, 2015). Phone batteries wear out due to inconsistent electricity supply. All these need to be considered while developing SMS text messages as an intervention. Studies have proposed additional means, at patient level, of addressing financial constraints in ways that could usefulness of SMS text message interventions (Weiser et al., 2015). However, SMS text messaging has been argued as a cost effective, less laborious intervention (Koshy et al., 2008) and cheap compared to audio and other interventions and so they don't impose any significant financial burden to intended users (Gurman et al., 2012; Maar et al., 2016).

From our study, there was a need to tailor, personalize and customize interventions for the targeted end-users. We developed a novel health worker centred SMS text messaging app, to be used by health workers at the cervical cancer clinic of MRRH to reduce lost to follow up of women undergoing treatment for cervical lesions while able to educate, support, prepare and motivate recipients to return for scheduled reviews. Involving health workers, who are the intended app users (senders of these SMS text messages) improves ownership and overall usage of the intervention. Health workers identified 5 key aspects that needed to be considered while developing the SMS content. These included the sender identity, reason for the reminder, venue for the follow up visit, identity of the message recipient and date for the follow up visit. This enhances our knowledge about the benefits of mhealth interventions when designed and developed with participation of end users as described previously (Atukunda et al., 2021; Dick et al., 2011; Ybarra et al., 2012; Campbell et al., 2017; Bock et al., 2015; Lotto et al., 2020).

Our intervention was designed to send automatic SMS text messages which are customized in a number of aspects. We planned to have women decide their preferred language (English or Runyankore), preferred time of the day to receive the SMS reminder text, preferred day of the week to receive the SMS reminder text and their preferred phone number for receiving the SMS reminder text. This was based on prior

knowledge that customisation of mhealth intervention to the needs of end users enhances engagement and improves uptake (Bendixen et al., 2017). By providing an option for a woman to choose different preferences like timing and frequency of SMS text messages, we hoped to avoid unnecessary repetition, technology fatigue, boredom, making the messaging intervention an overall acceptable tool to improve follow up of cervical cancer patients as highlighted in previous studies (Shaw et al., 2013).

We opted for a standard automatic messaging app that would be exact and prompt in delivery of reminder text messages directly to women's mobile phones, while adhering to their preferences. This approach has been said to keep women connected to the clinic and keeps them motivated (Atukunda et al., 2021). We also provided an option for women to include an alternative phone number, probably, for a next of kin, to which an SMS text message could be sent. This was based on previous research findings (Atukunda et al., 2017), that involvement of significant others improves the impact of the intervention, say in resource mobilisation, which in this case would be transport to the clinic.

We followed the preparation phase of the MOST framework while designing our intervention that we considered appropriate for a mobile phone non naïve community to improve uptake. Previous studies have documented that phone experience, as well as experience with similar technology are very important considerations when designing and developing appropriate mhealth interventions (Atukunda et al., 2021; Dick et al., 2011; Ybarra et al., 2012; Campbell et al., 2017).

The major strength of this study is the fact that we used experienced health care workers to provide information that we later used for content development. All health workers had worked at the cervical cancer clinic for an average of 10 years and were well versed with the challenges and possible solutions to the challenges of the clinic. We also document the various ways we customised our SMS text message intervention. In this way, we took care of almost all women's preferences while designing and intervention that would benefit and be acceptable among the rural communities of South Western Uganda and all other communities with comparable socioeconomic status. Our customised SMS text message content was designed to a maximum of 150 characters, and this can suit the different types of phones held by women in this rural community. We also used well established methodologies in conducting interviews, data analysis, content development and eventually development of the prototype, which makes our findings scientifically grounded, acceptable meaningful and easily generalizable to populations.

We acknowledge the fact that we were unable to use all the phases of the preparation phase of the MOST framework, and so we did not perform pilot tests for this prototype. We also did not include intended recipients of the SMS text messages (women treated for cervical lesions and given return dates for follow up). This would reinforce the scientific ground of our study findings as this group of participants could be having different thoughts about this intervention. Our research findings may also be non-applicable to populations with a higher socio-economic status, given the fact that there are differing network connectivity and mobile phone types. Also, we did not cater for a feedback mechanism. Recipients can only receive but cannot send any feedback something that is said to improve long term usage of mhealth interventions (Bendixen et al., 2017). We did not perform acceptability and feasibility studies for our SMS text messaging app. We are proposing a future clinical trial to pilot this intervention.

5. Conclusion

Our study describes the process of developing a novel health worker centred and user-friendly SMS text messaging app that automatically sends customised follow up reminder messages to reduce loss to follow up of cervical cancer patients at MRRH, South Western Uganda. By involving experienced health workers from the cervical cancer clinic of

MRRH, we were able to capture the most relevant considerations for development of this intervention. And by so doing, we took care of women's preferences thus creating a sense of ownership and inclusiveness. This supports the current role of mhealth interventions, particularly SMS text messages, in healthcare delivery and presents an alternative means of interaction between health care providers and patients. Our next step is to study the intervention in a pilot clinical trial to assess its feasibility, acceptability, and preliminary efficacy in reducing loss to follow up.

6. Availability of data and materials

All data from which this article was generated is available from the corresponding author upon reasonable request.

7. Ethics approval and consent to participate.

Ethical review and approval was obtained from Mbarara University of Science and Technology Research Ethics Committee (MUST-2022-670). All methods involved in this study were carried out in accordance with relevant guidelines and regulations. Written Informed consent was obtained from every participant before participating in the study.

8. Consent for publication

Not applicable.

Author contribution

FS conceived the idea and developed the first draft of the protocol. RK, MG, AN, NK, ET, SM, DT, TCR and ECA refined the protocol, guided data collection and analysis, provided overall guidance in the entire write up of the manuscript. All authors read and approved the final version of the manuscript prior to submission.

Funding

This research project was entirely funded by The Government of Uganda, under the Directorate of Research and Graduate Training, Mbarara University of Science and Technology, small research grants; grant number DRGT/SG/FY22-23/R1/T1P1.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

We acknowledge the staff and patients of the cervical cancer clinic at Mbarara Regional Referral Hospital.

Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.gore.2024.101338>.

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