Smartphone usage and preferences among postpartum HIV-positive women in South Africa

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DECLARATION

I, Pheposadi L. Mogoba, Student No. MGBPHE001, declare that the work that I have submitted is my own and where the work of others has been used (whether quoted verbatim, paraphrased or referred to) it has been attributed and acknowledged.

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DISSERTATION ABSTRACT

Introduction. In South Africa, HIV-positive women receiving antiretroviral therapy (ART) often are lost to care postpartum and strategies to support long-term engagement in care are needed. Mobile health (mHealth) interventions are emerging as potential strategies for supporting long-term engagement in the prevention of mother-to-child transmission (PMTCT) of HIV care continuum. Smartphone technology and mobile data are getting cheaper and more accessible, however little research has been done to explore the potential for smartphone-based interventions in the PMTCT cascade in low-resource settings. This study explored smartphone use and the acceptability and feasibility of mHealth interventions among postpartum women who were attending the Gugulethu Community Health Centre in Cape Town, South Africa.

Methods. This mini-dissertation is composed of three parts. Part A, the protocol, outlines the study methodology and the ethical considerations of the proposed study. Part B, the structured literature review, synthesises available data on uses of mobile phone-based applications to support the PMTCT continuum as well as end-user perceptions and preference for mHealth interventions for PMTCT. The review considered published quantitative and qualitative studies that were conducted in sub-Saharan Africa, the most comparable settings to the study population. Part C, the journal ready manuscript, presents the results of six focus group discussions (FGDs) conducted with 27 HIV-positive, postpartum women who were using a smartphone. Questions assessed the respondent's general smartphone use, as well as their exposure to and perceptions of mHealth interventions.

Results. The review shows that, despite a range of evidence on short message service (SMS) and/or voice call interventions, smartphone-based interventions have not been a focus of prior research to support the PMTCT continuum of care or maternal lifelong ART. Results are promising for SMS and/or voice call to enhance maternal retention, infant HIV testing and infant ART initiation. The review found evidence of acceptability and feasibility of mHealth interventions offered directly to women, or also including their partners and health workers as support systems to address PMTCT challenges. The primary research found little turnover in phones and phone numbers, and about half the women shared their devices with family and friends. Respondents reported high familiarity with smartphone applications

such as WhatsApp and Facebook, with WhatsApp cited as the preferred method of smartphone communication. Women had access to reliable data sources such as data bundles, airtime and Wi-Fi, with data bundles perceived as the most cost-effective method to access the internet. Nearly all women were familiar with MomConnect, a national mHealth text support service in South Africa, and most described it positively. Women expressed interest in future HIV mHealth applications including complementary health information on physical activity, nutrition, mental health and basic social services.

Conclusions. In the context of rapidly increasing access to smartphones, even in low-resource settings, these findings suggest that future smartphone mHealth interventions may be appropriate to support the PMTCT continuum of care in low-income settings of South Africa. These results call for further studies to evaluate the feasibility and effectiveness of smartphone interventions in similar settings.

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Structured Literature Review

PART A: PROTOCOL

LIST OF ABBREVIATIONS

ACT	Acceptance and commitment therapy
ANC	Antenatal Care
Apps	Applications
ART	Antiretroviral therapy
CDC	Centers for disease control and prevention
CHW	Community Health Worker
eMTCT	elimination of mother-to-child transmission
EID	Early infant diagnosis
FGDs	Focus Group Discussions
GCHC	Gugulethu Community Health Center
HIV	Human immunodeficiency virus
HTC	HIV Testing and Counselling
IMEI	International mobile equipment identity number
IQR	Interquartile range
LMIC	Low- and middle-income countries
MCH	Maternal and Child Health
mHealth	Mobile Health
MTCT	Mother-to-child transmission
PLHIV	People living with HIV
PMTCT	Prevention of mother-to-child-transmission
RCT	Randomized clinical trial
SMS	Short message service
UN	United Nations
WHO	World Health Organisation

Introduction

PMTCT as a global response to maternal and child HIV

Vertical transmission of the human immunodeficiency virus (HIV) during pregnancy, labour, delivery or breastfeeding has been identified as the main contributor to new HIV infections in children living in Sub-Saharan Africa (HIV.gov, n.d.; Myer & Phillips, 2017; Tamuzi Lukenze Jacques, 2016; World Health Organization (WHO), 2012). With global goals of eliminating HIV in infants and keeping their mothers healthy, prevention of mother-to-child transmission (PMTCT) strategies have received high priority over the past decade (Nachega et al., 2012; South African National AIDS Council, 2017; UNAIDS, 2013). The use of antiretroviral therapy (ART) to suppress maternal HIV viral load has been hugely successful in reducing mother-to-child HIV transmission (MTCT). In 2013 the World Health Organization (WHO) recommended Option B+ (lifelong ART offered to all pregnant and breastfeeding women living with HIV regardless of CD4 cell count or clinical stage) as the standard of care and more recently universal ART for all HIV-positive individuals. This has rapidly expanded access to and uptake of ART during pregnancy and has helped to drive significant global reductions in MTCT (Gumede-Moyo, Filteau, Munthali, Todd, & Musonda, 2017; HIV.gov, n.d.; Kihara & Gichoya, 2015; Mackie & Sim, 2013). According the WHO, sustained use of ART throughout the PMTCT cascade can facilitate reduction in infant infection from 35% to <2% in low-income settings (World Health Organization (WHO), 2012). Indeed, since adoption of PMTCT Option B+ by the South African government in 2015, HIV transmissions (at six weeks of birth) have reduced from above 3.5% in 2010 to approximately 1.5% in 2016 (NEWS, 2015; South African National AIDS Council, 2017). Even though these reductions are significant, current PMTCT strategies remain suboptimal to ensure an AIDS-free generation in the near future (Haas et al., 2017; Johnson et al., 2016; Kim et al., 2015).

There is growing evidence of women dropping out of HIV care during pregnancy and, more frequently, after delivery (Clouse et al., 2013; Gumede-Moyo et al., 2017; Nachega et al., 2012; Shaffer, N., Abrams, E. J., & Becquet, 2014; Sibanda, Weller, Hakim, & Cowan, 2013; Wang et al., 2011). This raises concerns about whether current MTCT rates will reach the targeted zero mark (South African National AIDS Council, 2017). Maternal disengagement

from care undermines the potential benefits of maternal ART use during pregnancy and/or breastfeeding and infers increased risk of MTCT as well as maternal morbidity and mortality. Barriers including disclosure, stigma, lack of partner support and various structural factors have been associated with high disengagement and low ART adherence (Gourlay, Birdthistle, Mburu, Iorpenda, & Wringe, 2013; McMahon et al., 2017; Phillips et al., 2014; Psaros, Remmert, Bangsberg, Safren, & Smit, 2015). If South Africa is to attain the global targets of eliminating MTCT by 2030, implementation of innovative and more patient centred approaches that will address these known gaps that affect access to HIV care in PMTCT programs is warranted (Phillips et al., 2014; South African National AIDS Council, 2017) .

Mobile phone use for HIV care and PMTCT

Mobile technologies are amongst some of the promising interventions for improving HIV service delivery and patient outcomes. In a total of 75 peer reviewed articles identified through two systematic reviews by Catalani et al. and Ridgeway et al., focusing on studies that investigated the influence of mobile health (mHealth) on HIV outcomes, included studies revealed effective improvement in ART adherence and retention in HIV care in the presence of mHealth interventions (Catalani, Philbrick, Fraser, Mechael, & Israelski, 2013; Ridgeway et al., 2018). In both reviews, the majority of interventions in the projects were short message service (SMS) based, providing alerts and reminders to the patients to encourage adherence to their medication and retention in care. However, despite these promising results, both reviews also identified gaps in availability of literature that rigorously evaluates the use of mHealth in HIV-positive high priority populations such as pregnant women, adolescents and children, and instead data mainly focused generally on people living with HIV (PLHIV).

To date, the few studies that explore mHealth interventions targeted to pregnant and postpartum HIV-positive women mainly sent one- or two-way SMS messages and reminders, with little literature focusing on smartphone interventions. These studies found improved postpartum retention, infant HIV testing and adherence to ART among women

receiving the messages (Coleman, Bohlin, Thorson, Black, Mechael, Mangxaba, & Eriksen, 2017; Joseph-Davey et al., 2013; Odeny et al., 2014; S R Schwartz et al., 2015). In 2014, South Africa rolled out MomConnect, an opt-in, free SMS service that provides stage-based informational text messages and appointment reminders to all pregnant and postpartum women (Western Cape Government, 2014). This program was an important first step for using mHealth technology to connect patient to care and demonstrates a government commitment to mHealth. However, MomConnect does not focus on the specific needs of HIV-positive women and understanding their smartphone preferences and specific needs and concerns regarding smartphone based interventions remains a gap.

Cell phones are as common in South Africa as they are in most developing countries, according to a relatively recent Pew Research study that found that 89% of adults owned a cell phone in 2014 (Pew Research Center, 2015). Another study by Clouse et al. conducted among HIV-positive women attending a public antenatal care (ANC) in Johannesburg found that phone ownership was ubiquitous, and the median time with the current phone number was three years (Clouse et al., 2015). Additionally, smartphone use is increasing rapidly; a 2015 survey found that 42% of South African respondents owned a smartphone (Poushter, 2016). We know that cheaper smartphones and better wireless broadband infrastructures are increasingly available in Africa and have presented an opportunity for smartphone based interventions in PMTCT (Betjeman, Soghoian, & Foran, 2013). However, in this rapidly changing landscape, current data on uses of smartphones and acceptability of smartphone based interventions for PMTCT and maternal health in low-income settings is not available. This study aims to understand the potential role of smartphone mHealth interventions for improving ART adherence and retention of postpartum women.

Background of the proposed dissertation

The proposed study will conduct a secondary analysis of responses collected as part of exploratory formative research that took place between January and March 2017 in postpartum, HIV-positive women receiving PMTCT services at Gugulethu Community Health Centre in Cape Town, South Africa. A set of focus group discussions (FGDs) were held as part

of a larger pilot study to develop a smartphone application for postpartum HIV-positive women (The CAMPA study HREC REF 792/2016). The pilot study sought to develop a next-generation mHealth smartphone application that would serve as both a patient linking service and a mobility research tool to better address the healthcare needs of a mobile population. The primary objective of the FGD was to engage smartphone users to identify core design elements promoting the usability and acceptability of a mobile phone application. This proposed analysis will focus specifically on smartphone usage and preferences for future mobile phone applications.

Study Rationale

Because of the availability of cheaper smartphones and improved wireless broadband infrastructures in Africa, an opportunity has been presented for smartphones to be considered for strengthening PMTCT services and improving child and maternal health outcomes. Smartphone ownership and access is rapidly increasing, even in low-income settings (Poushter, 2016). It is therefore important for us to start planning potential interventions making use of this technology. Current mHealth programmes have mostly been limited to SMS based interventions, and data from low-income settings evaluating the potential of using smartphones to improve PMTCT and maternal health are limited. However, these are populations which should not be excluded from the potential benefit of smartphone based mHealth interventions.

The FGDs conducted contained questions that addressed smartphone use and preferences amongst HIV-positive postpartum women that could inform knowledge on acceptability of smartphone mHealth interventions in this population. However, data collected from the primary research has not been analysed or reported. This proposed secondary research will use these data to investigate current smartphone usage amongst postpartum HIV-positive women living in an urban South African township, which will inform future smartphone based mHealth interventions in this population. Additionally, studies evaluating perceptions, concerns and needs of this population for promoting adoption of smartphone mHealth interventions are scarce. The proposed study will explore women's experiences, concerns and preferences for mHealth messages. The work will create a knowledge base for future

efforts in developing impactful and patient-centred smartphone mHealth interventions for strengthening PMTCT services offered to HIV-positive postpartum women in low-income settings.

Aims and objectives of the study

Study aim

The principal aim of this study is to evaluate the potential for smartphone based mHealth interventions targeting HIV-positive postpartum women receiving PMTCT services in Cape Town.

Objective

The primary objectives are to describe patterns of smartphone use, internet connectivity as well as experiences and preferences for mHealth messages.

Research questions

Do patterns of smartphones usage, internet connectivity as well as experiences and preferences for mHealth messages among HIV-positive postpartum women living in low-income settings of South Africa create an opportunity for future smartphone based mHealth interventions aiming to improve retention and adherence to PMTCT services?

Sub-questions to be addressed:

- How do HIV-positive postpartum women generally use their smartphones?
- Are HIV-positive postpartum women familiar with smartphone applications? How do they connect to these applications on their mobile devices? What are their challenges in connecting to the applications?
- Are HIV-positive postpartum women familiar with an existing mHealth service, MomConnect? What are their experiences with MomConnect? What are their recommendations for ways to improve the service?
- Do HIV-positive postpartum women have interest in engaging with mHealth messages on their smartphones? What are their concerns in accessing messages on their devices? What is the women's preferred message content for future mHealth interventions?

We hypothesize that smartphone based mHealth interventions have a potential role in supporting PMTCT and maternal health and that they could be acceptable to HIV-positive postpartum women.

Methods

Study design

This secondary research will use transcripts from FGDs conducted during the formative work for a larger pilot study between January and March 2017. The strength of using a qualitative approach is to yield in-depth data of sufficient detail to create an understanding of phenomena and lived experiences. This depth of information is appropriate to address the research questions in this proposed study.

Study setting

The primary study took place at the Gugulethu Community Health Centre (GCHC), Cape Town, South Africa. The centre has a large primary level antenatal clinic that also provides PMTCT services that are based on the South African national guidelines (Myer et al., 2015). The facility serves an estimated population of 350,000, who are predominately black; Levels of unemployment are high with 60% of the community living in informal housing (Myer et al., 2015; Phillips et al., 2014). HIV prevalence among pregnant women is approximately 30% and MTCT rates at six weeks postpartum estimated at 2-4% (Myer et al., 2016). Disengagement from care within six months postpartum period was estimated at 32% in 2014 (Phillips et al., 2014). Smartphone ownership within this community is expected at 40-50%, an approximation based on the previously reported South African smartphone coverage of 42% (Poushter, 2016).

Study population

The study participants were adult (≥18 years) women who were HIV-positive and recently postpartum (<12 months since delivery) attending regular care at the primary study site, and who were using a smartphone.

Study procedures

The data for this secondary analysis will be taken from Participant and Smartphone Assessment form and FGD transcripts from the primary study. The procedures employed in the primary research to collect data are summarized below.

Recruitment

Respondents included in the primary study were recruited from postpartum women attending routine HIV care services at the GCHC. The women were approached by trained study recruiters and given brief information about the FGD. If they were interested they were screened for eligibility to ensure they were ≥18 years old, HIV-positive, <12 months postpartum and that they were using a smartphone. Those who were eligible and interested were invited to complete written informed consent (Appendix A) and enrolled into the primary study.

The Participant and Smartphone Assessment form

Following enrolment into the primary study, the staff completed the Participant and Smartphone Assessment form with each participant. The form did not collect any participant identifiers. The participant section collected information which allowed description of characteristics of those who participated in the focus groups including age, date of ART initiation, date of delivery, how long they have had their current phone and phone number, and how many phones they have had in the past two years. The smartphone information section was used to get a sense of the types of mobile phone women were using which could assist in future development of suitable applications for this setting. Information collected included either an International Mobile Equipment Identity number (IMEI) or phone manufacturer and model details, service provider and type of service.

Focus group activities

In total, 27 consented participants were enrolled into six FGD, each session lasting 45-90 minutes. The FGD were conducted in isiXhosa, the predominant local language, by a trained moderator fluent in the language, using the semi-structured FGD guide (Appendix B). The FGD took place in a private room at a community hall located near the GCHC.

Data analysis

All FGD were audio-recorded, and transcribed verbatim and translated from isiXhosa into English. The quality of the transcripts was checked by a second isiXhosa speaker. For the proposed analysis, transcripts will be coded in NVivo 11 (QSR International, Mary Victoria, Australia) software using both a priori codes and emerging themes. Code reports and matrices will be developed for major themes and patterns arising from the data. Data applicable to the objectives of this secondary analysis will be extracted for this study (Refer to questions: 1-11, 26, 28-30 on the FGD guide).

Human subjects protection

Ethics approval

The primary pilot study research protocol, consent forms and data collection tools were reviewed and approved by the Institutional Review Boards at Vanderbilt University and the University of Cape Town in South Africa in 2016. Documentation for approval of the primary study is included in Appendix C. All research activities occurred in South Africa and all procedures have conformed to U.S. and South African ethical standards for human subjects research. For the secondary research, no additional contact will be made with the participants.

Informed consent

All women who met the eligibility criteria and were interested in participating in the primary study provided written informed consent, which was available in English and isiXhosa. The consent form confirmed the eligible woman's understanding of the study procedures and her informed willingness to participate and for audio recording. The key messages of the informed consent process included: 1) a description of the study goals and procedures, 2) voluntary participation in the study, 3) that the study team cannot assure confidentiality from all participants in the FGD, 4) the right to withdraw at any time, and 5) the standard of care received at the GCHC will not differ according to participation in the study. Once the consent form had been explained to the participant, any questions she may have had were answered. If a woman did not wish to participate or did not provide her consent for all the activities, she did not sign the consent form and was not enrolled. A second copy of the

form was provided for her to sign and keep. The study staff who administered the form provided their name, signature and date as a witness to the signing. Signed informed consent forms are stored in binders within a locked office and are only accessible by study staff. For the purpose of this secondary analysis, no further informed consent will be required from the study participants, however primary investigators have been consulted for the use of data in the secondary research.

Privacy and confidentiality

The FGDs were conducted in a private room at a community hall close to the clinic, providing privacy as far as possible for all participants. No records will be used in this analysis that would reveal the identity of the participants. Participants were asked to choose a pseudonym (choice of colour) which was used throughout the FGD to protect their anonymity during the discussion; no names were used or recorded.

Furthermore, for this secondary research privacy and confidentiality will be protected in the following ways: 1) no participant will be identified in any report or publication; 2) all signed informed consent forms remain kept in a locked office; 3) data will be analysed collectively and individual participant data will remain anonymous.

Data safety

All audio files, transcriptions and study data have been stored on the University of Cape Town secure network drive and any files for transcription or review will be shared as password-protected encrypted files or through a secure file share program, such as UCT file sender or on the RedCap platform.

Potential risks

There is always the possibility of a breach of confidentiality when conducting research, however since this is a secondary research, there will be no direct contact with the study participants and thus posing a very low risk to the primary participants. The identity of the sample participants will remain anonymous during the research period. Participants are only identifiable by the selected study colour. Furthermore, all study staff and investigators,

including students, received training on ethics and confidentiality. Given the minimal risk, the potential benefit from the knowledge gained in the proposed study outweighs the potential risks.

Potential Benefits of the proposed research to human subjects and others

The information obtained in this study will provide valuable information for future design and implementation of interventions using smartphone technology and aiming to improve PMTCT and retention in care among HIV-positive postpartum women. The individual FGD participants are unlikely to experience personal benefit or harm from use of the primary data.

Participant remuneration

Following standards set by the University of Cape Town Research Ethics Committee, all FGD participants were reimbursed R150 in the form of cash and grocery vouchers for transport and missed opportunity costs. Reimbursement was made one time per participant following the FGD. No further reimbursement will be made to the primary participants for this secondary research.

Potential limitations

This proposed secondary research has a few limitations. Firstly, the sample size of the primary research of 27 was smaller than the anticipated 40 as stated in the original protocol. The FGDs were stopped when the emerging themes seemed to have reached saturation however this sample may not have captured all the experiences and perceptions of the target population. These data were collected from January-March 2017. We know the mobile phone landscape changes rapidly and findings may not be an exact reflection of the most current issues in this setting.

Time frame

Table 1. Time frame for dissertation activities

Time frame					
	Early May	May 2018	May 2018	May - June 2018	July 2018
Departmental and ethical approval					
Literature review					
Data analysis					
Manuscript write up					
Dissertation submission					

Dissemination

Given the defined objectives of this research project, the findings of the study are expected to inform future work aiming to strengthen current PMTCT programmes through mHealth interventions. Stakeholders who are likely to gain knowledge from these findings include but not limited to mHealth researchers, mHealth application developers, the South African Department of Health, health practitioners in HIV-related health care services and women receiving PMTCT services in South Africa. Results will also be presented at conference platforms and will be submitted to a peer-reviewed journal.

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PART B: STRUCTURED LITERATURE REVIEW

Introduction

Mother-to-child transmissions (MTCT) of HIV, which occurs during pregnancy, delivery, and the breastfeeding period, is most prevalent in sub-Saharan Africa (UNAIDS, 2010). Current prevention of mother-to-child transmission (PMTCT) guidelines recommend initiation of all HIV-positive pregnant women onto lifelong antiretroviral therapy (ART), ensuring that their infants remain uninfected and mothers stay in optimal health (World Health Organization (WHO), 2012). PMTCT steps that a mother usually navigates include uptake of antenatal care (ANC), maternal HIV testing and counselling (HTC), timely uptake of ART for HIV seropositive women, safe labour and delivery, and postnatal follow up of the mother-infant pair with sustained engagement in ART care for the mother and periodic HIV testing of the HIV exposed infant and timely infant ART initiation if required (UNAIDS, 2016; Vrazo et al., 2017). Adherence and retention through all these steps are necessary for both mother and child to experience the benefits of life-long ART (Doherty & Ciaranello, 2014). However, within many sub-Saharan African countries, poor ART adherence and retention along the PMTCT continuum of care hinders the attainment of the goals of eliminating MTCT and keeping mothers in optimal health (Centers for Disease Control and Prevention (CDC)., 2013; De Schacht et al., 2014; Phillips et al., 2014). Given that women in PMTCT are often faced with multiple patient and/or health system challenges that lead to their suboptimal engagement in care, it has become essential that innovative and patient-centred interventions are put in place to complement current PMTCT strategies (Bhardwaj, Carter, Aarons, & Chi, 2015; Gourlay, Birdthistle, Mburu, Iorpenda, & Wringe, 2013; Rotheram-Borus, Tomlinson, Swendeman, Lee, & Jones, 2012).

The United Nations (UN) and the WHO have recognized the use of mobile health (mHealth) technologies in health practice as a promising solution to provide effective and patient-centred care (Coleman, Bohlin, Thorson, Black, Mechael, Mangxaba, & Eriksen, 2017; World Health Organization, 2011). These technologies allow patients to have direct access to medical information, self-care skills, personal support, and crisis interventions for various medical conditions (Rotheram-Borus et al., 2012). The rapid growth of mobile phone use and availability of cheaper wireless broadband networks in sub-Saharan Africa has created an opportunity to use mobile phone technologies to address some of the existing challenges

in health care delivery (Betjeman et al., 2013; Pew Research Center, 2015). mHealth interventions are emerging as a potential solution for addressing PMTCT programmatic challenges. Several systematic reviews have found evidence of effective mHealth interventions to improve ART adherence and retention of pregnant and postpartum women in HIV care (Tamuzi Lukenze Jacques, 2016; Vrazo et al., 2017). However, short message service (SMS) technology remains the primary mode of delivering these interventions for PMTCT. One example includes MomConnect, a national mHealth text support service offered to pregnant women in South Africa (Barron, Pillay, Fernandes, Sebidi, & Allen, 2016). Given the rapid expansion of cellular network coverage and increasingly available cheaper smartphones in Africa, smartphone-based interventions may be appropriate in PMTCT. However, there is little evidence for the use of this technology to support the PMTCT continuum.

This dissertation "Smartphone usage and preferences among HIV-positive postpartum women" aims to evaluate the potential for smartphone-based mHealth interventions targeting HIV-positive postpartum women receiving PMTCT services in Cape Town. In order to inform this research, the current literature review seeks to evaluate the evidence on the uses of mobile phone-based interventions for improving service uptake and retention along the PMTCT continuum within sub-Saharan Africa. It will address the following objectives:

- Describe the evidence on the effectiveness of mobile phone interventions to address gaps in the PMTCT continuum of care within sub-Saharan Africa
- Synthesise the evidence on end-user (e.g. mother, health workers, etc.) perceptions and preferences regarding the use of mHealth interventions for improving the uptake and retention in PMTCT services

Methods

Search strategies

An electronic search for relevant peer-reviewd published literature on mHealth interventions and PMTCT service uptake and retention was conducted using PubMed and Google Scholar. The literature search strategy involved the use of search terms grouped into

four categories of interest: mHealth, PMTCT, HIV and geographic terms. The terms were combined with Boolean operators "AND" and "OR". The literature search was further extended to reference lists of identified articles and relevant systematic reviews to screen for other studies. The search strategies included combinations of key terms highlighted in Box 1.

Box 1: Search strategy

Mobile health: mHealth, mobile health, mobile phone, cellular phone, smart phone, smartphone, smart phone application, App, mobile applications, application, texting, text, text messag*, short messag*, SMS, short message service, Interactive Voice Response, voice call, reminder, cell phone

PMTCT: pregnancy, pregnant women, pregnan*, gestation, vertical transmission, child transmission, mtct, PMTCT, perinatal transmission, maternal, maternal health, child health, child*, infant*, baby, neonatal, newborn*, premature*, prenatal care, antenatal care, postnatal care, postpartum, postnatal OR antenatal

HIV: HIV, ART, antiretroviral therapy

Geographic: sub- Saharan Africa

Selection criteria

This review only included studies which took place in sub-Saharan African countries as these are the most likely comparable settings to the study population included in this dissertation. These included 48 countries defined according to the World Bank Classification (World Bank, 2015). No time restrictions on the literature were made, however, only papers written in English were considered. The detailed inclusion and exclusion criteria applied in the selection of the relevant articles are illustrated in Table 1.

Data extraction

The identified articles were initially screened for inclusion by applying the selection criteria based on their titles and abstracts. The remaining articles were reviewed based on the full text and only papers that complied with the above selection criteria were included. Studies were classified based on their mHealth application area in the PMTCT continuum, study

country, study design, mHealth technology used, and the population of focus. The following details were also extracted from each study: author, year, sample size, outcome measures, and study findings. A summary of study details and their key findings is provided in Table 2.

Table 1: The inclusion and exclusion criteria of the selected studies

Inclusion	Exclusion
Study Design: Comparative studies (E.g. cohort, case-control) Randomized and non-randomized controlled trial data Mixed methods studies Formative qualitative studies (surveys, focus group discussions)	Technical reports and reviews, descriptive case studies and case series, expert opinion, editorial discussions
Study setting: Applied in sub-Saharan Africa	Other regions
Study participants: Women in PMTCT programs, their partners or infants Health workers working along the PMTCT cascade	Other possible stakeholders
Intervention: mHealth-basic mobile phone or smartphone-based approaches delivered through either voice calls, text message through SMS, applications (Apps)	Telemedicine , and other eHealth implementation
Outcome measures: PMTCT service uptake, retention	
Language: Written in English	Non-English language papers
Publication status: All peer reviewed published data	Unpublished data, non-peer reviewed data
Date of publication: All dates	
Material availability: Full text	Non-full text material

Results

The literature search resulted in 26 articles, 23 from PubMed and three from reference searches of the identified articles. After applying the inclusion and exclusion criteria as well as screening the full text, 10 articles were excluded. Four of these were systematic reviews, two were protocols for ongoing studies, one represented methods on an ongoing research project, one article was inaccessible, and the other two focused on outcomes that were not relevant to the focus of this review. The remaining 16 papers were included in this review. Papers were published between years 2012 and 2018, with the majority of the publications appearing from 2015 onwards. Only six sub-Saharan African countries were represented by the articles, with most studies being conducted in Kenya (n=7) and South Africa (n=5). One study was identified from each of Malawi, Zambia, Nigeria, and Botswana. All studies utilized SMS and/or voice call interventions, and there were no studies that included smartphone-based interventions.

Quantitative findings

Table 2 shows ten intervention studies looking at the following PMTCT outcomes: Maternal retention (Coleman, Bohlin, Thorson, Black, Mechael, Mangxaba, & Eriksen, 2017; Finocchario-Kessler et al., 2014; Mushamiri, Luo, Iiams-Hauser, & Ben Amor, 2015; Mwapasa, Joseph, Tchereni, Jousset, & Gunda, 2017; Odeny et al., 2014; S R Schwartz et al., 2015), maternal ART initiation and adherence (Dryden-Peterson et al., 2015; Kassaye et al., 2016), infant HIV testing and transmission rates (Coleman, Bohlin, Thorson, Black, Mechael, Mangxaba, & Eriksen, 2017; Mushamiri, Luo, Iiams-Hauser, et al., 2015; Odeny et al., 2014; S R Schwartz et al., 2015), and infant ART initiation (Finocchario-Kessler et al., 2014; Sutcliffe et al., 2017).

Maternal ART initiation and ART adherence

Results on the impact of mHealth on maternal ART initiation and adherence were negative. Two studies using mobile phone interventions to improve maternal ART initiation amongst HIV-positive pregnant women found a non-significant effect compared to control (Dryden-Peterson et al., 2015; Kassaye et al., 2016). One study conducted in Botswana compared

the effects of an SMS-based CD4 result distribution system to a standard CD4 distribution procedure to health centers and found that, though the intervention significantly reduced the turnaround time to patient receipt of results, the intervention did not increase ART initiation in eligible pregnant women (Dryden-Peterson et al., 2015). The other study from Kenya assessed the effect of a combining gestation-based PMTCT SMS and increased communication between women and community health workers (CHW) on ART initiation in ANC as well as ART adherence at 34-36 weeks of gestation and delivery. The authors reported no significant difference in either ART initiation or adherence between the intervention arm and the control arm who were allowed to directly communicate with the CHW whenever they needed but did not receive any PMTCT SMSs (Kassaye et al., 2016). However, the same study found that within the concurrent period, regardless of study arm facilities enrolled in the study had achieved better ART initiation compared to other facilities in the region not enrolled in the study. Another study in a Nigeria offered women newly diagnosed with HIV a session of diagnosis acceptability and ART commitment therapy (ACT) and a weekly health promotion SMS for three months during pregnancy, and found improved psychological flexibility in women, hypothesised to improve ART uptake, but they did not link this specifically to ART initiation (Ishola, 2013).

Maternal retention

Almost all studies investigating retention found that the mHealth intervention improved maternal retention in care. The studies differed in the types of outcome definitions but most interventions used SMS reminders either aimed at the patient or CHW. Six studies compared standard care with SMS and/or voice call combination interventions that included reminders, laboratory result notification or health promotion messages to improve maternal retention in the PMTCT continuum (Coleman, Bohlin, Thorson, Black, Mechael, Mangxaba, & Eriksen, 2017; Finocchario-Kessler et al., 2014; Mushamiri, Luo, Iiams-Hauser, et al., 2015; Mwapasa et al., 2017; Odeny et al., 2014; S R Schwartz et al., 2015). One study in Kenya offered two-way text messaging and weekly calls to women during pregnancy and the postpartum period. This led to an increased number of women who attended their postpartum visit in the first eight weeks after delivery (Odeny et al., 2014). The second study, also in Kenya, found higher retention at ANC when they sent CHWs a reminder SMS

prompting them to visit women at their homes to alert them of their upcoming ANC visit (Mushamiri et al., 2015). The third study, conducted in South Africa, integrated automated SMS in the early infant diagnosis (EID) continuum which was sent to women upon availability of infant HIV test results and reported high retention in the EID continuum at 9 months compared to not receiving the intervention (Finocchario-Kessler et al., 2014). The fourth study in South Africa provided women attending ANC one-way maternal health information SMSs twice-weekly throughout pregnancy and up to one year postpartum. This study similarly reported improved ANC visit attendance (Coleman et al., 2017). In contrast to the other studies, a study in Kenya that sent SMS reminders to CHW to facilitate tracking of mother and infant pairs who missed their scheduled clinic visits, found no improvement on maternal retention at 12 months postpartum (Mwapasa et al., 2017). Similarly, a study in South Africa that offered HIV-positive women during late pregnancy motivational text messages and phone calls through a case manager until first six weeks of delivery, also reported no difference in retention at 12 months postpartum (S R Schwartz et al., 2015).

Infant HIV testing and infant transmission rates

Five studies evaluated the effect of using mHealth interventions on infant HIV testing and infant HIV transmission rate. Most reported improved outcomes with the mHealth intervention (Coleman, Bohlin, Thorson, Black, Mechael, Mangxaba, & Eriksen, 2017; Kassaye et al., 2016; Mushamiri, Luo, Iiams-Hauser, et al., 2015; Odeny et al., 2014; S R Schwartz et al., 2015). The study that offered Kenyan women a combination of tailored gestation-based SMS and weekly calls found higher rates of early infant HIV testing in the SMS group compared to the control group (Odeny et al., 2014). A second study in South Africa provided one-way maternal health SMS twice-weekly throughout pregnancy and for one year after birth and also reported high infant HIV testing rates within six weeks after birth (Coleman et al., 2017). A third study, also in South Africa, found that an intervention offering women a combination of SMS and voice call reminders through to six weeks postpartum increased infant testing rates during the intervention period compared to pre-intervention (S R Schwartz et al., 2015). Relating to infant HIV transmission rates, two studies evaluated the effects of SMS interventions on this outcome. A Kenyan study sent CHWs text messages to prompt them to remind women of their upcoming appointments

and found significantly lower HIV transmission rates at both 9 and 18 months postpartum in comparison those in the group not receiving the intervention (Mushamiri et al., 2015). The final study, also conducted in Kenya, offered 3-6 weekly, semi-automated stage-based SMSs, together with airtime, to women to facilitate an increased communication with PMTCT trained CHWs until their final 6-8 postpartum visit. They found no significant difference in either infant HIV testing rates or infant HIV transmission rates with this intervention (Kassaye et al., 2016).

Infant ART initiation

Two studies, one from Zambia and the other from Kenya, evaluated the effects of notifying mothers earlier of infant HIV test results through mobile phone interventions. Both aimed to have quicker infant ART initiation and both reported positive outcomes. (Finocchario-Kessler et al., 2014; Sutcliffe et al., 2017). The Kenyan study assessed the impact of faster laboratory result distribution through SMS technology to facilitate quicker result dissemination of HIV-infected infants to fast track their initiation on ART, and found that initiation had been reduced from 38 to 7 median days (Finocchario-Kessler et al., 2014). The other study in Zambia found that by offering mothers owning mobile phones the option of being contacted by study staff when their child's test results were available, infants in the intervention group were initiated on ART at a median of 66 days compared to the previous median of 101 days without the intervention (Sutcliffe et al., 2017).

Qualitative findings

The six qualitative studies (Table 2) used structured in-depth interviews or focus group discussions (FGDs) to assess acceptability, feasibility as well as user's views on the use of mobile phone interventions to improve PMTCT uptake and maternal retention in care (Clouse et al., 2015; Jennings, Ong Ech, Simiyu, Sirengo, & Kassaye, 2013; Musoke et al., 2017; Nachega et al., 2016; Ronen et al., 2018; van Heerden, Norris, Tollman, Richter, & Jane, 2013). Two mixed methods studies also reported qualitative components and are presented (Mushamiri, Luo, Iiams-Hauser, et al., 2015; S R Schwartz et al., 2015).

Feasibility of mobile phone interventions in PMTCT

Five studies evaluated feasibility of using mobile phone interventions for PMTCT activities, and reported on metrics: patterns of mobile phone usage and ownership, sustained mobile contact between health workers and participants, network coverage (Clouse et al., 2015; Jennings, Ong Ech, Simiyu, Sirengo, & Kassaye, 2013; Nachega et al., 2016; Schwartz et al., 2015; van Heerden, Norris, Tollman, Richter, & Jane, 2013). Studies in Kenya and South Africa assessed mobile phone ownership among HIV-positive pregnant women and found high mobile ownership in study settings (Clouse et al., 2015; Jennings et al., 2013; Nachega et al., 2016). However, there were contrasts in sharing practices across studies. One study in Kenya reported significant phone sharing among women and their partners, while a more recent study in Kenya and another in South Africa revealed low rates of mobile phone sharing among women (Clouse et al., 2015; Ronen et al., 2018).

In assessing patterns of mobile phone usage, women showed literacy for using SMS technology to communicate with mobile phones (Jennings et al., 2013; Nachega et al., 2016). Only one study assessed other mobile phone activities among women but reported low rates of internet and email usage with mobile phones (Clouse et al., 2015). Furthermore, work by Jennings et al. and Nachega et al. demonstrated that women had prior experience in using their mobile phones to execute health-related activities such as asking the health provider to call them back when they needed assistance (Jennings et al., 2013; Nachega et al., 2016). Another study from Kenya similarly assessed health providers' patterns of phone use and found that CHWs and nurses were less likely than the participating women and their partners to share their mobile phones. However, they had also used their mobile phones for health-related matters, particularly in communicating health information relating to patients between each other (Jennings et al., 2013). A study in South Africa reported the high feasibility of case manager facilitated mobile interventions by finding sustained mobile phone contact between study participants and case managers throughout the study period (Schwartz et al., 2015). Finally, another South African study reported high feasibility of a mobile phone-assisted data collection intervention because of good network coverage found in study clinics (van Heerden et al., 2013).

Acceptability of mobile phone interventions in PMTCT

Several studies evaluated acceptability of mHealth interventions, and overall reported high acceptability of the interventions by women in PMTCT as well as partners and health workers (Musoke et al., 2017; Nachega et al., 2016; Ronen et al., 2018; Schwartz et al., 2015; van Heerden et al., 2013). High acceptability was reported for: 1) the mobile phone-assisted personal interview intervention for collecting maternal and child data along the PMTCT continuum; 2) case manager facilitated SMS and voice call motivational intervention among HIV-positive pregnant women; 3) direct SMS interventions to support women's ART adherence and retention in care (Musoke et al., 2017; Nachega et al., 2016; Ronen et al., 2018; Sheree R Schwartz et al., 2015; Van Heerden, Norris, Tollman, Richter, & Jane, 2013) . Participants thought interventions would have higher acceptance if they engaged couples jointly and also created an opportunity for in-personal consultations with health workers (Jennings et al., 2013; Musoke et al., 2017).

Facilitators to intervention usage

Overall, participants in the qualitative studies thought having the interventions would offer them motivational, emotional and educational support, encourage communication between health workers and patients, encourage communication between couples, offer other educational information important for their well-being, as well as remind them to adhere to treatment and appointments (Mushamiri et al., 2015; Musoke et al., 2017; Schwartz et al., 2015). For health workers, benefits cited included ability of intervention to facilitate timely reminders for patient clinic visits, improved efforts to tracking patients and the added benefit of building relationships between patients and health workers (Jennings et al., 2013; Mushamiri et al., 2015; Musoke et al., 2017; van Heerden et al., 2013).

Barriers to intervention usage

These studies also identified barriers to use of mobile phone interventions. Participants across several studies expressed concerns about unintended disclosure, lack of guaranteed confidentiality and privacy (Musoke et al., 2017; Nachega et al., 2016; Ronen et al., 2018; van Heerden et al., 2013). Participants in a Kenyan study that was evaluating ART adherence were concerned that other people would find out about their HIV status, especially because

some women had newly been diagnosed (Nachega et al., 2016). Participants included in a study assessing women's preference between overt and covert HIV-related messages showed that women would accept overt messages when there was a low risk for status disclosure. But others, including those who shared their phone, preferred covert messages (Ronen et al., 2018). For participants that took part in the mobile-phone assisted interviews, unfamiliarity with mobile phone technology capabilities increased fears that their privacy might be invaded (van Heerden et al., 2013). For women who had not disclosed to their partners, their concerns were related to potential conflict if their status was disclosed unintentionally to their partner (Musoke et al., 2017). Other challenges cited included lack of electricity to charge mobile phones and occasional network failure which could delay access to messages (Jennings et al., 2013; Mushamiri et al., 2015; Musoke et al., 2017).

Similar concerns noted by patients that were also cited by health workers. These included unintended disclosure between partners, lack of electricity for charging devices, previous experience in a failure of network coverage (Jennings et al., 2013; Mushamiri et al., 2015). Other concerns were a lack of a verification system to check if messages were received by intended recipients as well as difficulties using the intervention as designed if the health workers were not adequately trained to use the technology (Musoke et al., 2017; van Heerden et al., 2013).

Intervention design and content preferences

Included studies revealed inconsistencies in user preferences based on language, timing, frequency and message content. A study in South Africa found English to be the language of preference while women in a study in Kenya showed interest in having an option to choose the language of preference within the intervention (Jennings et al., 2013; Schwartz et al., 2015). Two studies in Kenya highlighted variations relating to women's preference for message frequency. For some they thought there would be benefit from more contact while others thought to receive more messages would lead to intervention fatigue and preferred to receive messages only once a week (Jennings et al., 2013; Musoke et al., 2017).

The study that evaluated the potential of an intervention to promote male partner involvement for PMTCT highlighted gender-based variations in intervention preferences (Jennings et al., 2013). The study showed that the preference differences also depended on whether couples were sharing mobile phones or whether the phone owner would be traveling. For content, the male partner participants preferred messages that covered issues relating to family pride and community recognition as a male role model. They also suggested the intervention to come with an option to share received messages with other male friends (Jennings et al., 2013). For women, there was a high preference for HIV treatment adherence messages, however, with a further interest in receiving integrated health messages that were individually-tailored, used neutral language, and also allowed a two-way interaction (Jennings et al., 2013; Musoke et al., 2017; Nachega et al., 2016; Ronen et al., 2018). Overt HIV-related messages were preferred only when there was a low risk of status disclosure (Ronen et al., 2018). Phone calls were preferred for conversations that required longer discussions while SMS interventions were thought to be appropriate for short and private messages (Jennings et al., 2013)

Relating to timing, one study showed that women preferred receiving messages either early in the morning or at night when they would be in possession of the mobile phone and could ensure only they would see the message (Musoke et al., 2017). For the mobile phone assisted data-collection intervention, women mostly preferred to have the interviews conducted in a side-by side position rather than sitting across the interviewer as it allowed them to see what was being captured and assured them that they were not being filmed during the data collection process (van Heerden et al., 2013).

Health workers recommended that messages should reinforce the importance of face-to-face counselling rather than replacing this counselling with mobile technology. They also preferred for messages to focus on encouraging clinic visit adherence and to have treatment adherence addressed in-person at the clinic visit (Jennings et al., 2013; Musoke et al., 2017). In addition, health workers felt interventions should motivate male partner and community involvement to encourage better retention of women in PMTCT services (Musoke et al., 2017).

Ongoing studies

Three articles about ongoing research in this field were identified. One study from Kenya will conduct an unblinded, triple-arm randomized clinical trial (RCT) of a one-way versus two-way gestation-based motivational SMS interventions with aims to improve maternal ART adherence and retention in care by two years postpartum (Drake et al., 2017). Another study will be a two-arm open RCT, also in Kenya, that will enrol women at their first ANC visit and similarly follow them through 24-months postpartum. In this study, participants will receive an interactive weekly SMS and based on the response by the participant, a PMTCT nurse will be prompted to follow-up on any indications of problems. The primary outcome will be infant retention in care by quantifying the number of infants testing for HIV at 24 months from delivery (Awiti et al., 2016). The most recent protocol is a randomized pilot trial, taking place in South Africa, which evaluates the feasibility of a conducting a larger pilot study that will assess the effectiveness of an interactive weekly text message plus motivational interviews to improve adherence to breastfeeding by HIV-infected women. The aim of the intervention is also to improve ART adherence by offering women access to personalized adherence advice and support (Zunza, Cotton, Mbuagbaw, Lester, & Thabane, 2017).

Discussion

Availability of evidence on the use of mobile phone interventions for PMTCT service uptake and retention is growing, however, to our knowledge, there are no studies to-date in sub-Saharan Africa assessing smartphone-based interventions in the context of PMTCT and maternal ART. Findings presented here from the available evidence using non-smartphones are promising. This literature review identified 10 quantitative studies assessing interventions, of which six reported effectiveness in using mobile phone interventions to improve various outcomes along the PMTCT continuum. Specifically, interventions targeted maternal ART initiation, maternal visit attendance along the PMTCT continuum, early infant HIV testing and early infant ART initiation. In addition, six qualitative studies were identified which assessed acceptability, feasibility and user perceptions and preference for mobile phone interventions for ART adherence, maternal retention as well as maternal and infant

data collection along the PMTCT continuum. Most studies were fairly recent, suggesting a growing interest in this field in the last few years.

Consistent with prior reviews, all studies included in the current review were assessing potential of SMS and/or voice call based interventions, with no evidence for smartphone interventions (Ambia & Mandala, 2016; Geldsetzer et al., 2016; Vrazo et al., 2017). As cheaper smartphones are increasingly becoming available and network coverage rapidly expanding across most parts of sub-Saharan Africa, this has created an opportune time for researchers to assess the potential of this technology for addressing gaps existing within PMTCT services. However, even after expanding the literature search to include studies from other parts of the world, there was still no evidence of studies assessing smartphone-based interventions for PMTCT. Findings are consistent with those from a review that sought to synthesize uses of smartphone technology in addressing HIV care continuum which found gaps in literature around linkage to care, retention in care, and initiation of ART within diverse HIV care programs (Muessig, Nekkanti, Bauermeister, Bull, & Hightow-Weidman, 2015). This suggests a global research gap for data that could show the appropriateness of using smartphones in PMTCT and warrants a need for future evaluations. Expanding this evidence base will inform future practice in the development of impactful smartphone-based interventions as this technology becomes widely available in sub-Saharan Africa, and will further prevent delays in intervention scale-up. MomConnect, although not PMTCT specific, is a national text-message service in South Africa, available to all pregnant and postpartum women. It sends stage-based messages through pregnancy and up to one year postpartum with the aim to improve overall maternal and child health. This review did not identify evidence of smartphone usage in PMTCT activities, however MomConnect has recently expanded towards offering their services through WhatsApp (a smartphone messaging application) as a way to reduce costs related to using SMS technologies as well as to allow flexibility in message content (Peter, Benjamin, LeFevre, Barron, & Pillay, 2018). Overall, this evidence highlights the need for future studies to address gaps in understanding the potential suitability of smartphone-based interventions to support the PMTCT continuum within the diverse populations in the sub-Saharan African region.

Quantitative studies included in this review suggest that mobile phone interventions targeted for PMTCT can improve maternal retention in ANC and early postpartum, infant HIV testing rates, reduce infant transmission rates and improve infant ART initiation (Coleman, Bohlin, Thorson, Black, Mechael, Mangxaba, & Eriksen, 2017; Finocchario-Kessler et al., 2014; Mushamiri, Luo, Iiams-Hauser, et al., 2015; Odeny et al., 2014; S R Schwartz et al., 2015; Sutcliffe et al., 2017). Though inconsistent effects of mHealth interventions for maternal retention and early infant HIV testing rates were observed, the majority of individual studies on these outcomes are promising. Results also reinforced findings of earlier reviews that suggested that mobile phone interventions were effective to improve maternal retention in PMTCT and uptake of early infant HIV testing (Ambia & Mandala, 2016; Geldsetzer et al., 2016; Tamuzi Lukenze Jacques, 2016; Vrazo et al., 2017).

Findings from this review agree with those from a previous review that found that improved retention did not persist over time along the PMTCT continuum (Ambia & Mandala, 2016). The two negative studies included in this review were measuring maternal retention at later time points of the PMTCT continuum, while the positive studies measured retention in ANC and early postpartum. This suggests that the short-term effectiveness of retention interventions may not necessarily guarantee their impact in the long-term. In addition, women may experience different needs at various stages of the PMTCT continuum that may require different interventions. Rigorous research is needed to assess effects of interventions over longer time periods and to explore facilitators and barriers of interventions aiming to support long-term retention of the women on ART.

Consistent with a previous review, findings from two studies showed that mobile phone interventions did not increase maternal ART initiation (Tamuzi Lukenze Jacques, 2016). One possible reason for the Kenyan study finding could be that the way the study was designed which made it difficult to tease out the effect offered by the SMS component. Future studies should consider evaluation of each intervention separately to be able to draw conclusions about the impact of different components on maternal ART initiation, adherence or infant HIV transmission rates (Kassaye et al., 2016). Results from Botswana showed that SMS-

based CD4 result distribution interventions were not effective in improving ART initiation in ART-naive pregnant women, but when a similar intervention was assessed for infant ART initiation results were positive (Dryden-Peterson et al., 2015; Sutcliffe et al., 2017). This may suggest that faster result dissemination may not be sufficient to get women rapidly initiated on ART and that women may require additional interventions to address other barriers that hinder ART uptake. Future studies should consider other complementary interventions to ensure that benefits offered by mHealth interventions in facilitating the faster availability of HIV resulting would result in successful linkage to ART (Geldsetzer et al., 2016). For example, as was done in the study from Nigeria, upon receiving diagnoses women could simultaneously be offered ACT messages that might assist women in understanding the importance of early ART initiation and help them to stay adherent when initiated on treatment (Ishola, 2013). Previous reviews have reported an evidence gap for studies that assessed ART adherence in pregnant and breastfeeding women, however, the one study identified in this review is the Kenyan study that introduced two interventions concurrently making it difficult to make conclusions about the individual components (Chaiyachati et al., 2014; Kassaye et al., 2016; Tamuzi Lukenze Jacques, 2016). Overall, the findings show that further research is needed to evaluate the effects of mobile phone interventions on maternal ART initiation and maternal ART adherence and retention. Additional evidence can be expected as results of the ongoing studies become available.

Qualitative studies included in this review found an overall high acceptability of SMS-based interventions for improving maternal ART adherence, maternal retention as well as the use of mobile phones for collecting maternal and infant data along the PMTCT continuum (Musoke et al., 2017; Nachega et al., 2016; Ronen et al., 2018; Schwartz et al., 2015; van Heerden et al., 2013). Acceptability of interventions was highlighted in studies that targeted HIV-positive women in PMTCT services, their partners as well as healthcare workers. The major benefit cited across studies was the ability of interventions to facilitate communication and lasting relationships between women and their partners as well as with healthcare workers (Jennings et al., 2013; Musoke et al., 2017). This finding is consistent with prior reviews that have indicated the importance of social support in successful ART adherence and retention of women in PMTCT (Govindasamy et al., 2014). Furthermore, an

earlier review had shown that male partner involvement in PMTCT significantly reduced infant HIV transmission (Ambia & Mandala, 2016). Findings from this review suggest that mobile phones may be acceptable to facilitate male partner involvement to support PMTCT outcomes (Jennings et al., 2013; Nachega et al., 2016). Given that studies were representing Kenyan and South African experiences, there is a need for research in other settings to assess the generalisability of such interventions.

A prior review has demonstrated that CHWs can be effective in increasing service uptake and retention of HIV-positive mothers and their infants in PMTCT programs, and this review found similar results (Vrazo et al., 2017). Studies in this review have highlighted the vital role that can be played by CHW in complementing and maximizing successes of mHealth interventions to improve PMTCT service uptake and retention along the PMTCT continuum. Studies revealed the potential of CHWs to facilitate access of health messages to women who may not be able to access the messages directly, for example where women do not own a phone or are sharing phones with other family members. An example is the study that used CHWs to link women with SMS reminders for upcoming visits (Mushamiri et al., 2015). CHWs may facilitate improved engagement in PMTCT services by tracking women's progress along the PMTCT continuum, which was found to be acceptable to both the women and CHW (van Heerden et al., 2013). Alternatively, where male involvement interventions are not appropriate, CHW could stand in as the support system needed to enhance women's engagement with PMTCT services, and these could be in a form of offering women motivational, educational and emotional support (Coleman, Bohlin, Thorson, Black, Mechael, Mangxaba, Eriksen, et al., 2017; Kassaye et al., 2016; Mushamiri, Luo, Iiams-hauser, & Amor, 2015; Musoke et al., 2017; S R Schwartz et al., 2015).

Overall, the high feasibility of mobile interventions was suggested in evidence of high mobile phone ownership, high SMS literacy, prior experience in using a phone for health-related activities, reports of high network coverage and high perceptions of intervention usefulness(Clouse et al., 2015; Jennings et al., 2013; Nachega et al., 2016; Schwartz et al., 2015; van Heerden et al., 2013). Important barriers highlighted across most studies included concerns with disclosure, lack of guaranteed confidentiality and privacy, access to electrical

power to charge mobile phones and unfamiliarity with technology (Jennings et al., 2013; Musoke et al., 2017; Nachega et al., 2016; Ronen et al., 2018; van Heerden et al., 2013). These barriers highlight groups of women that may not have equitable access to the benefits offered by proposing mobile phone interventions, highlighting the ethical considerations when developing mobile phone interventions for PMTCT. Lack in electricity has previously been shown to affect uptake of mobile phone interventions and thus highlights a need for extensive feasibility studies in different settings to ascertain the availability of supporting technology and infrastructures to create the opportunity for equitable access to interventions by all women in PMTCT services (Brinkel, Krämer, Krumkamp, May, & Fobil, 2014; Van Velthoven, Brusamento, Majeed, & Car, 2013). Another important barrier that might affect uptake includes perceived ease of use and usefulness of the intervention due to unfamiliarity with the technology. One study evaluated potential for mobile-phone assisted data collection and found both ease of use and perceived usefulness improved after health workers were trained (van Heerden et al., 2013). This suggests the need for adequate training of users to ensure that acceptability of interventions and to ensure they are optimally used to achieve intended outcomes.

This review found evidence of formative studies that sought to evaluate both the effectiveness of interventions as well as user preferences for intervention design and content. This information is critical for the design of appropriate interventions that could have an impact on improving service uptake and retention along the PMTCT continuum. There was no consensus across studies relating to user preference in message content, the form of mobile phone contact, timing, frequency and language. However, the most prevalent suggestions were for the needs for interventions to ascertain maintenance of user privacy. Interventions should also offer two-way text messages that are neutral and tailored to content, timing, and frequency while offering a wide variety of health topics to support healthy living with HIV. Findings are consistent with those found in a meta-analysis that was done on RCTs evaluating SMS interventions for improving ART adherence in people living with HIV (Finitsis, Pellowski, & Johnson, 2014). Understanding the context in which an intervention will be implemented will be important to inform the design of acceptable and relevant interventions to support needs of women in different PMTCT settings.

Limitations

In this review, the definition of mHealth was narrowed to the applications of basic mobile phones and smartphones for service uptake and retention along the PMTCT continuum. Other mobile devices including tablets, patient monitoring devices, personal digital assistants, and other wireless devices, telemedicine devices were excluded (World Health Organization, 2011). This criterion could have missed other valuable information on applications of mHealth technology in PMTCT and maternal HIV care. The majority of the studies were conducted in South Africa and Kenya, with only five other countries represented in one study each. Results of this review should be generalised to other settings with this in mind and specific contexts must be considered. Further, literature searches were limited to PubMed, Google Scholar and reference lists of identified articles, other possible sources with relevant studies conducted in other sub-Saharan Africa countries may have been overlooked.

Conclusion and further research

This review indicates that mobile phone interventions can be effective in supporting various points along the PMTCT continuum and are highly acceptable for use in sub-Saharan African countries. The majority of available evidence for applications and acceptability comes from Kenya and South Africa and the strongest evidence exists for SMS and/ or voice call based technologies. Future research should evaluate the applicability of smartphone-based interventions on service uptake and maternal retention along PMTCT continuum with considerations for the entire sub-Saharan Africa context, as no one intervention would be appropriate to cover the needs of all settings. Research could focus on the effectiveness of interventions, user characteristics (e.g. end-user perceptions of use smartphone-based intervention for PMTCT as well as preferences intervention design and content preference) together with the technological aspects. Further research is required to evaluate smartphone and other mHealth interventions and to address known patient barriers affecting the uptake and retention of women along each point of PMTCT continuum.

Given the gaps identified by this review, this proposed research aims to evaluate the potential for smartphone-based mHealth interventions targeting HIV-positive postpartum women receiving PMTCT services in Cape Town by describing the patterns of smartphone use, internet connectivity as well as their experiences and preferences for mHealth messages. Evidence gained will inform future work aiming to strengthen current PMTCT programs through mHealth interventions.

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Table 2 Characteristics of included studies and summary of findings

First Author, Year, Country	Sample	Study type	Intervention studied and tools used	Outcome measures	Key study findings
Quantitative studies					
Mushamiri, 2015, Kenya	176 HIV-positive pregnant women attending ANC and CHW	Cohort	SMS reminders sent to CHW who visited the expectant mother in her home to remind her of an upcoming appointment	Uptake of ANC services Vertical transmission rates CHW and women's perceptions about the intervention	Higher retention in ANC for women receiving intervention compared to women in the comparison group MTCT rate at 18 months in control arm was 9%, compared to MTCT rate of 0% at both 9 and 18 months in intervention arm
Coleman 2017, South Africa	821 HIV-positive pregnant women attending ANC	Retrospective cohort	Free SMS to ANC patients, providing one-way, twice-weekly, maternal health information sent throughout pregnancy and for one year after birth	Retention in ANC Infant HIV testing rates Birth outcomes for HIV-positive women and their infants	Improved ANC visit attendance Increased chance of a normal vaginal delivery and a lower risk of delivering a low-birth weight infant High infant testing rates within six weeks after birth as well as a lower mean infant age in weeks
Schwartz, 2015, South Africa	50 HIV-positive pregnant women in ANC and 50 women of similar eligibility who received care pre-intervention	Pre/post Cohort study	Motivational SMSs and telephone calls through a case manager until six weeks delivery	Intervention acceptability and feasibility HIV testing rates in infants by 10 weeks of birth Maternal retention in care at 12 months postpartum	High acceptability of the interventions No improvement in retention due to the intervention Higher infant HIV testing rates by 10-weeks of birth in presence of the intervention than prior the intervention
Kassaye, 2016, Kenya	HIV-positive women 280 intervention arm vs 270 in the control arm	Cluster-randomized controlled	3-6 weekly semi-automated stage based SMS, airtime and communication with CHW throughout the study period	ART uptake and adherence in ANC Infant HIV testing rate Vertical transmission rate	No significant difference in outcomes between the compared groups within study facilities Higher ART uptake and adherence in study facilities compared to non-study facilities within the concurrent period

Table 2 (continued)

First Author, Year, Country	Sample	Study type	Intervention studied and tools used	Outcome measures	Key study findings
Odeny, 2014, Kenya	388 HIV-infected pregnant women with PMTCT:195 women in SMS group and 193 in control group	Parallel-group, unblinded, RCT	Combination of tailored gestational-based SMS (8 pre-delivery and 6 postpartum) and weekly calls vs usual care	Postpartum retention Infant HIV testing	Improved maternal postpartum visit attendance Both study arms achieved high early infant HIV testing rates, but higher testing rates in the SMS infants compared to the control arm
Finocchario-Kessler, 2014, Kenya	523 HIV-infected mothers together with their HIV exposed infants in EID continuum	Prospective Observational	SMS alert sent to mothers on availability of infant test results	Retention in EID continuum Result notification turnaround time ART initiation turnaround time	High retention in EID at 9 months Reduce turnaround times for outcomes Increased ART initiation in HIV infected infants
Sutcliffe, 2017, Zambia	119 HIV-infected mothers together with their HIV exposed infant pair	Prospective Observational without comparison group	CD4 result distributed through SMS from lab clinic Mobile phone, text or voice calls to report Availability of infant HIV test results	Mobile phone ownership Result notification type preferred (text vs health care center)	The majority of the mothers consented to receiving a mobile phone notification when the results were available 50% reduction in time between clinic result delivery and dissemination to the mother Quicker infant ART initiation with intervention than without the intervention.
Dryden-Peterson, 2015, Botswana	366 HIV-infected pregnant women in PMTCT	Stepped wedge cluster random trial	CD4 testing support SMS based CD4 distribution Airtime to staff to call patients to initiate ART	CD4 test 26 weeks in gestation Time between clinic CD4 collection and result receipt ART initiation before 30 weeks of pregnancy	Rapid and efficient CD4 result delivery due to SMS-based platform The cost of the SMS platform was cheaper for CD4 distribution than standard delivery method No improvement in time to antenatal CD4 testing or maternal initiation to ART

Table 2 (continued)

First Author, Year, Country	Sample	Study type	Intervention studied and tools used	Outcome measures	Key study findings
Ishola, 2015, Nigeria	144, HIV-positive pregnant women in PMTCT	RCT	Weekly ACT messages for 3 months	Psychological flexibility overtime	Substantial advance in psychological flexibility after the ACT intervention
Mwapasa, 2017, Malawi	1350 HIV-positive pregnant women	Three arm Cluster RCT	SMS reminders to CHW to facilitate tracking of mother and infant pair	Retention of mother- infants in elimination of MTCT (eMTCT) care at 12 months after delivery	No observed improvements in retention rates of mothers and their HIV exposed infants in eMTCT care at 12 months after delivery
Qualitative studies					
Clouse, 2015, South Africa	20 HIV-positive pregnant women in ANC	Semi-structured interview	Text message intervention	Mobile phone use Internet and Email use	Feasibility of mobile phone interventions, but Internet and email-based interventions not yet suitable
van Heerden, 2013, South Africa	12 mothers living with HIV (FGD) 512 mothers living with HIV (RCT)	Structured interviews	Mobile phone-assisted personal interviews to track progress within PMTCT continuum	Acceptability Feasibility	High acceptability and feasibility of mobile phone intervention for collecting mother-infant pair health data Slight concerns around confidentiality and privacy
Jennings, 2013, Kenya	45 participants: HIV-positive women in PMTCT, together with their male partners, CHWs, and nurses	Focus groups and in-depth interviews	Gender-tailored SMS to support PMTCT	Mobile phone usage Perceived benefits and challenges Design and content of gender-tailored SMS	High access to a mobile phone Perceived benefits: allowed linkage with health workers, protection of confidentiality, and receiving reminders and other information Perceived challenges: Lack in guarantee for privacy, charging the phone, uncertainty in reception of messages by the intended recipient Gender-tailored messages were considered as motivating male involvement in PMTCT and communication between partners

Table 2 (continued)

First Author, Year, Country	Sample	Study type	Intervention studied and tools used	Outcome measures	Key study findings
Ronen, 2018, Kenya	87 HIV-positive peripartum women	FGDs	SMS to support ART adherence	Acceptability Perceptions on SMS intervention Desirability of HIV-related content SMS content preference	Overt HIV-SMSs preferred when possibility for status disclosure was small Preference for interventions that would permit for participant's choice of HIV-related content while still preventing unwanted disclosure
Musoke, 2017, Kenya	20 HIV-positive pregnant/post-partum women, together with their male partners n=20, and 30 health care providers	Partner-matched individual interviews; 4 FGDs for care providers	SMS intervention for supporting ART adherence and retention for women in care	Acceptability Perceived benefits and challenges Design and content preferences	High acceptability intervention Perceived benefits: encourage ANC service uptake and likely to strengthen patient–provider relationship, also supported by HCP Perceived challenges: undesired status disclosure and possible disagreements amongst couples, lack of access to a reliable electrical source to charge mobile phones Preference for both partners to be informed about the intervention as well as for consent be requested from both Preferred messages: combination of ART adherence and other HIV-related health messages, and supportive messages for healthy living with HIV HCP recommendation: Messages should only promote clinic visit adherence and should not be treatment specific

Table 2 continued

First Author, Year, Country	Sample	Study type	Intervention studied and tools used	Outcome measures	Key study findings
Nachega, 2016, South Africa	n=20 (FGD) and n=109 (interview) HIV-infected, pregnant women	Cross-sectional FGD and Structured interview	SMS text messaging for ART adherence	Acceptability of SMS Access to mobile phones SMS usage	High mobile phone access and cell phone literacy The women were interested in receiving messages for promoting ART adherence as well as support messages received in a form of motivation, reminders and drug updates Preference for tailored reminders

PART C: MANUSCRIPT

Smartphone usage and preferences among postpartum HIV-positive women in South Africa

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The authors declare no conflicts of interest.

[1] The article meets the requirements set out in the Instructions for Authors for *AIDS CARE* journal. As per the MPH dissertation guidelines, co-authors and their contributions are noted in the acknowledgments section of this dissertation. The *AIDS CARE* Instructions for Authors are included in Appendix E of the dissertation.

Abstract

In South Africa, HIV-positive women receiving antiretroviral therapy (ART) often are lost to care postpartum; strategies to support long-term engagement are needed. Mobile health (mHealth) interventions are emerging as a possible solution for supporting long-term engagement in the prevention of mother-to-child transmission (PMTCT) of HIV care continuum. In order to explore acceptability and feasibility of mHealth interventions in this context, we conducted focus group discussions (FGDs) to assess trends in smartphone usage in postpartum women. In six FGDs, we interviewed 27 HIV-positive, postpartum women who attended regular care at the Gugulethu Community Health Centre in Cape Town, South Africa, and who use a smartphone. Questions assessed the respondent's general trends in smartphone use, as well as their exposure to and perceptions of mHealth interventions. We found little turnover in phones and phone numbers, and about half the participants shared their devices with family and friends. Respondents reported high familiarity with smartphone applications, including WhatsApp, Facebook, YouTube, and Twitter, with WhatsApp as their preferred method of smartphone communication. Data bundles were most often used to connect to the internet, motivated by the perception that data bundles last longer and are cheaper than airtime, but respondents were adept at locating Wi-Fi sources at work or other public spaces. Nearly all participants were familiar with MomConnect, a national mHealth text support service in South Africa, and most described it positively. Respondents expressed interest in future HIV mHealth applications including complementary health information on physical activity, nutrition, mental health and basic social services. Participants were active and engaged smartphone users with reliable internet connections and a positive attitude towards mHealth platforms. Future mHealth interventions show promise in this population.

Keywords: smartphone; mobile health; mHealth, HIV/AIDS; pregnant; postpartum

Introduction

In 2012, the World Health Organisation (WHO) recommended that HIV-positive pregnant women initiate life-long ART irrespective of their CD4 count, a policy known as Option B+ (Odeny et al., 2014; UNICEF, 2012; World Health Organization (WHO), 2012). This approach is endorsed for accelerating progress in eliminating new vertical HIV infections and improving maternal health outcomes, and the importance of ART adherence is emphasised for both the antenatal and postpartum phases (Gopalappa, Stover, Shaffer, & Mahy, 2014; Nachega et al., 2012; UNICEF, 2012). Some studies have shown a trend of disengagement in care and ART non-adherence during the postpartum period (Clouse et al., 2014; Myer & Phillips, 2017; Psaros, Remmert, Bangsberg, Safren, & Smit, 2015). There is an urgent need for innovative and patient-centred interventions to strengthen current PMTCT strategies and improve postpartum engagement in HIV care (Bhardwaj, Carter, Aarons, & Chi, 2015; Rotheram-Borus, Tomlinson, Swendeman, Lee, & Jones, 2012).

In recent years, a growing body of evidence has explored the use of mHealth technology in HIV and maternal and child health (MCH) (Jennings, Ong Ech, Simiyu, Sirengo, & Kassaye, 2013; Laflamme, 2017; Lee et al., 2016; Odeny et al., 2014; Watterson, Walsh, & Madeka, 2015). However, most studies have focused on short message service (SMS) text-based interventions (Coleman et al., 2017; Joseph-Davey, Ponce, Augusto, Traca, & de Palha de Sousa, 2013; Musoke et al., 2017; Nachega et al., 2016; Odeny et al., 2014; Schwartz et al., 2015). A notable example is MomConnect, offered by the South African Department of Health since 2014, which enrols pregnant women in antenatal care (ANC). MomConnect sends SMS-based information throughout pregnancy and facilitates requesting additional pregnancy-related information (Department, 2014; Fölster, 2017). The mobile landscape is changing quickly in South Africa with readily-available cheaper smartphones, and less expensive wireless networks, yet few studies have reported smartphone usage patterns and preferences among HIV-positive populations in sub-Saharan Africa (Betjeman, Soghoian, & Foran, 2013). Additionally, there is a lag in impact data from available mHealth tools aimed at supporting the continuum of MCH (Cargo, 2013; Watterson et al., 2015). Studies of acceptability and user-perception of mHealth-based interventions in postpartum HIV positive women within sub-Saharan African settings are also limited (Coleman et al., 2017). Within this context, we explored the acceptability and feasibility of smartphone based

mHealth interventions among HIV-positive postpartum smartphone users in Cape Town, South Africa.

Methods

Study Setting

This study was conducted at a large primary healthcare facility located outside of Cape Town, South Africa. The facility predominately serves a black African population with substantial poverty, high levels of unemployment, and with 60% of the community living in informal housing (Myer et al., 2015; Phillips et al., 2014). ART services are integrated with ANC during pregnancy and the study site provides antenatal, obstetric and postpartum services to over 4000 women annually; antenatal HIV prevalence is 30% (Myer et al., 2015, 2016) Disengagement from care within six-months postpartum is approximately 32% (Phillips et al., 2014).

Study participants and design

From January–March 2017, we conducted six FGDs with 27 women. Women were recruited from existing studies using convenience sampling, and each participant only joined one FGD. Adult (≥18 years) women who were HIV-positive, recently postpartum (<1 year) and using a smartphone – defined here as a mobile phone with a touchscreen interface and internet access – were eligible.

Ethical considerations

Participants provided written informed consent for FGD participation and audio recording. Privacy and confidentiality in a FGD setting was discussed in the informed consent. All activities were approved by the human research ethics boards of Vanderbilt University and the University of Cape Town.

Data collection

Basic participant characteristics were collected at enrolment. FGDs had 2-8 participants and lasted 40-120 minutes. Discussions were conducted in isiXhosa, the predominant local language, by a trained moderator using a pre-designed facilitation guide and were audio recorded. During the FGDs, participants were identified using different colours to protect

confidentiality. Open-ended questions explored current smartphone usage and mobile app preferences, modes and perceived challenges in mobile connectivity, and opinions on MomConnect and future mHealth interventions.

Data Analysis

The coding, analysis, and reporting of qualitative data was completed by following the COREQ guidelines, an evidence-based qualitative methodology (Tong, Sainsbury, & Craig, 2007). The focus group sessions were transcribed verbatim and translated to English. Transcripts were uploaded on NVivo 11 (QSR International, Victoria, Australia) qualitative data analysis software. We used a deductive approach to create a framework for analysis by identifying codes using research questions (Pope, Ziebland, & Mays, 2000). Data were analysed by grouping text into themes. Text under each theme was then examined for convergent and divergent patterns, concepts and associations; themes were further deflated into main themes and sub-themes. We extracted relevant quotes from the text to illustrate findings. For quantitative data, we provide medians and interquartile ranges (IQR).

Results

Participant characteristics

Median participant age was 30 years (IQR: 23,34), time on ART was 16 months (IQR: 11,51), and time since delivery was seven months (IQR: 2,9). Median time with the current smartphone was 15 months (IQR: 8,24), and women reported having the same mobile number for a median of 48 months (IQR: 24,84).

Overall smartphone usage

Participants reported internet, social media, emails, and camera as the top reasons for using a smartphone, noting they could send and receive messages quickly, save on cell phone operation costs, easily access multifunctional smartphone applications, and conveniently access the internet.

> *"The reason I use a smartphone is that I can easily access anything so I do not need to go to the internet café. Because, like, you send emails from home, all you need is data then you are sorted. It gives you access to social media."* [Maroon, FGD 6]

Most reported that their friends also used smartphones, and for similar reasons.

"My friend…most of the time she likes perhaps to go out and boast to me so she believes in taking photos and likes to send me pictures to show me what her weekends are like…So, it is easy for her to take photos, but if she was having a 'tilili' [standard phone] she wouldn't be able to take photos." [White, FGD 5]

"Most of my friends are using smartphones for WhatsApp because when… airtime runs out, it is easy to communicate by WhatsApp and Facebook. The other thing with a smartphone you can go to a place even if you don't know where it is, it directs you…GPS." [Red, FGD 1]

Participants were split nearly evenly on the issue of sharing smartphones. Sharing occurred most commonly with immediate family members. Privacy concerns related to sharing a smartphone with a boyfriend were raised, but sharing with husbands was noted.

"No, I don't share. Mine is having a password and I am the only one who knows it." [White, FGD 2]

"I don't share my phone with other people…what is on the phone is mine. Facebook is mine, WhatsApp is mine, messages are mine, numbers on the phone are mine." [Green, FGD 4]

"I do share whenever someone asks to use my phone. Maybe their phone has problems and they wanted to use WhatsApp." [Black, FGD 4]

"I share with my family my phone; the person I don't share my phone with is my boyfriend." [Purple, FGD 1]

"I share my phone with my husband, especially Facebook and WhatsApp." [Blue, FGD 1]

Familiarity with smartphone applications (Apps)

Participants showed high familiarity with smartphone applications; WhatsApp was reported as the most popular application and the preferred method to communicate on smartphones, rather than making voice calls.

"I only like WhatsApp…there is no other thing besides WhatsApp." [Yellow, FGD 2]

"Say we are going to do an event…maybe have a group…we organize through our WhatsApp." [Blue, FGD 3]

After WhatsApp, Facebook was the most widely reported app, followed by YouTube and Twitter. Only two of the 27 participants reported never using smartphone Apps.

"My friends are using it and I don't; WhatsApp and Facebook they are using them...I use it to send SMS and phoning only." [Red, FGD 2]

Voice calls were noted for use when communicating with those who use basic phones, particularly older family members who may not be acquainted with the technology of smartphones.

"I connect by WhatsApp, because WhatsApp is cheaper than phoning, but when I phone my father, my father doesn't have WhatsApp. I phone him, and other people who don't have smartphones, I SMS." [Red, FGD 1]

"I like to use phone calls because mostly I like to call elderly people who don't understand WhatsApp." [Gold, FGD 1]

Internet connectivity

Nearly all respondents reported purchasing data bundles as their primary method of accessing the internet on their smartphones. The use of a combination of data bundles and airtime for internet surfing was less frequently noted. Data bundles were preferred over airtime because they were cheaper and perceived to last longer.

"Airtime does not last at all, so it is better to use data bundles." [Maroon, FGD 6]

"I cannot survive without data bundles." [Black, FGD 6]

Some of the respondents reported also using Wi-Fi from their workplaces or from available public Wi-Fi hotspots in places such the mall and local restaurants.

"I buy bundles but when I am at work I use Wi-Fi." [Black, FGD 4]

"If I go to the mall I will locate the Wi-Fi hot spots, such as KFC, and sit for two hours." [Black, FGD 6]

"I use data or airtime and then when I am in the area with free Wi-Fi, I close my data and use Wi-Fi." [Yellow, FGD 5]

"I use data bundles because Wi-Fi is difficult to find unless you got it in your house or workplace." [Maroon, FGD 6]

Many participants noted cost savings associated with communicating via WhatsApp using inexpensive data, compared to airtime for phone calls and text messaging.

"When you have data and don't have airtime, you can make a call on WhatsApp." [Black, FGD 1]

"For WhatsApp, I buy R8.50 worth of data for a month…If I was using airtime, I would have to buy more airtime than that." [White, FGD 2]

Some participants suggested that if they did not have airtime or data bundles, they would easily borrow a smartphone device from friends or family members.

"In my case, if I don't have data and don't have airtime, I borrow a phone from someone who has data at home and do what I want to do." [Orange, FGD 1]

In addition to internet access, respondents reported battery life as a frequent limitation to connectivity, especially in informal settlements where electricity may not be readily available to charge their devices.

"We are staying at [informal settlement] with no electricity. To have electricity, you charge in other areas with electricity sometimes." [Red, FGD 5]

Knowledge and perceptions of MomConnect

Most women reported some level of familiarity with the text service MomConnect offers, from both first-hand experience, and having heard about the services at a certain point in time.

"*I had heard about MomConnect and then…while I was also pregnant last year I got a number there, sometimes the number is outside your booklet and enter those digits, even now I am still getting SMS's from them on what must you do when your child is crawling, when he is having diarrhoea, what must you give him, things like that."* [Black, FGD 1]

"I heard about it here, at the clinic...they tell you that when the baby is in this stage what you must do and when the baby is in this situation what must you do...It is where they explain to you about your pregnancy and after you gave birth." [White, FGD 3]

Nearly all of the participants reported having positive opinions about MomConnect, but still felt there was a lot that could be done to improve the services.

"MomConnect helps a lot; it's encouraging in a lot of things...Sometimes it tells you that when you feel certain pains, go to the clinic…It gives you information." [Red, FGD 5]

"[*The] messages were very helpful to me in things related to high blood pressure – on how dangerous is it – so I had the information."* [Green, FGD 3]

However, some women reported inconsistency in receiving the messages after registering with MomConnect.

> *"In my case…I think I got it while I was two weeks pregnant and then I was told three times what I must do about my pregnancy…I don't [know] what happened after that…I have never received any SMSs again."* [Pink, FGD 1]

When participants were asked how to improve MomConnect, most indicated the need to choose a preferred language to receive messages in, so as to prevent language barriers. Participants also highlighted the need to correctly register the women's gestational age at registration so that messages received correspond with their actual stage of pregnancy, hence tailoring messages to a woman's individual pregnancy experiences and needs.

> *"Their messages are late. If only when you are registering there could be something saying 'how many months are you pregnant' so that they could know that you had a child this month, so that your messages won't be late or early."* [Red, FGD 1]

> *"They must send SMS's written in Xhosa, not English only because other people don't understand English, they cannot even read it."* [Black, FGD 1]

> *"My baby is a premature, so their messages are counting with my months that I was supposed to give birth, whereas he has been here long ago."* [White, FGD 3]

Others reported wishing for a two-way interaction with MomConnect. Participants felt that the MomConnect services were characterised by uni-directional flow of information that did not offer them a platform to ask more personalised questions.

> *"I think they give us good information; the only thing is that we also would like to ask questions because in most cases they are the ones who are talking, so you are left with question mark and on the day you go to the clinic, you have forgotten it because maybe the time has long passed."* [Pink, FGD 3]

> *"In WhatsApp there is 'WhatApp call.' Maybe when you want to talk with someone or you need counselling…maybe have a calling side where you can make calls or landline which you can call when you need help."* [Black, FGD 1]

Attitudes towards future mHealth interventions

Most participants expressed interest in receiving health information using their smartphone, because of the convenience of having the information readily available in an electronic format.

"It would be nice because we lose the pamphlets…and you lose out on the important information about your baby's diet, for example." [Maroon, FGD 6]

"It would be nice because some of us do not have enough knowledge. So, I would like it." [White, FGD 6]

When asked about the type of health-related messages they would prefer accessing from mHealth initiatives, respondents suggested that, in addition to HIV-related information, messages should include complementary health information on physical activity, child nutrition, mental health, domestic violence and basic social services. The variability of responses suggested for future mHealth initiatives suggests that participants recognised that health is a social aspect that should be addressed holistically. Women expressed a particular need for assistance accessing child-grants and social services.

"Children's nutrition, because other people seem like they get confused on how to feed the children. A person would feed the child yoghurt for the day and would think that the child is full. Yoghurt it is a snack, not food for the child." [Yellow, FGD 2]

"If they could maybe, let's say, have programmes like sports…We are [HIV] positive people so most of the time we are staying in the houses... [but if an app] said 'in a certain hall we are having a certain programme at a certain time,' we would be doing exercises for HIV-positive people just for fun so that they don't keep on thinking such things and their blood doesn't stand in one place." [Red, FGD 5]

"I would say the counselling thing is important because [a] person doesn't get enough. When she hears that she is HIV positive, she goes to the clinic and [is] counselled, but doesn't get enough and [she] doesn't know what she can do. So at least even if there can be an app sometimes she can talk with maybe [someone] who can she tell." [Pink, FGD 1]

"I am thinking that 'child sexual abuse' could be added on because the children are raped out there and other children are secretive and in most cases, it happens here at home." [Blue, FGD3]

"Explain how do you get a birth certificate and where." [Yellow, FGD 2]

Discussion

These findings show that mHealth interventions have potential to support PMTCT services in this setting. Postpartum, HIV-positive women attending care in a public clinic in Gugulethu,

South Africa, reported being active and engaged users of smartphones and were highly amenable to mHealth interventions. Respondents confidently engaged popular smartphone applications – particularly WhatsApp – and reported few connectivity difficulties.

Data bundles were overwhelmingly cited as the main source of internet connection, given their lower cost than airtime. The high internet usage in this population was different from the low internet usage previously reported amongst pregnant women in a study conducted in Johannesburg in 2013. However, the same study did predict an increase in internet use in future years as internet-enabled phones became more affordable (Clouse et al., 2015). The perceived affordability of data bundles is consistent with reports of steady declines in data prices, as well as the emerging data usage explosion in African countries (Ericsson, 2016). Participants were also familiar with alternative wireless internet sources (Wi-Fi), which they accessed at work and other public spaces. This is consistent with reports showing that South Africa and other low- and middle-income countries (LMIC) are investing in improved wireless infrastructures as well as faster transmission speed (Ericsson, 2016; Rotheram-Borus et al., 2012; World Health Organization, 2011). Expanded connectivity enables people from diverse economic backgrounds to access affordable internet options, and highlights the opportunity for mHealth interventions in populations within lower-income settings. However, researchers may still need to assess the availability of such infrastructure outside of a peri-urban setting like ours.

Participants' responses of occasional lack of electricity for charging smartphones are consistent with those found in a qualitative study conducted in Kenyan HIV-positive peripartum women, who cited a lack of electricity as a potential barrier to an mHealth intervention (Musoke et al., 2017). Smartphone-based interventions pose an added burden on daily battery consumption and researchers should be aware of this challenge, particularly in rural areas and informal settlements, where electricity scarcity may hinder equitable access to the benefits offered.

Most participants had previously received health-related text messages through MomConnect, and found the messages as useful for addressing their pregnancy-related needs, emphasising potential acceptability of similar mHealth interventions. One participant

said she could not understand the messages as they were delivered in English, instead of isiXhosa. However, MomConnect offers all 11 South African languages (Barron et al., 2018). Similarly, complaints were lodged about the timing of messages. Although MomConnect is designed to target messages to specific gestational time points, if the gestation is not correctly specified at enrolment these messages will not be stage appropriate. This demonstrates the misconceptions that can arise when users are not efficiently trained to effectively use mHealth tools, and also potential shortcomings of MomConnect's system. We suggest providers consider providing support to users to ensure a better user experience, as well as to ensure the sustainability of the interventions. Many participants emphasized the importance of two-way interaction on smartphones, whether with friends on WhatsApp, or with a health facility on MomConnect.

Participants expressed willingness to engage future general health-related messages on their devices to enhance their knowledge, noting the convenience of accessing the messages whenever needed. Messages providing information on child nutrition, mental health, domestic violence, as well as social services available in their community were most commonly requested. Participants suggested that integration of these different topics within a single application would offer an opportunity to address their concurrent health challenges, and again stressed the need for person-to-person interaction.

This study had several limitations, including a population limited to postpartum women attending a single health facility and who used smartphones. We acknowledge the findings may not be generalizable to women who never attended the clinic or do not use smartphones. While smartphone ownership and usage preferences may vary in other settings, smartphone use is increasing rapidly and we sought to explore user behaviour in this setting to inform future interventions. Further research is needed to quantify the penetration of smartphones in other low-income areas. While the sample size was small, it was appropriate for drawing rich information on experiences, perceptions and needs during the FGDs.

Conclusion

This study provides novel insights into smartphone use as well as perceptions and preferences of smartphone-based messages for HIV-positive women in low-income settings. Despite the rising availability of smartphones, inexpensive data, and public Wi-Fi which allows users in low-resource settings to access smartphone applications and on-demand information, studies of smartphone use and preferences in low-income settings are lacking. Our results show that HIV-positive, postpartum women from a low-income, peri-urban community in South Africa who have access to smartphones are engaged and active users of the technology who support the development of integrated, interactive mHealth interventions in this population. Further research is needed to assess the feasibility and potential impact of mHealth interventions in this and other low-resource settings.

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PART D: APPENDICES

Appendix A: CAMPA study HREC renewal letter

UNIVERSITY OF CAPE TOWN

FACULTY OF HEALTH SCIENCES
Human Research Ethics Committee

FHS016: Annual Progress Report / Renewal

HREC office use only (FWA00001637; IRB00001938) This serves as notification of annual approval, including any documentation described below.			
☐ Approved	Annual progress report	Approved until/next renewal date	
☐ Not approved	See attached comments		
Signature Chairperson of the HREC		Date Signed	29/1/2018

Comments to PI from the HREC

Principal Investigator to complete the following:

1. Protocol information

Date (when submitting this form)	15 Jan 2018		
HREC REF Number	792/2016	Current Ethics Approval was granted until	
Protocol title	Focus group discussions to explore mobile phone usage and preferences among postpartum HIV-positive women in South Africa		
Protocol number (if applicable)			
Are there any sub-studies linked to this study?	✓ Yes ☐ No		
If yes, could you please provide the HREC Ref's for all sub-studies? Note: A separate FHS016 must be submitted for each sub-study	HREC REF 227/2017		
Principal Investigator	Ms Tammy Phillips		
Department / Office Internal Mail Address	Office 5.38 Level 5 Falmouth Building		

1.1 Does this protocol receive US Federal funding?	✓ Yes	☐ No

(Note: Please complete the Closure form (FHS010) if the study is completed within the approval period)

Appendix B: Secondary study HREC approval letter

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E53-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6626
Email: shurella.thomas@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

16 May 2018

HREC REF: 325/2018

Ms Tamsin Phillips
Epidemiology and Biostatistics
Level 5, Office 5.38
Falmouth Building

Dear Miss Phillips

PROJECT TITLE: SMARTPHONE USAGE AND PREFERENCES AMONG POSTPARTUM HIV-POSITIVE WOMEN IN SOUTH AFRICA (MPhil-candidate- P Mogoba) SUB-STUDY LINKED TO 792/2016

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30 May 2019.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

The HREC acknowledge that the student, Pheposadi Mogoba will also be involved in this study.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

HREC 325/2018

Appendix C: CAMPA Informed Consent form V1.0

TITLE OF RESEARCH: **Focus group discussions to explore mobile phone usage and preferences among postpartum HIV-positive women in South Africa**

WHAT IS THE PURPOSE OF THIS STUDY?

We are researchers from the University of Cape Town and Vanderbilt University. You are being invited to take part in a voluntary study that is being conducted at the Gugulethu Community Health Centre. This document is to help you decide if you would like to participate. The purpose of this study is to gain knowledge about women's opinions about a potential smartphone application and their own mobile phone usage

Applications, or "apps", are programmes like Facebook and WhatsApp that run on a smartphone. We are in the process of developing a smartphone app that we hope would link women to new antiretroviral therapy (ART) facilities while they travel. This app is still in development and we would like to ask your opinion about what you might like it to look like and offer as features.

You are being asked to take part in this study because you are HIV-positive, recently postpartum, use a smartphone and receive care at the Gugulethu Community Health Centre. The purpose of this consent is to give you information to help you decide if you want to take part in this study.

WHAT DO I HAVE TO DO IF I AGREE TO TAKE PART?

If you agree to take part, you will be asked to do the following:

- Complete a short participant and smartphone assessment.
    - This assessment will collect your age, date of ART initiation and date of your most recent delivery. It will ask a few questions about your mobile phone usage, what type of phone you have and what service provider you use. We will also ask for the model number of your phone. This information is to help make sure the application we develop will be suitable for smartphones used in this setting.
- Participate in one focus group discussion, with up to 9 other women.
    - The focus group discussion will last approximately one hour.
    - The discussion will be guided by up to two facilitators and aims to understand cell phone use for yourself and your community and what existing mobile phone applications there for pregnant/postpartum HIV-infected women. We want to understand what you think would be most useful in an application which could assist you in finding an ART clinic if you needed to travel out of Gugulethu.
- The discussion will be digitally recorded to ensure accuracy. You will be given a code to identify yourself during the discussion and you real name will not be used on any recordings or documents.
- All recordings and study documents will be kept in a locked office with the digital files destroyed one year after study completion.

WHAT ARE THE POTENTIAL RISKS?
While most of the questions we ask are not personal in nature, we will ask for your frank input on your experiences and there are no right or wrong answers. Although every effort is made to ensure confidentiality, the focus group discussion will include up to ten participants. We will ask that everyone keep the discussion to themselves but we cannot assure confidentiality from other participants. You may refuse to answer any question that you do not want to answer and you can withdraw from the study at any time. Should you feel sad or down during or after your focus group discussion and would like to talk to someone, our counsellor or nurse counsellor will consult with you. If you are still feeling upset, we will refer you to additional psychological services. Should you require assistance accessing HIV/ART care, we will also refer you to the appropriate services.

WHAT ARE THE POTENTIAL BENEFITS?
There is no direct benefit to you if you take part in this study. The information gained in this study may help develop a smartphone app that offers a benefit to mobile women.

WHAT IS THE ALTERNATIVE TO TAKING PART?
The alternative to taking part in this study is to continue to receive regular care at the Community Health Centre without participating in this research study.

WHAT ABOUT CONFIDENTIALITY?
If you agree to take part, all information collected during the study will be kept strictly confidential. Your name will not be used in connection with any information that is collected as part of the study.

Your name will only appear on this signed consent form, which will be stored in a locked filing cabinet. Only study staff will have access to these materials. All staff involved in data collection and management will get specific training in confidentiality.

There will be up to ten participants taking part in the focus group discussions. Everyone will be asked to keep the discussion confidential but the study team cannot assure you that all participants will maintain confidentiality.

Even with these procedures in place, if the study staff learns that you are a risk to yourself or someone else or of possible child abuse and/or neglect, study staff will tell the proper authorities.

WILL I BE GIVEN ANYTHING FOR TAKING PART?
You will receive R150 in the form of cash and grocery vouchers for your time and transport reimbursement.

ARE THERE ANY COSTS?
There is no cost for being in this study.

CAN I LEAVE THE STUDY?
Yes. Participation in the study is fully voluntary. You have the right to decide not to take part in the study, to refuse to answer any questions, or to withdraw from the study at any time without any penalty. It will have no effect on the care that you receive at the Gugulethu Community Health Centre or any other health facility.

DO YOU HAVE ANY QUESTIONS?
If there is anything that is unclear or if you need further information, please ask us and we will provide it. Do you have any questions?

FOR ADDITIONAL INFORMATION:
If you have any questions or have any problems while taking part in this research study, you should contact:

Dr Landon Myer
School of Public Health and Family Medicine
Faculty of Health Sciences, University of Cape Town
Tel: 021 406 6661
Email: Landon.Myer@uct.ac.za

Dr Kate Clouse
Vanderbilt Institute for Global Health
Vanderbilt University
Nashville, TN, USA
Tel: +1 615 875 9814
Email: kate.clouse@vanderbilt.edu

If you have any questions about your rights as a research participant, you may contact the following member of the ethics committee, an independent committee to help protect the rights of research participants:

Prof Marc Blockman
Chair, Human Research Ethics Committee
Faculty of Health Sciences, University of Cape Town
Tel: 021 406 6338

Vanderbilt University Human Research Protection Program
Tel: +1 615 322 2918

CONSENT STATEMENT:
I have read this form, or someone has read it to me. I have been offered a copy of this consent form. I was encouraged and given time to ask questions. I agree to be in this study. I also provide consent for audio recording of the focus group discussion. I know that after choosing to be in this study, I may withdraw at any time. My being in the study is voluntary. I understand that whether or not I participate will not affect my health care services received today, or at any time in the future.

Please indicate your consent with your signature.

Volunteer's name _____

_____
Signature of Volunteer Date

Staff member's name_____

_____
Signature of study staff Date

If the volunteer is unable to read or write the entire counselling process must be observed by an independent witness who can then confirm the procedure once the she has given consent.

Fingerprint of volunteer:

Witness:
I confirm that I am independent of the study and that I witnessed the entire informed consent counselling process in the home language of the volunteer
Name: _____

Signature: _____

Date: _____
Thank you.

Appendix D: CAMPA FGD interviewer guide V1.0

Focus Group Discussion Guide

Introduction

Welcome, thank you for joining us today. Today we are going to talk about some ideas for a new application we would like to develop for cell phones. When we say application, we mean programmes on your smartphone like Facebook and WhatsApp. Today we will describe our idea and ask for your thoughts.

We will ask you some questions but there are no right or wrong answers. We are interested in your thoughts and experiences.

General Use of Smartphones

To start the discussion, let's talk about phones. All of you here today use a smartphone. When I say smartphone, I mean a mobile phone that includes advanced functionality beyond making phone calls and sending text messages. Most smartphones have the capability to display photos, play videos, check and send e-mail, and surf the Web.

1. Why do you use a smartphone?

2. Do most of your friends use smartphones?

    - Why do you think you friends use smartphones?

3. Do you share your phone with anyone? Think about your sisters and friends.
    - How common do you think it is that women share their phone?

4. What is the main way that you stay in touch with people on your phone? Is it by placing calls, sending SMSs, Facebook, WhatsApp, or something else? What do you like about that?

General use and understanding of Apps

Are you all familiar with what I mean by "app"? That is a short version of "application" and refers to programs on your phone like Facebook, WhatsApp and others.

5. What are some apps that you like?
    - What do you like about them?

6. When you want to use apps and the internet on your phone, what do you do to connect?
    - Do you buy a data bundle?
    - Do you just use regular airtime?
    - Do you connect over wifi?
    - What do you prefer?

7. How often do you wish that you could use an app on your phone, but you can't because you don't have data?
   - What do you do?

8. Do you ever have trouble getting service on your phone?
   - How do you resolve this problem?

9. Have you ever heard of MomConnect?
   - [IF YES, ask questions 10 and 11]

10. When you were recently pregnant, did you receive MomConnect messages?
    - How did you feel about these messages?

11. If you were going to improve the MomConnect programme, what would you suggest?

The New App

The application we would like to develop would help to connect women who travel to ART clinics in the new area. For example, if a woman returns to the Eastern Cape after giving birth and stays for a few months, she could open the app on her phone and look up a new ART clinic.

12. What do you think about using a cell phone app to look up other ART clinics?

13. Would you want to do this? Why or why not?

We also could design the app to send a notification when you are traveling away from your home. Using our earlier example of the woman who goes from Gugulethu to the Eastern Cape, she could get a pop-up notification on her phone letting her know that ART clinics are nearby.

14. What do you think of sending notifications to people who travel to let them know about nearby ART clinics?

15. Should the notification come as a text message or as an alert at the top of her phone? Something else?

16. How long should the woman be away from her home in Gugulethu before she is sent a message?

17. How far (in km) should she have traveled away from Gugulethu before she receives a notification message?
    - Should she be still in/out of Cape Town, Western Cape or South Africa?

18. How often should the app send notification messages?

19. Should the notification make a noise?

20. Is there a particular time of day or night the app should send the notification?
    - Or do you want to set the time yourself?

21. Would you want to receive such notifications? Why or why not?

22. What concerns would you have about receiving messages about nearby ART clinics?

The last feature of the app would be invisible. It would use the phone's GPS, or mapping ability, to follow the movement of the person holding the phone. We would like to do this to better understand how women travel around the time of pregnancy and how they access care. In our example, we would be able to tell that the woman has traveled to the Eastern Cape because the phone would record her general location coordinates. When I say general, I mean that we could tell the town or village she's in, but not the specific building, because that is not of concern to us. We as researchers then would use that information to describe how women who use the app travel around and why they may not return to care in Gugulethu.

23. What do you think about a cell phone recording location so that researchers can use it?

24. Would you want your phone to share your location with researchers? Why or why not?

Now that you have an idea of the app we would like to build

25. What do you think we should name such an app?

26. Are there any privacy issues that concern you with the app we have described?

27. Would you like this app to be available in English, isiXhosa or both?

28. Do you have other concerns about using the app?
    - Data usage, battery life etc.

The first phase of the app that we're designing will just focus on helping women find new ART clinics. However, in the future, we may expand this to offer other services on your smartphone.

29. What type of health or public service information would you like to receive on your smartphone?
    - Probe (if not mentioned): How about health or nutrition information? What do you think about that? What would you like to receive? How would you like to receive it?
    - Probe (if not mentioned): How about access to social grant offices? What do you think about that?
    - Probe (if not mentioned): How about mental health offices? What do you think about that?
    - Probe (if not mentioned): How about domestic violence services? What do you think about that?

30. Do you have any suggestions of things we should add to this app?

APPENDIX E: *AIDS CARE* instructions for Authors

Instructions for authors

Thank you for choosing to submit your paper to us. These instructions will ensure we have everything required so your paper can move through peer review, production and publication smoothly. Please take the time to read and follow them as closely as possible, as doing so will ensure your paper matches the journal's requirements. For general guidance on the publication process at Taylor & Francis please visit our Author Services website.

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References

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