Assessment of Design and Implementation Attributes of mHealth Interventions: A Systematic Review

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Abstract: Usage of mobile phones in achieving health objectives (mHealth) has greatly increased in Sub-Saharan Africa. This is based on the premise that mHealth interventions improve the reach and quality of healthcare services. This systematic review examined mHealth intervention designs and implementation strategies and assessed their effect on interventions' outcomes. Major databases and grey literature were searched for relevant studies using main search terms 'mHealth' and 'Africa'. The search was restricted to articles published from 2010 to 2020. Only studies evaluating effectiveness of non-internet based communication services available on mobile phones such as text messaging, voice messaging and voice calling were eligible for inclusion. After screening, eleven studies were included in this systematic review. The review demonstrated that; i) mHealth interventions in Sub-Saharan Africa are mostly effective, ii)Weekly text medication reminders without additional motivational or health education information are significantly more effective, iii)Tailored and personalised health promotion text messages are significantly more effective, iv)Interactivity and messaging automation do not significantly improve effectiveness of mHealth interventions and, v)Use of behaviour change theories does not consistently improve effectiveness of mHealth interventions. Short text messages and tailored messages have more potential for successful mHealth interventions. Health promotion interventions could leverage the use of these attributes to enhance the reach and quality of healthcare services.

Keywords: mHealth, Health Promotion, Mobile phones, Design attributes, Effectiveness.

1. Introduction

The public health sector in Sub-Saharan Africa (SSA) is beseeched by a multitude of problems cumulating into inadequate reach of healthcare services to the population (Afriyie et al., 2019; Ahmat et al., 2022). The region shoulders the highest burden of disease (Abbafati et al., 2020). Communicable diseases in SSA are still a major public health concern while non-communicable diseases are on the rise (Bygbjerg, 2012; Modjadji, 2021; Peer, 2015). Considering this, achieving the Sustainable Development Goal no. 3 of ensuring healthy lives and promoting well-being for all by 2030 (United Nations, 2016) remains a tall order for SSA. This highlights the need for innovations in healthcare delivery systems in SSA. mHealth, defined by the WHO as "the use of mobile and wireless devices to support the achievement of health objectives (Rehman et al., 2017) presents a vital tool for health promotion. mHealth interventions have been shown to improve the reach and quality of healthcare services around the world (Gleason, 2015). In SSA, there are many examples of both effective mHealth interventions which have been scaled-up to national levels (Hopkins, 2015; Levine et al., 2015) and others which have not delivered as expected (Betjeman et al., 2013). These mHealth interventions have provided valuable insight into feasibility and effectiveness of mHealth interventions in resource poor settings. While feasibility and effectiveness of mHealth interventions are being analysed through experimental, reviews and analysis studies (Hall et al., 2015), the authors' preliminary literature search found no systematic review (SR) or meta-analysis that examined design attributes and implementation strategies of mHealth interventions. This lack of research in this area was best exposed by Hall et al. (2015,) who commented that "we found limited evidence across the population of studies and reviews to inform recommended intervention characteristics" (Hall et al., 2015, para. 1). They recommend that "research is needed to …..... identify recommended intervention characteristics" (Hall et al., 2015, para. 1). This SR therefore, assessed intervention designs and implementation strategies of mHealth interventions and their effects on interventions' outcomes.

2. Objectives and Significance of the SR

2.1 Objectives of the SR

The SR was aimed at identifying design and implementation variables of mHealth interventions and infer their effects on interventions' outcomes.

2.2 Significance of the SR

This SR helped pool together design and implementation attributes of mHealth interventions which are critical for success. By referring to these attributes, mHealth intervention designers will be informed by attributes that have been shown to be effective. It is hoped that this will help them in designing effective mHealth interventions.

3. Methods

This SR was conducted and is reported following the Preferred Reporting Items for Systematic Reviews and Meta–Analyses (PRISMA) guidelines (Liberati et al., 2009).

3.1 Literature Search Strategy and Study Inclusion Criteria

To identify all relevant literature, a systematic search was conducted in three stages. The first stage involved searching for relevant published studies in eight electronic databases (CINAHL, PubMed, Web of Science, mHealth evidence, Google scholar, Global Index Medicus, ClinicalTrial.gov and African Journals Online). Main search terms used were 'mHealth' and 'Africa'. The search was expanded using MeSH and thesaurus terms of the main search terms and directed by Boolean operators 'OR' and 'AND'. Table 1 below shows the full search input used in the databases.

Table 1: *Search Input*

mHealth OR m-Health OR eHealth OR e-Health OR telemedicine OR tele-medicine OR (mobile health) OR sms OR (short message service*) OR (text messag*) OR telehealth OR tele-health OR (mobile phon*) or cellphon*	AND	Africa OR (Sub-Saharan Africa) OR (Sub Saharan Africa) OR (low income countr*) OR (low in-come countr*) OR (developing countr*)

Second stage of literature search involved searching for grey literature on WHO and K4Health websites. In addition, clinicaltrials.gov was searched for recently completed unpublished trials. Third stage of literature search involved manual screening of reference lists of all potential papers which were reviewed in full. All papers which cited these potential papers were also screened for relevancy. After every stage of literature search, the results were imported into RefWorks bibliography citation software for duplicates exclusion. To avoid selection bias, two authors screened all identified studies against the full inclusion criteria. Any differences were discussed by all the two authors and decision taken accordingly. Table 2 shows inclusion and exclusion criteria and figure 1 presents a flow diagram of the literature search and screening process

Table 2. *Inclusion & Exclusion criteria*

Parameter	Inclusion criteria	Exclusion criteria
Language	English only	Not in English
Time	2010 – 2020	Before 2010
Mode of communication	Non-internet based communication services available on mobile phones such as text messaging, voice messaging and voice calling	Internet based communication services such as social media and multimedia Messaging Services (MMS)
ICT equipment used in trials	-Cell phones / Mobile phones -Smart phones	-Tablet, Laptop and desktop computers -Personal Digital Assistants (PDA) -Patient monitoring devices
Study designs	-Randomised controlled trials (RCT) -Controlled experimental trials -Effectiveness evaluation trials	All other experimental and non-experimental study designs such as, SRs, cohort studies, case control studies, controlled before-after studies and literature, narrative and critical reviews
Type of study	-Intervention's effectiveness evaluation studies only	All other study types like descriptive studies looking at technology and population demographics of mHealth services users
Type of intervention	HP interventions only	Clinical and other types of mHealth interventions
Location of interventions	Sub-Saharan Africa	Any other region of the world

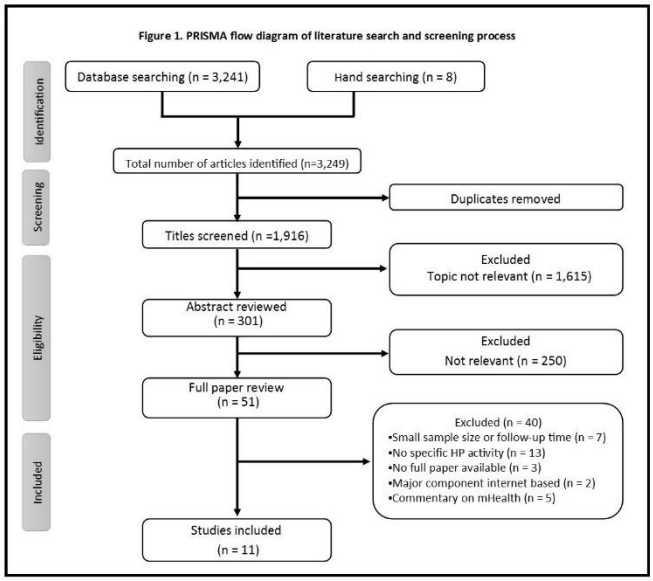

Figure 1. *PRISMA flow diagram of literature search and screening process*

3.2 Data Extraction and Analysis

A data extraction form was developed and used to extract data from included studies. Main category of data extracted included;

i. Intervention characteristics which included type of intervention and sample sizes,
ii. Intervention design which included duration of intervention, mode of communication, communication interactivity and frequency, message personalisation and automation, use of BCT and incentives, stakeholders involved and accompanying intervention.
iii. Intervention outcomes which included intervention effectiveness and significance.

The extracted data was first summarised and presented in tables. Then a narrative summary on designs of interventions, participants and outcomes was developed. The narrative summary was guided by questions developed to inform on review themes. Table 3 below shows review themes and questions on which summaries were developed.

Table 3: *Review themes and questions on which summaries were developed*

#	Theme	Questions
1	Opportunities and barriers to successful implementation of mHealth HP interventions	What opportunities are present for successful implementation of mHealth interventions in SSA?
		What barriers hinder successful implementation of mHealth interventions in SSA?

2	Behaviour Change Theories (BCT) used in mHealth interventions	Which BCTs are used in mHealth interventions?
		What effect do BCTs have on outcomes of mHealth interventions?
3	Design and implementation variables of mHealth interventions	Which project design and implementation variables are used in mHealth HP interventions in SSA?
		How do these variables affect outcomes on mHealth interventions?
4	Recommendations on design and implementation strategies of mHealth interventions in SSA	What design and implementation strategies are recommended for mHealth interventions in SSA?

4. Results

A total of 3,249 studies were identified during the literature search. After title and abstract review, 51 studies were selected for full paper review. Eleven studies met the full inclusion criteria and were included in this SR. Ten of the eleven studies were RCTs and one Crawford et al. (2014) was a pilot project evaluation. The studies were published between 2010 and 2016. Study interventions were conducted in seven SSA countries as follows; three in Kenya and one each in Cameroon, Ghana, Malawi, Nigeria, South Africa and Uganda and one trial Barnabas et al. (2016) was conducted concurrently in South Africa and Uganda. All eleven studies ultimately aimed at finding the most efficient way of implementing an mHealth intervention and assessing whether an mHealth approach is effective for a particular health promotion activity. Six of eleven included studies aimed at assessing effectiveness of text message reminders on promotion of medication adherence and clinical appointments attendance. Among the remaining five studies, four were on promotion of maternal and child health services while one was on promotion of Voluntary Medical Male Circumcision (VMMC) uptake. The eleven included studies had a combined total of 13,235 participants. Crawford et al. (2014) with 5,000 and Mbuagbaw et al. (2012) with 200 had the highest and lowest number of participants respectively. Participants of nine trials had to periodically attend health facilities for various healthcare services. Two trials were wholly community-based. All interventions studies recruited adults aged at least 16 years old. Table 4 shows details and design characteristics of included studies.

Table 4: *Study Details and Design Characteristics of Included Studies*

Study	Aim	Participants	Intervention Design	Communication characteristics	Outcome
Barnabas et al. (2016), RCT, South Africa and Uganda	▪Assessing effectiveness of linking HIV negative men to VMMC through text messaging.	▪750 uncircumcised HIV negative men (16-49 yrs) ▪288 in SMS reminder group ▪232 in lay counsellor follow-up visit group and ▪230 in clinical referral group	▪One text message promoting VMMC; one at three weeks after HIV testing and another at six weeks if not yet circumcised. ▪Lay counsellor home visit to promote VMMC at one month after HIV testing and at two months if not yet circumcised.	▪Text messages not tailored ▪One-way push messaging ▪Non-interactive ▪Automated messaging ▪No BCT and incentives used ▪Health Care Workers (HCW) only stakeholder involved	▪VMMC uptake significantly higher in both interventions groups compared to usual care group: a) SMS group 48% (RR=1.72, 95% CI 1.36-2.17, P < 0.0001) b) Lay visit group 47% (RR=1.67 95% CI 1.29 – 2.14) P = 0.0001 ▪Usual care 28% CI 1
Bobrow et al. (2016), RCT, South Africa	▪Assessing efficacy of SMS adherence support for HBP medication and identify better mode of SMS delivery	▪1372 adult (≥21 yrs.) patients on HBP medication ▪457 in usual care group ▪457 in information-only SMS group and ▪458 in interactive SMS group	▪One SMS per week in both intervention groups ▪Information-only group received text messages providing medication collection and adherence reminders and health education on HBP ▪Interactive SMS group received messages as in information-only group, in addition they could interact with the system for changing appointments and preferences	▪SMS not tailored ▪Preferred language and time of message reception used ▪Both one-way push and interactive messaging ▪Automated messaging ▪Integrated Theory of Health Behaviour Change used in developing messages ▪No incentives used ▪HCWs only stakeholder involved	▪Both information-only and interactive SMS interventions lead to significant increase medication adherence and clinical attendance resulting in significant decrease in blood pressure compared to usual care a) Info-only: RR = 1.4 (95% CI, 1.0–1.9; *P*=0.04) b) Interactive: RR = 1.4 (95% CI, 1.0–1.9; *P*=0.04)
Crawford et al. (2014), Pilot project evaluation, Malawi	▪Determining delivery success of various modes of text messages and corresponding quality of user experience for promotion of MCH services.	▪More than 5000 pregnant women and child (≤5 yrs.) caregivers	▪Toll-free hotline offering health information, advice, and referrals ▪One or two messages per week offering health tips and clinical appointment reminders to pregnant women, guardians of young children, and women of childbearing age ▪Participants could choose either to receive pushed text messages, retrieved	▪SMS tailored to gestation and child's ages ▪One-way push messaging ▪Interactive through voice calls ▪Automated messaging ▪No BCT used ▪No incentives used ▪HCWs, traditional leaders and network providers involved in	▪All SMS modalities led to high levels of satisfaction, comprehension, and new information learned. ▪Pushed SMS participants significantly more likely to report intended or actual behaviour change than voice message participants (P=0.01) ▪Pushed text messages preferred due to lower cost, higher delivery success, and

			text messages or retrieved voice messages	intervention.	higher levels of intended or actual behaviour change.
Flax et al. (2014), Cluster RCT, Nigeria	▪To determine whether mHealth services improves early breastfeeding (BF) initiation and exclusive BF for 6 months.	▪461 pregnant women (15-45 years) in microcredit* groups. ▪Intervention group had 229 women from 40 microcredit groups ▪Control group had 232 women from 39 microcredit groups	▪BF promotion lessons during monthly microcredit meetings ▪Two SMS per week for four months than two SMS per fortnight for three months (same SMS sent as voice then as text two days later) ▪SMS health information discussed by women during weekly meetings and songs or drama created on the health information to be presented on monthly meetings	▪Text messages not tailored ▪One-way push messaging ▪Automated messaging ▪No interactive used ▪No BCT and incentives used ▪Microcredit organisations only stakeholder involved	▪Odds of exclusive breastfeeding to 6 months significantly increased in intervention group compared to control group (OR=2.4, 95% CI 1·4–4·0; P < 0.01) ▪Odds of initiating breastfeeding within one hour of delivery significantly increased in intervention group (70%) compared to control group (48%) (OR=2.6 95% CI 1.6–4.1)
Lester et al. (2010), Multisite RCT' Kenya	▪To assess whether mobile phone communication between HCWs and patients initiating ART improves adherence and suppression of HIV	▪538 adults (≥18 yrs) initiating ART. ▪273 in intervention group ▪265 in control group	▪Intervention group participants received SMS medication reminders once a week to which they had to respond either that they are well or unwell ▪Unwell participants received voice calls from HCWs ▪Any intervention participant could request for a call from intervention HCWs for HC support anytime	▪Text messages not tailored ▪Non-automated messaging ▪Two-way interactive SMS ▪Voice call when participants were unwell or upon request ▪No BCT and incentives used ▪HCWs and university only stakeholders involved	▪Compared to control group, intervention group participants had significantly low risk of: a) non-adherence (RR=0.81, 95% CI=0.69-0.94, P=0.006) and b) viral load suppression failure (RR=0.84, 95% CI=0.71-0.99, P=0.04)
Lund et al. (2014)' Cluster RCT, Tanzania	▪To assess whether text message reminders and health education improves antenatal services attendance and utilisation	▪2550 pregnant women attending antenatal care ▪1311 women in intervention group and ▪1239 women in control group	▪Two SMS per month and two SMS per week before and from gestation week 36 respectively ▪SMS providing clinical appointment reminders and HE. ▪Participants given small mobile phone vouchers and mobile phone numbers of intervention HCWs to contact them in cases of obstetric emergencies	▪SMS tailored to gestation age ▪One-way push messaging ▪Automated messaging ▪Voice calls on demand ▪No BCT used ▪Small mobile phone voucher incentive given ▪HCWs only stakeholder involved	▪The odds of attending four or more antenatal care visits were more than double for women in intervention group as compared to control group (OR=2.39; 95% CI, 1.03-5.55)
Mbuagbaw et al. (2012), RCT, Cameroon	▪Evaluating effectiveness of motivational SMS for adherence to ART medication	▪200 adults on ART for more than one month ▪101 in intervention group ▪99 in control group	▪One SMS per week motivating and reminding participants to take their medication ▪Intervention participants could also request for a phone call from intervention HCWs for HC support	▪SMS not tailored ▪Participants' preferred language used ▪One-way push messaging ▪Interactive through calls ▪Non-automated messaging ▪HBM used ▪No incentives used ▪HCWs only stakeholder involved	▪No significant difference in number of participants reaching ART adherence of more than 90% between intervention and control group (RR=1.06, 95% CI 0.89 – 1.29, P=0.54)
Odeny et al. (2014)' RCT, Kenya	▪Assessing effectiveness of an SMS intervention on maternal postpartum clinical attendance and infant HIV testing within 8 weeks of birth.	▪388 pregnant women (≥18 yrs.) ▪195 in intervention and ▪193 in control group	▪14 text messages for routine clinics and vaccinations appointment reminders sent. ▪Up to eight text messages sent during pregnancy and the remaining 6 sent once per week for the first 6 weeks after delivery ▪Healthcare support from HCWs if women request for a phone call	▪Text messages personalised and tailored to gestation age. ▪One-way push messaging ▪Interactive through phone calls ▪Automated messaging ▪Health Belief Model used in development of messages ▪No incentives used ▪HCWs only stakeholder involved	▪Significant more intervention group women than control group women attended postpartum clinics (RR=1.66, 95% CI 1.02-2.70, *P*=0.04) ▪Significant more infants in intervention group underwent HIV testing than infants in control group (RR=1.08, 95% CI 1.00-1.16, *P*=0.04)
Pop-Eleches et al. (2011), RCT, Kenya	▪Assessing efficacy of SMS reminders on adherence to	▪431 adults who just initiated ART ▪139 in control group	▪Short SMS offered medication reminders only ▪Long SMS offered medication reminders and additional moral support.	▪Text messages not tailored ▪One-way push messages ▪Automated messaging	▪Short weekly SMS significantly improved adherence (of at least 90%) over control (68% v 47%, P=0.01)

	ART medication	▪70 in daily short SMS group ▪72 in daily long SMS group ▪73 in weekly short SMS group and ▪74 in weekly long SMS group		▪Non interactive ▪No BCT used ▪Participants given mobile phones and small credit vouchers ▪Telecommunication network provider and HCWs only stakeholders involved	▪Other intervention groups showed improvement over control group but not significant
Raifman et al. (2014), RCT, Ghana	▪To assess impact of SMS reminders on malaria medication dosage completion.	▪1140 all individuals acquiring malaria medication ▪277 in reminder only group ▪309 in reminder and encouragement group ▪554 in control group	▪Six SMS for three days at 12 hours' interval to coincide with likely time of taking medication ▪Reminder only group received medication adherence reminder only ▪Reminder and encouragement group received medication adherence reminders and encouragement to finish dosage	▪SMS not tailored ▪One-way push messaging ▪Non-interactive messaging ▪Automated messaging ▪No BCT and incentives used ▪Stakeholders involved were HCWs, vendors and community representatives	▪SMS reminders only significantly improved odds of completing dosage compared to control (OR=1.45 95% CI 1.03-2.04, p=0.03) ▪SMS reminder and encouragement did not significantly improve odds of completing dosage compared to control (OR=0.77 95% CI 0.50-1.20, P=0.25)
Siedner et al. (2015), RCT, Uganda	▪Identifying predictors of receipt, comprehension and appropriate response to an SMS invitation to return to care	▪385 HIV positive adults undergoing CD4 cell count examination ▪46 in direct SMS group ▪49 in PIN protected SMS group and ▪43 in coded SMS group	▪Up to seven SMS sent; one SMS per day informing participants of their CD4 cell count results and requesting them to return to health facilities ▪Participants who returned within 7 days of first SMS sent had their transport money reimbursed	▪SMS not tailored ▪Participants' language and reception time preferences used ▪One-way push messaging ▪Non interactive messaging ▪Automated messaging ▪No BCT used ▪Transport money reimbursement used as incentive ▪Stakeholders were HCWs, patient groups and ICT experts	▪Ability to read a complete sentence on enrolment was significantly associated with accurate identification and returning to health facility within 7 days ▪Compared to direct SMS, receipt of PIN-protected SMS decreased significantly: a) likelihood of identifying the message (AOR=0.11, 95% CI 0.03-0.44, P=.002) and b) returning to health facility (AOR=0.26, 95% CI 0.10-0.66, P=.005)

5. Discussion

5.1 Summary

Among all eleven included studies only one (Mbuagbaw et al., 2012) did not report significant difference in primary study outcome between intervention and control groups. This shows that mHealth interventions in SSA are mostly effective. Similar finding is shown in SRs by Aranda-Jan et al. (2014) and Betjeman et al. (2013).

5.2 Communication Interactivity

Among all eleven included studies, six deployed interactive communications while five used one-way communication systems. Five of the six interactive interventions reported significant improvements in primary study outcomes. All five interventions which deployed one-way communication systems reported significant improvement in primary study outcomes among intervention groups as compared to control groups. The observation that one-way communication interventions were just as effective as interactive interventions presents opportunities in implementation of mHealth services as interactive interventions are more complicated and expensive to run (Crawford et al., 2014; Hall et al., 2015; WHO, 2011). A meta-analysis by Head et al. (2013) similarly found that interactive interventions are not more effective than one-way communication interventions. This finding is mostly unexpected as one would expect that interactive interventions which are more engaging would probably result in higher knowledge acquisition and enactment of promoted behaviour (Ritterband et al., 2009).

5.3 Message content

Among all eleven included studies, two (Pop-Eleches et al., 2011; Raifman et al., 2014) tested the effect of varying the content of text messages on study outcomes. Both studies found that short text message medication reminders with no additional information were significantly more effective than medication reminders with additional motivational or health education information. This finding contradicts that by Horvath et al. (2012) whose meta-analysis found that long text message reminders were just as efficacious in improving medication adherence as short text messages. Interventions that send short medication reminders have additional implementation benefits, as they are comparatively easier to implement with automated messaging systems thereby requiring less personnel to implement (Crawford et al., 2014) and resulting in less expensive interventions.

5.4 Use of BCTs

Among all eleven included studies, only three (Bobrow et al., 2016; Mbuagbaw et al., 2012; Odeny et al., 2014) used BCTs to inform on interventions' design. Two of the three studies (Mbuagbaw et al., 2012; Odeny et al., 2014) reported significant improvement in primary study outcomes in intervention groups. Only (Odeny et al., 2014) acknowledged the positive effective of BCT used on study outcomes. BCTs are conspicuously underutilised in mHealth interventions in

SSA and where they have been used, results have not been consistently positive. It is difficult to draw any conclusion on the effect of BCTs in this SR as only three studies mention their use, of which only one acknowledges BCTs' positive effect. Nevertheless, the fact that two of the three studies which used BCTs had significant positive results is encouraging. This is consistent with findings by Head et al. (2013) who in a meta-analysis found that use of BCTs did not significantly improve effectiveness of interventions. This contradicts Bull & Ezeanochie. (2015) who in an SR found significant positive effects of BCTs in mHealth interventions.

5.5 Use of Incentives

Among all eleven included studies, only three (Lund et al., 2014; Pop-Eleches et al., 2011; Siedner et al., 2015) made use of incentives in interventions' implementation. All three interventions reported significant improvement in primary study outcomes in intervention groups. None of the three studies acknowledged the effect of incentives used on either study outcomes or conduct of interventions. While literature on mHealth interventions acknowledges the positive effect of incentives on securing participation of participants (Aranda-Jan et al., 2014; ITU - WHO, 2012) the authors did not find any meta-analysis which has calculated the effect of incentives on mHealth interventions' outcomes. This calls for further studies to determine the effect, importance and feasibility of using incentives in mHealth interventions. The fact that seven of eleven studies included in the presented SR did not use incentives but were effective is one positive step towards scaling-up of pilot mHealth interventions and achievement of sustainability.

5.6 Frequency of Communication

Only one study (Pop-Eleches et al., 2011) assessed the effect of varying frequency of sending text messages on final study outcome. Pop-Eleches et al. (2011) found that weekly short text messages were significantly more effective in promoting ART adherence compared to control (68% against 47% adherence, P=0.01). Comparatively, daily short text message reminders were not significantly more effective compared to control group (49% against 47% adherence, P=0.80). This finding is similar to those of Finitsis et al. (2014), Head et al. (2013) and Horvath et al. (2012) whose findings showed that less frequent text message reminders were more effective. The apparent correlation between increased frequency of text messaging and decreased response effect was highly unexpected. However, this may be explained by habituation, which may lead to decreased sensitivity or even dislike of perceived intrusion on a daily basis. Further studies may try to determine what might be the most optimal frequency of messaging for specific interventions between the daily and weekly frequency.

5.7 Message tailoring

Among all eleven included studies only three (Crawford et al., 2014; Lund et al., 2014; Odeny et al., 2014) tailored content of messages sent to particular situation of participants. All three interventions reported significant improvement in primary study outcomes. None of the three interventions acknowledged any effect of tailoring message content on final study outcomes. This finding supports that of meta-analyses by Finitsis et al. (2014) and Head et al. (2013) who found that interventions which tailored and personalised text messages were comparatively more effective. Similarly, Park et al. (2014) in a quantitative SR reported positive effect in interventions which tailored or personalised text messages. Message tailoring is purported as one of the most important factors determining effectiveness of mHealth interventions (Finitsis et al., 2014; Hall et al., 2015). It is therefore surprising that only three of eleven included studies tailored message content to participants' situations or needs. In this SR it is difficult to infer the true effect of message tailoring as a meta-analysis could not be conducted.

5.8 Messaging automation

Nine of eleven included studies utilised automated messaging systems and all reported significant improved outcomes. It is difficult to make a link between messaging automation and the final study outcomes in the presented SR. However, a meta-analysis by Head et al. (2013) found no difference in effect between interventions based on messaging automation or not. This finding should be obvious, as one cannot tell just from the SMS received whether it was sent automatically or not. Notwithstanding this finding, deploying messaging automation is advantageous, as interventions become less labour intensive, more efficient and relatively less costly to run (Barnabas et al., 2016; Crawford et al., 2014; Lester et al., 2010; Pop-Eleches et al., 2011). That nine of eleven included studies deployed messaging automation should be considered as a positive step towards scaling-up of mHealth interventions in SSA as large scale interventions would require messaging automation.

5.9 Identified Opportunity for Successful Implementation of mHealth Interventions in SSA

All eleven included mHealth studies demonstrated some design and implementation opportunities which can be utilised in new and scaling-up interventions. Among these opportunities are:

i. Effectiveness of less frequent (weekly) SMS reminders. A weekly SMS based medication or appointment reminder intervention is comparatively less expensive and easy to manage than a more frequent (daily) reminders intervention.
ii. Automation of messaging in mHealth interventions. This demonstrates that mHealth interventions can be less labour intensive and effective. This is important as there is an acute shortage of well-trained healthcare personnel in SSA to provide effective health promotion (Crul, 2014);
iii. Non usage of incentives. Eight of eleven included studies did not provide incentives but were effective nevertheless. This shows that it is possible to implement mHealth interventions in SSA without use of incentives to secure full involvement of participants;
iv. Effectiveness of simple and short time mHealth interventions. Effectiveness shown by interventions by Barnabas et al. (2016) and Raifman et al. (2014) which sent a maximum of two and six text messages respectively shows that some mHealth interventions can be effective while being relatively cheap, short term and simple. This presents an opportunity to achieve health promotion goals at a

relatively low cost once applicable areas of these kinds of interventions can be identified.

Incorporating these design and implementation opportunities can help in the drive of scaling-up effective mHealth interventions in SSA.

5.10 Identified Barriers for Successful Implementation of mHealth Interventions in SSA

Included studies demonstrated many barriers to successful implementation of mHealth interventions which include;

i. Decreasing effect of interventions over time as demonstrated by Barnabas et al. (2016), Flax et al. (2014), Mbuagbaw et al. (2012) and Pop-Eleches et al. (2011). The effect of interventions tapered-off over the follow-up period which may be explained by habituation. This may require constant changing of messages or intervention designs which is likely to be more expensive to implement.
ii. Underdevelopment of telecommunication infrastructure. Frequent interruption of mobile phone network coverage was blamed by Crawford et al.(2014) and Raifman et al. (2014) for participants' failure to access messages. This may lead to mHealth intervention failing to produce desired outcomes.
iii. Underdevelopment of electric infrastructure. Frequent power interruption and unavailability of electricity to charge mobile phones batteries mostly in rural areas hinder effective implementation of mHealth interventions as participants fail to receive messages or make calls on time(Crawford et al., 2014).
iv. Confidentiality in highly sensitive interventions like those dealing with HIV/AIDS. In situations where mobile phones are shared there is a high concern for confidentiality (Lester et al., 2010; Mbuagbaw et al., 2012) which may become even greater once interventions are scaled-up. These barriers to successful implementation of mHealth interventions need to be considered carefully during the design and implementation phases of mHealth interventions if success is to be achieved.

5.11 Implication of the study

As the findings of this SR have shown that some design and implementation attributes of effective mHealth interventions may not be the most obvious or what are considered logical. There is a need for further research on health promotion interventions that pool together effective design attributes. The authors believe that there is a need to go beyond conducting SRs or meta-analyses which show effectiveness of mHealth interventions. Assessing design and implementation attributes which have made the interventions to be effective is very important as it would aid health promoters and project designers to be informed by practice which have been shown empirically to be effective.

5.12 Strengths and limitations of the presented SR

The presented SR has a number of strengths and limitations. Among the strengths are:

i. The inclusion and exclusion criteria of studies was appropriate which enabled identification of relevant evidence to answer the review question;
ii. A comprehensive English language literature search was conducted which gives confidence that the presented SR is informed by almost all the best and relevant English language evidence available;
iii. Quality assessment of all included studies was thoroughly conducted to ensure that findings of the presented SR are interpreted correctly;
iv. The presented SR is informed by good quality RCTs which had considerably long follow-up periods (average 15 months) and high number of participants (minimum 200 participants).

Among the limitations of the presented SR are:

i. Only English language studies were included which leaves the possibility that some relevant non-English language papers maybe left out resulting in language bias.
ii. A meta-analysis could not be conducted due to heterogeneity of included studies. The presented SR could have benefited from a meta-analysis which could have enabled assessment of effects of design and implementation variables on study outcomes.

These strengths and limitations should be referred to in interpretation of findings.

6. Conclusions

The presented SR aimed at identifying design and implementation attributes of mHealth health promotion interventions critical for success of the interventions in SSA. Overall, this review found that mHealth interventions in SSA are mostly effective. In medication adherence interventions, mHealth implementers should consider use of weekly short SMS reminders without any additional motivational or health education information, as they have been shown to be more effective. Tailored and personalised messages have also been shown to be more effective, therefore, mHealth project implementers should consider adopting them. Interactivity and messaging automation have not been shown to be more effective therefore project designers can choose the system which best suits their situation; however, messaging automation has been shown to have many other advantages. BCTs which are currently underutilised in mHealth interventions in SSA should be considered in predominantly behaviour change interventions like smoking cessation. Finally, mHealth implementers should consider involving a wide variety of stakeholders in designing and implementing interventions.

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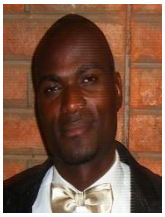

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