One-way SMS and healthcare outcomes in Africa:
Systematic review of randomised trials with meta-analysis

Linde, Ditte S.; Korsholm, Malene; Katanga, Johnson; Rasch, Vibeke; Lundh, Andreas; Andersen, Marianne S.

Published in:
PLOS ONE

DOI:
10.1371/journal.pone.0217485

Publication date:
2019

Document version:
Final published version

Document license:
CC BY

Citation for published version (APA):
Linde, D. S., Korsholm, M., Katanga, J., Rasch, V., Lundh, A., & Andersen, M. S. (2019). One-way SMS and healthcare outcomes in Africa: Systematic review of randomised trials with meta-analysis. PLOS ONE, 14(6), [e0217485]. https://doi.org/10.1371/journal.pone.0217485

Go to publication entry in University of Southern Denmark's Research Portal

Terms of use
This work is brought to you by the University of Southern Denmark.
Unless otherwise specified it has been shared according to the terms for self-archiving.
If no other license is stated, these terms apply:
• You may download this work for personal use only.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying this open access version
If you believe that this document breaches copyright please contact us providing details and we will investigate your claim.
Please direct all enquiries to puresupport@bib.sdu.dk

Download date: 15. Oct. 2023
RESEARCH ARTICLE

One-way SMS and healthcare outcomes in Africa: Systematic review of randomised trials with meta-analysis

Ditte S. Linde1,2,3*, Malene Korsholm1,2,4, Johnson Katanga5, Vibeke Rasch1,2, Andreas Lundh1,3,6,7, Marianne S. Andersen1,8

1 Department of Clinical Research, University of Southern Denmark, Odense, Denmark, 2 Department of Obstetrics and Gynaecology, Odense University Hospital, Odense, Denmark, 3 Odense Patient Data Explorative Network (OPEN), University of Southern Denmark, Odense, Denmark, 4 Danish Centre for Health Economics (DaCHE), Department of Public Health, University of Southern Denmark, Odense, Denmark, 5 Department for Cancer Prevention Services, Ocean Road Cancer Institute, Dar es Salaam, Tanzania, 6 Centre for Evidence-Based Medicine (CEBMO), Odense University Hospital, Odense, Denmark, 7 Department of Infectious Diseases, Hvidovre Hospital, Hvidovre, Denmark, 8 Department of Medical Endocrinology, Odense University Hospital, Odense, Denmark

* dsondergaard@health.sdu.dk

Abstract

Background

The impact of one-way SMS on health outcomes in Africa is unclear. We aimed to conduct a systematic review of one-way SMS randomised trials in Africa and a meta-analysis of their effect on healthcare appointments attendance and medicine adherence.

Methods

PubMed, Embase, CENTRAL, The Global Health Library, ClinicalTrials.gov, ICTRP, and PACTR were searched for published and unpublished trials in Africa without language restriction (up to April 2018). Trials reporting effect estimates on healthcare appointment attendance and medicine adherence were assessed for risk of bias and included in meta-analyses using random-effects models. Other outcomes were reported descriptively. The protocol is registered in PROSPERO, ID:CRD42018081062.

Results

We included 38 one-way SMS trials conducted in Africa within a broad range of clinical conditions. Eighteen trials were included in the meta-analyses, and four were assessed as overall low risk of bias. One-way SMS improved appointment attendance, OR:2.03; 95% CI:1.40–2.95 (12 trials, 6448 participants), but not medicine adherence, RR:1.10; 95% CI:0.98–1.23 (nine trials, 4213 participants). Subgroup analyses showed that one-way SMS had the highest impact on childhood immunisation attendance, OR:3.69; 95% CI:1.67–8.13 (three trials, 1943 participants). There was no clear evidence of one-way SMS improving facility delivery, knowledge level (reproductive/antenatal health, hypertension), diabetes- and hypertension management.
Conclusion

In an African setting, the clinical effect of one-way SMS is uncertain except for appointment attendance where the effect seems to vary depending on which clinical condition it is used in.

Introduction

Mobile health (mHealth) interventions have a growing focus within global health research as these interventions have the potential to reach underserved communities and remote populations in innovative ways [1]. mHealth is defined as the use of mobile and wireless technologies for health [2] and involves different communication channels including one- or two-way Short Message Service (SMS), applications (apps), and mobile phone calls targeted healthcare clients or -professionals [3]. Moreover, the content and the length of the SMS may vary and can include reminders, education or a combination. This review concerns one-way SMS, which means that the receiver cannot respond to the SMS. It is the simplest form of mHealth as it does not allow for interaction between the sender and receiver, thus it can be implemented in most settings with minimum costs [4].

Few systematic reviews have been published on mHealth interventions in "low- or middle-income countries" (LMIC) [5–7], and the effect of one-way SMS in this setting is unclear. This can be due to the reviews including all forms of mHealth interventions and looking across too diverse populations and settings. To better estimate the effect of one-way SMS, it may be relevant to make a regional restriction, apart from an economic restriction, as digital literacy, network infrastructure, and cultural/social acceptance of mHealth interventions may be more homogenic within a certain region [3]. As all countries in Africa have moderately comparable economies—all countries are “LMIC” apart from the Seychelles [8]—it is relevant to look at this continent specifically. A series of Cochrane reviews published between 2012–2017 assessed the effect of SMS on various health issues with no restriction on type of setting [9–14]. Only two of these reviews included trials from Africa and concluded that SMS was effective in improving healthcare appointment attendance and HIV medicine adherence [12,13]. However, of the 10 trials included in these two reviews, only two trials concerned one-way SMS interventions in Africa, both with evidence [12,13] of one-way SMS improving healthcare appointment attendance [15] and HIV medicine adherence [16].

As there remains a lack of evidence of the effect of one-way SMS in resource-limited settings, we conducted a systematic review of one-way SMS trials in Africa and a meta-analysis of their effect on healthcare appointment attendance and medicine adherence. This review will provide an overview of the effect of one-way SMS among different clinical conditions in Africa and may help clarify which health areas this separate element of mHealth should be prioritised in future mHealth strategies and policies in Africa.

Material and methods

For this systematic review and meta-analysis, we searched PubMed, Embase, Cochrane Central Register of Controlled Trials (CENTRAL), and The Global Health Library for trials published in any language (from inception up to 18 April 2018; S1 File). The search strategy was developed in collaboration with an information specialist and included search terms such as “trial” AND “Africa” AND “text message” OR “sms” OR “mobile phone intervention”. We searched...
relevant reviews and reference lists of included trials and ClinicalTrials.gov (April 2018), the International Clinical Trial Registry Platform (ICTRP) (April 2018), and the Pan African Clinical Trial Registry (PACTR) (Oct 2018) for additional eligible and ongoing or unpublished trials. United Nations and World Bank databases were searched for reports containing relevant trials (May 2018). Our protocol was registered in PROSPERO prior to study conduct (ID: CRD42018081062, 10 January 2018).

After removing duplicates, two authors independently screened titles and abstracts (DSL, JK) and full-text (DSL, MK) using Covidence (www.covidence.org/). Disagreements were resolved through discussion. We included published and unpublished randomised controlled trials (RCTs) in any language, including cluster- and pilot RCTs. The setting was limited to Africa, and trial participants could be all types of healthcare clients including guardians for healthcare clients. We included interventions that used SMS to affect healthcare behaviour and health knowledge. At least one intervention arm had to be exclusive one-way SMS, which the participant could not respond to. Included trials had to have a control group that received standard care, no- or placebo SMS. If co-interventions (e.g. written material) were received by participants in both intervention and control arms, this was considered to be part of standard care, and such trials were included.

One author (DSL) extracted data into a standardised Excel template and one co-author (MK) verified outcome data. Extracted data included: title, first author, publication year, journal/register, randomisation method, clinical conditions, setting, country, number of participants, gender distribution, inclusion/exclusion criteria, description of intervention/controls, study period, outcomes measures, and outcomes for finished trials. Twenty-six corresponding authors were contacted for clarification or to obtain missing data.

**Risk of bias assessment**

For trials that assessed the effect of SMS on healthcare appointment attendance or medicine adherence, two authors (DSL, MK) independently assessed risk of bias using the Cochrane Risk of Bias Tool [17]. We assessed the domains: random sequence generation and allocation concealment (selection bias), blinding of personnel (performance bias), blinding of outcome assessment (detection bias), incomplete reporting (attrition bias) and selective reporting (reporting bias). The domains were judged to have either low risk, high risk, or unclear risk of bias. In case of disagreement, another co-author (AL) was used as arbiter. Due to the overt nature of the intervention, study participants were not blinded. Therefore, judgement of performance bias was based solely on blinding of personnel. We did not assess risk of attrition bias on trials that only had healthcare appointment attendance as an outcome as incomplete outcome data was part of this outcome, i.e. non-attendance resulted in loss to follow-up (i.e. resulted in blank cells in risk of bias assessment). Cluster trials were additionally judged for risk of baseline imbalance and recruitment bias [17]. Trials were judged to have overall low risk of bias, if they scored low risk in selection, detection, and reporting bias. All other trials were considered to be overall high-risk of bias trials.

**Data analysis**

We expected that one-way SMS interventions were used in various types of populations and settings and therefore including multiple types of outcomes. Accordingly, we performed an overall descriptive analysis of all trials and performed meta-analyses restricted on the outcomes “appointment attendance” and “medicine adherence”, which we regarded to be uniform. For our descriptive analysis, we reported unadjusted trial results on the primary
outcome. If no quantitative estimates were reported for dichotomous data we calculated risk ratios (RRs), if possible.

Meta-analyses were done using Reviewer Manager 5-3 [18]. Due to anticipated clinical and methodological heterogeneity, we planned to use a random-effects model with the Mantel-Haenszel method for dichotomous data to calculate pooled RRs and estimate 95% confidence intervals (CIs) for both appointment attendance and medicine adherence. However, one trial [19] assessing appointment attendance was randomised at cluster level. The trial results were reported in odds ratios (OR) and analysed taking clustering into account, thereby avoiding unit-of-analysis error. For appointment attendance, we therefore calculated a pooled estimate in OR using the generic-inverse variance method to allow for the inclusion of this trial. The pooled estimate for medicine adherence was calculated as RR as planned. Heterogeneity was assessed using $I^2$.

We performed subgroup analyses comparing overall low risk of bias trials with high risk of trials, and clinical conditions. We performed sensitivity analyses using fixed-effect models and excluding the cluster randomised trial [19]. Additionally, in our analysis on appointment attendance, one trial was an outlier with an extreme result [20]. We discovered that this trial was published in a journal on Beall’s list of potential predatory publishers [21]. We then assessed all trials and discovered another of the included trials being published in a journal on Beall’s list [22]. We then did post-hoc sensitivity analyses excluding both trials.

Results

We identified 1681 records in our database search. After excluding 731 duplicates, 747 records were excluded following title-abstract screening (Fig 1). A total of 203 records were reviewed in full-text and 172 were excluded. This led to an inclusion of 31 trials [15,16,19,22–49]. Searching other sources led to the inclusion of seven additional trials [20,50–55]. In total, we included 38 trials, of which 25 were published [15,16,19,20,22–42], and of the 13 unpublished trials, nine were ongoing [46–52, 54, 55], three were finished [43,44,53], and one was interrupted before enrolment of all participants [45].

Trials were published between 2011–2018, and a total of 15438 participants were included (median: 304 participants) [15,16,19,20,22–42] (Table 1). In the unpublished and ongoing trials (excluding an interrupted and cluster trial), a total of 10783 participants were planned to be enrolled (median: 600 participants) [43,46–55]. Age among participants ranged from 45 days to 54 years. Five trials targeted infants and children where the caregiver was the receiver of the SMS intervention. All, but one trial, were set in Sub-Saharan Africa; 25 in East and Southern Africa, 12 in Western Africa, and one Northern Africa (Fig 2). Sixteen out of 38 trials were set in either Kenya or South Africa. Settings ranged from rural outpatient clinics and health centres to regional hospitals and drug shops.

The function of the one-way SMS interventions varied from educational and motivational messages to reminders and test results, or a combination of these. For example, a combined educative and reminder message read, “Immunization protects your child against killer diseases such as polio, whooping cough, diphtheria, measles, pneumonia and tuberculosis. You are reminded that the vaccination appointment will be due in 7 days from today” [35] while a motivational message could be, “If you test and you’re HIV+ you can go on free drugs when you need to. HIV is longer a death sentence. You can live a long, normal life with HIV. Plz test!” [39]. Most trials only sent SMS reminders [16,19,20,24,25,27,28,36–38,41,44,45,48,50,51] or reminders combined with educative messages [15,23,30,31,35,39,40,47] (Table 1). Two trials reported that the SMS content was developed based on behavioural theories [39,53] and 16 trials reported that the SMS content had been pre-tested or developed in consultation with...
experts, clinical staff and/or potential participants [16,24–27,29–33,36,40,41,46–48]. Clinical conditions included HIV (n = 13), immunization (n = 5), reproductive and antenatal health (n = 5), and malaria (n = 4). Fourteen trials [16,22,24,25,27,32,34,36,41,44,48,50,51,54] had medicine adherence as primary outcome though it was measured in various ways including timely pick-up of medicine, pill counts, self-reported behaviour, and pillbox openings. Eleven trials [15,19,20,28,30,35,37,38,43,47,53] had appointment attendance as primary outcome,
### Table 1. One-way SMS trials in Africa.

| Finished trials, published | Country | Clinical area | Trial size (n) | Female | Age (Mean) | Follow-up (weeks) | Primary endpoint† | Intervention A (type) | Effect of intervention on primary endpoint compared to control |
|---------------------------|---------|---------------|---------------|--------|------------|------------------|-------------------|----------------------|-----------------------------------------------|
| 2018 (Unger) [33]         | Kenya   | Antenatal care | 298           | 100%   | 23 median | 24               | Facility delivery | SMS§ (E§§+M§§)       | RR = 1.0 [95% CI: 1.0 to 1.0] |
|                           |         |               |               |        |            |                  |                   | SMS+quiz            | RR = 1.0 [95% CI: 1.0 to 1.0] |
| 2017 (Ahaza) [23]         | Egypt   | Diabetes      | 73            | 56%    | 51.5       | 12               | ΔHbA1c            | SMS (E+R§§)          | Δ0.29 [95% CI: -0.4 to 1.0] |
| 2017 (Linnemayr) [24]ª   | Uganda  | HIV           | 332           | 60%    | 18.3       | 52               | Medicine adherence| SMS (M)              | Proportion taken/total prescribed = 0.64, (p = 0.27) |
|                           |         |               |               |        |            |                  |                   | Two-way SMS         | Proportion taken/total prescribed = 0.61, (p = 0.15) |
| 2017 (Reid) [25]ª         | Botswana| HIV           | 108           | 44%    | 41.1       | 47               | Medicine adherence| SMS (R)              | OR = 2.4 [95% CI:0.9 to 6.4] |
| 2017 (Rokicki) [26]ª      | Ghana   | Reproductive knowledge | 756 | 100% | 17.7 | 12 | Increase knowledge (Pregnancy prevention/ STD††) | SMS (E+R§§) | Δ0.29 [95% CI: -0.4 to 1.0] |
| 2017 (Talisuna) [27]ª     | Kenya   | Malaria (infant) | 1677     | 47% categories³ | 4 | Medicine adherence | SMS (R) | OR = 1.1 [95% CI:0.4 to 3.1] |
| 2017 (Thomas) [28]ª       | Nigeria | Psychosis     | 200          | 54%    | 33.7       | 2-4              | Attendance follow-up appointment | SMS (R) | OR = 1.8 [95% CI:1.0 to 3.2] |
| 2017 (Wanyoro) [29]ª      | Kenya   | Cervical cancer screening | 286   | 100% | 38.8 | 52 | Attendance follow-up screening | SMS (R) | OR = 8.0 [95% CI:4.7 to 13.7] |
| 2016 (Bobrow) [29]ª       | South Africa | Hypertension | 1372   | 72%   | 54.3       | 52               | Acastic blood pressure | SMS (E+M+R) | -2.2mmHg [95% CI: -4.4 to -0.04] |
|                           |         |               |               |        |            |                  |                   | SMS+two-way SMS     | -1.6mmHg [95% CI: -3.7 to 0.6] |
| 2016 (Davey) [30]ª        | Mozambique | HIV        | 830          | 60%    | 36.9 median | 52               | Appointment attendance | SMS (E+R) | RR = 1.0 [95% CI:1.0 to 1.1]** |
| 2016 (Hacking) [31]       | South Africa | Hypertension knowledge | 223   | 80%⁴ | 52.8 | 17 | Increase knowledge (Hypertension) | SMS (E+R) | Score = 17.5, (p = 0.69) 19 questionnaire items, max score = 19 |
| 2016 (Haji) [19]ª         | Kenya   | Childhood immunization* | 1116 | 49% | 45 days median | 16 | Vaccination attendance (3rd dose) | SMS (R) | OR = 5.6 [95% CI: 3.0 to 10.4] |
|                           |         |               |               |        |            |                  |                   | Sticker              | OR = 1.1 [95% CI:0.7 to 1.6] |
| 2016 (Liu) [32]ª          | Nigeria | Malaria       | 686          | 42%    | 32.8       | 4 days           | Medicine adherence | Short SMS (E+T§§) | OR = 1.4 [95% CI:0.9 to 2.2] |
|                           |         |               |               |        |            |                  |                   | Long SMS (E+T+E)    | OR = 1.1 [95% CI:0.7 to 1.5] |
| 2016 (Nsagha) [22]ª       | Cameroon| HIV           | 90           | 61%    | 38.8       | 4                | Medicine adherence | SMS (E) | RR = 1.5 [95% CI:1.0 to 2.2]** |
| 2016 (Steury) [34]ª       | Zambia  | Malaria       | 96           | 48% categories³ | 1 | Medicine adherence | SMS (R) | RR = 0.9 [95% CI:0.7 to 1.3]** |
| 2015 (Bangure) [35]ª      | Zimbabwe | Childhood immunization* | 304   | 100% mothers | 26.5 median | 14 | Vaccination attendance (3rd dose) | SMS (E+R) | RR = 1.3 [95% CI: 1.1 to 1.4]** |
| 2015 (Orrell) [36]ª       | South Africa | HIV    | 230          | 65%    | 34.5       | 48               | Medicine adherence | SMS (R) | aOR = 1.1 [95% CI:0.8 to 1.5] |
| 2015 (Sclumberger) [37]ª  | Burkina Faso | Childhood immunization* | 523   | 100% mothers | unknown | 52 | Vaccination attendance (3rd dose) | SMS (R) | RR = 1.4 [95% CI: 1.9 to 1.6]** |
| 2014 (Bigna) [38]ª        | Cameroon | HIV (infant) | 242          | 85%    | 42.8       | unknown         | Attendance follow-up appointment | SMS (R) | OR = 2.9 [95% CI:1.3 to 6.3] |
|                           |         |               |               |        |            |                  |                   | Call                 | OR = 5.5 [95% CI:2.3 to 13.1] |
|                           |         |               |               |        |            |                  |                   | SMS+call             | OR = 7.5 [95% CI:2.9 to 19.0] |

(Continued)
| Country                  | Clinical area                  | Trial size (n) | Female Age (Mean) | Follow-up (weeks) | Primary endpoint              | Intervention A (type) | Effect of intervention on primary endpoint compared to control |
|-------------------------|--------------------------------|----------------|-------------------|-------------------|-------------------------------|-----------------------|-------------------------------------------------------------|
| 2014 (Constant) [39]    | South Africa                   | Medical abortion | 469               | 100%              | 25.8                          | 12                    | Decrease anxiety level                                      | SMS (E+R)                                      |
|                         |                                |                |                   |                   |                               |                       | Absolute difference = 1.3, p = 0.01                        | HADScale with 14 items each scored 0–3         |
| 2014 (Lau) [40]         | South Africa                   | Antenatal knowledge | 206             | 100%              | 27.0                          | 40                    | Increase in knowledge                                       | SMS (E+R)                                      |
|                         |                                |                |                   |                   |                               |                       | Mean = 10.2 [95% CI:9.8 to 10.6]                            | 9 questionnaire items, max score: 18           |
| 2014 (Raifman) [41]§    | Ghana                          | Malaria        | 1140              | 55%               | 3 days                        | Medicine adherence    | OR = 1.24 [95% CI: 1.0 to 1.6]**                            | SMS A (R)                                      |
|                         |                                |                |                   |                   |                               |                       | OR = 0.8 [95% CI: 0.5 to 1.3]**                             | SMS A+B (M+R)                                 |
| 2012 (Odeny) [15] §     | Kenya                          | HIV prevention | 1200              | 0%                | 24.9 median                   | Attendance post-      | RR = 1.1 [95% CI: 1.0 to 1.2]                               | SMS (E+R)                                      |
|                         |                                |                |                   |                   |                               | circumcision          | appointment                                                 |                                               |
| 2012 (de Tolly) [39]    | South Africa                   | HIV            | 2553              | unknown           | 3                             | HIV testing           | OR = 0.9 [95% CI: 0.7 to 1.1]                               | 3xSMS (E)                                      |
|                         |                                |                |                   |                   |                               |                       | OR = 1.1 [95% CI: 0.8 to 1.4]                               | 10xSMS (E)                                     |
|                         |                                |                |                   |                   |                               |                       | OR = 0.7 [95% CI: 0.5 to 1.0]                               | 3xSMS (M)                                      |
|                         |                                |                |                   |                   |                               |                       | OR = 1.7 [95% CI: 1.2 to 2.4]                               | 10xSMS (M)                                     |
| 2011 (Pop-Eleches) [16]| Kenya                          | HIV            | 428               | 66%               | 36.3                          | Medicine adherence    | RR = 1.0 [95% CI:0.7 to 1.4]**                               | Short daily SMS (R)                            |
|                         |                                |                |                   |                   |                               |                       | RR = 1.0 [95% CI: 0.6 to 1.9]**                              | Long daily SMS (M+R)                           |
|                         |                                |                |                   |                   |                               |                       | RR = 1.3 [95% CI:1.0 to 1.8]**                               | Short weekly SMS                               |
|                         |                                |                |                   |                   |                               |                       | RR = 1.3 [95% CI:1.0 to 1.8]**                               | Long weekly SMS                               |
| Finished trials, unpublished |                                             |                |                   |                   |                               |                       |                                                             |                                               |
| 2016 (NCT02680613) [53]| Tanzania                       | Cervical cancer screening | 600            | 100%              | -                             | Screening attendance  | SMS (M)                                       | SMS+travel voucher                            |
|                         |                                |                |                   |                   |                               |                       |                                                            |                                               |
| 2016 (Gibson) [43]     | Kenya                          | Childhood immunization | 2432 | 100% mothers   | -                             | Vaccination attendance | SMS (R+M)                                       | SMS+75 shilling                                |
|                         |                                |                |                   |                   |                               |                       |                                                            |                                               |
|                         |                                |                |                   |                   |                               |                       | SMS+200 shilling                              |                                               |
| 2016 (Rossing) [45]    | Guinea-Bissau                  | Measles vaccination | 990          | 100% mothers     | -                             | <72                   | Measles vaccine coverage                           | SMS (R)                                      |
|                         |                                |                |                   |                   |                               |                       |                                                            |                                               |
|                         |                                |                |                   |                   |                               |                       | SMS (M)                                       | SMS+call                                     |
|                         |                                |                |                   |                   |                               |                       |                                                            |                                               |
| 2016 (Wagner) [44]     | Burkina Faso                   | HIV            | 72 centres        | unknown           | -                             | Medicine adherence    | SMS 1 (R)                                       | SMS 2 (R)                                    |
|                         |                                |                |                   |                   |                               |                       |                                                            |                                               |
|                         |                                |                |                   |                   |                               |                       | SMS 3 (R)+MMS                                      |                                               |
|                         |                                |                |                   |                   |                               |                       | MMS                                            |                                               |
| Ongoing trials, unpublished |                                             |                |                   |                   |                               |                       |                                                             |                                               |
| 2018 (PACTR201802003035922) [54] | Cameroon            | HIV/Tuberculosis | 228             | unknown           | -                             | Medicine Adherence    | 1xSMS weekly (R+M)                                |                                               |
|                         |                                |                |                   |                   |                               |                       | 2xSMS weekly                                    |                                               |
| 2017 (Drake) [46]      | Kenya                          | HIV            | 825               | 100%              | -                             | Maternal virologic failure (RNA>1000) | SMS (E+M+R)                                   | SMS+quiz                                     |

(Continued)
which included attendance to childhood vaccinations, screening, medical follow-up appointments and proxy measures for retention in HIV care. Four trials had surrogate outcomes as primary outcome (i.e. ΔHbA1c, Δblood pressure, RNA > 1000) [23,29,46,55], three trials had knowledge change as primary outcome [26,31,40], and six trials had either facility delivery [33], HIV test [42], tuberculosis cure [49], measles vaccine coverage [45], decrease in anxiety level [39], or consumption of >4 food groups [52] as primary outcome.

Seven published trials had outcomes that did not include adherence or attendance [23,26,31,33,39,40,42] and their primary outcome was therefore only analysed descriptively. One trial had a surrogate primary outcome (Δblood pressure) and secondary outcomes on adherence and attendance [29] and included in both the descriptive- and meta-analysis. One trial [26] of three trials on knowledge change found an intervention effect as one-way SMS increased reproductive health knowledge among adolescent girls with 11% (95% CI: 7–15%) compared to controls (3 months after baseline). Yet, knowledge increased with 24% (95% CI: 19–28%) if they also received an interactive SMS quiz. However, at 15 months follow-up, there was no difference in knowledge level (3%; 95% CI:-1% to 7%) between the one-way SMS group and controls. One trial [39] found one-way SMS decreased anxiety after medical abortion when measured on a HADScale (absolute difference 1-3, p = 0.01). Additionally, one trial

Table 1. (Continued)

| Country | Clinical area | Trial size (n) | Female Age (Mean) | Follow-up (weeks) | Primary endpoint† | Intervention A (type) | Intervention B | Effect of intervention on primary endpoint compared to control |
|---------|---------------|---------------|-------------------|-------------------|-------------------|----------------------|--------------|-----------------------------------------------------------|
| 2017 (Linde) [47] | Tanzania | Cervical cancer screening | 700 | 100% | - | 60 | Attendance follow-up screening | SMS (E+R) | - |
| 2017 (NCT03297190) [52] | Tanzania | Diet (infant) | 2400 | 100% | - | unknown | Consumption of >4 food groups | SMS (E) | - |
| 2016 (NCT02721420) [51] | Malawi | Anaemia (child) | 375 | unknown | - | 15 | Medicine adherence | SMS 1 (R) | - |
| 2016 (NCT02915367) [30] | Kenya | HIV | 350 | 100% | - | <104 | Medicine adherence | SMS (R) | - |
| 2015 (ISRCTN-70768808) [55] | South Africa/ Malawi | Diabetes | 1065 | unknown | - | 52 | ΔHbA1c | SMS (E+M+R) | - |
| 2015 (L’Engle) [48] | Ghana | HIV | 1600 | unknown | - | 52 | Medicine adherence | SMS (R) | - |
| 2014 (Bediang) [49] | Cameroon | Tuberculosis | 208 | unknown | - | 32 | Cure | SMS (R+M) | - |

*Primary endpoint as reported in trial. If several primary endpoints were reported, then the first mentioned is reported in this table.

†SMS = One-way SMS unless specified otherwise.

‡Talisuna 2017: <1yr = 10%, 1-5yrs = 89%, 5yrs = 1%.

§Steury 2016: 18-25yrs = 35%; 26-35yrs = 28%; 36-50yrs = 24%; <50yrs = 16%.

¶RAifman 2014: SMS/control = 17%/14% (<5yrs), 21%/16% (5-17yrs), 56%/63% (18-59yrs).

†Trial eligible for meta-analysis and assessed for risk of bias.

‡SMSs sent to mother’s/caregiver’s phone.

| Unpublished information received by corresponding author. |
| Unpublished information received by corresponding author. |

**Relative Risk (RR) calculated based on numbers stated in article.

††The trial only reports an adjusted OR. An unadjusted OR has been calculated based on numbers stated in article. The second SMS-arm (Long SMS) is a pseudo-randomised intervention arm.

‡‡STD: Sexual transmitted disease

§§E = Educative SMS; M = Motivational SMS; R = Reminder SMS; T = Test result SMS

https://doi.org/10.1371/journal.pone.0217485.t001
[42] found that one type of one-way SMS (10 motivational SMS) increased HIV testing (OR = 1.7, 95% CI: 1.2–2.4) while the other three types of one-way SMS had no effect compared to controls. Trials on facility delivery [33], diabetes management [23], and hypertension [29,31] found no statistically significant effect of one-way SMS on the primary outcomes.

Meta-analysis and risk of bias assessment

Eighteen published trials all set in Sub-Saharan Africa could be included in the meta-analysis and judged for risk of bias. Twelve trials [15,19,22,20,27–30,35–38] (6448 participants) were included in our pooled analysis on healthcare appointment attendance. We found that one-way SMS improved appointment attendance compared with no SMS, OR: 2.03; 95% CI: 1.40–
Nine trials \[16,22,24,25,27,29,32,34,41\] (4213 participants) were included in our pooled analysis on medicine adherence. Data from one additional trial could not be included as adherence was measured as a continuous outcome \[36\]. We found that one-way SMS did not improve medicine adherence compared with no SMS, RR: 1.10; 95% CI: 0.98–1.23; \(I^2\) = 85% (Fig 4). For appointment attendance, sensitivity analysis showed a somewhat lower treatment effect using a fixed effect model compared to a random effects model, Fixed OR: 1.62; 95% CI: 1.42–1.85 versus Random OR: 2.03; 95% CI: 1.40–2.95 (Fig A in S2 File). For medicine adherence the effect estimates were similar, however, they became statistically significant using the fixed effect model, Fixed RR: 1.09; 95% CI: 1.05–1.14 versus Random: RR 1.10; 95% CI: 0.98–1.23 (Fig F in S3 File). A sensitivity analysis excluding the cluster trial \[19\] gave similar results as our primary analysis on appointment attendance. Post hoc sensitivity analyses excluding the trials \[20,22\] from potentially predatory journals did not alter our previous findings. We still found a statistically significant effect of SMS on appointment attendance, 2.95; \(I^2\) = 85% (Fig 3).
though the effect estimate and heterogeneity decreased, OR: 1.66; 95% CI: 1.23–2.4, I² = 76% (Fig C in S2 File), and no statistically significant effect of one-way SMS on medicine adherence, RR: 1.08; 95% CI: 0.97–1.21, I² = 85% (Fig I in S3 File).

Four trials [15,27,29,38] were judged as overall low risk of bias trials and 14 as high risk of bias trials [16,19,20,24,25,28,30,32,34−37,41] (Fig 5; S4 File). When comparing low risk of bias trials with high risk of bias trials, we found a lower treatment effect on appointment attendance in low risk of bias trials, OR: 1.36; 95% CI: 1.01–1.84; I² = 66% versus OR: 2.62; 95% CI: 1.42–4.83; I² = 85% (interaction test, p = 0.06) (Fig D in S2 File). When comparing low risk of bias trials with high risk of trials, we found no difference in effect on medicine adherence, RR: 1.13; 95% CI: 0.63–2.03; I² = 99% versus RR: 1.08; 95% CI: 1.02–1.14; I² = 2% (interaction test, p = 0.09). However, when stratifying the analysis in relation to risk of bias, heterogeneity disappeared in the high risk of bias group and increased in the low risk of bias group (Fig G in S3 File).

When stratifying data on appointment attendance according to clinical conditions, the analysis showed that SMS had an effect on childhood immunization (n = 3 trials) but not on HIV appointment attendance (n = 4 trials), OR: 3.69; 95% CI: 1.67–8.13 versus OR: 1.48, 95% CI: 0.73–3.00. The remaining trials had different clinical conditions and showed differential effects (Fig E in S2 File). When stratifying data on medicine adherence according to clinical conditions, the analysis showed that SMS had an effect on HIV medicine adherence (n = 4 trials) but not on malaria medicine adherence (n = 4 trials), RR: 1.18; 95% CI: 1.02–1.37 versus RR: 1.04; 95% CI: 0.94–1.12. The last trial concerned adherence to hypertension medicine and found an effect, RR: 1.27; 95% CI: 1.11–1.46 (Fig H in S3 File).

Discussion

In this systematic review and meta-analysis of one-way SMS trials in Africa, we found that one-way SMS overall improved healthcare appointment attendance though not medicine adherence. When stratifying data according to clinical conditions, our results suggest that one-way SMS has the highest impact on attendance to childhood immunization (n = 3 trials) but not on HIV appointment attendance (n = 4 trials), OR: 3.69; 95% CI: 1.67–8.13 versus OR: 1.48, 95% CI: 0.73–3.00. The remaining trials had different clinical conditions and showed differential effects (Fig E in S2 File). When stratifying data on medicine adherence according to clinical conditions, the analysis showed that SMS had an effect on HIV medicine adherence (n = 4 trials) but not on malaria medicine adherence (n = 4 trials), RR: 1.18; 95% CI: 1.02–1.37 versus RR: 1.04; 95% CI: 0.94–1.12. The last trial concerned adherence to hypertension medicine and found an effect, RR: 1.27; 95% CI: 1.11–1.46 (Fig H in S3 File).
| Study            | Random sequence generation (selection bias) | Allocation concealment (selection bias) | Blinding of participants and personnel (performance bias) | Blinding of outcome assessment (detection bias) | Selective reporting (reporting bias) | Incomplete outcome data (attrition bias) |
|------------------|---------------------------------------------|----------------------------------------|----------------------------------------------------------|------------------------------------------------|------------------------------------|----------------------------------------|
| Bangure 2015     | ?                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Bigna 2014       | •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Bobrow 2016      | •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Davey 2016       | •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Haji 2016        | ?                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Linnemayr 2017   | •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Liu 2016         | ?                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Nsagha 2016      | •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Odeny 2012       | •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Orrell 2015      | •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Pop-Elefches 2011| •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Ralfman 2014     | •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Reid 2017        | ?                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Schlumberger 2015| •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Steury 2016      | ?                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Talisuna 2017    | •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Thomas 2017      | •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |
| Wanyoro 2017     | •                                           | •                                      | •                                                        | •                                              | ?                                  | ?                                      |

Fig 5. Risk of bias assessment. *Empty cell: No bias assessment.*

https://doi.org/10.1371/journal.pone.0217485.g005
overview of how one-way SMS works generally in Africa. This can guide future mHealth research and strategies within Africa.

Our meta-analysis indicates that one-way SMS appears to have differential effect across clinical conditions, which is not surprising. It is likely more acceptable and manageable to attend short-term childhood vaccination appointments than life-long HIV appointments. HIV-related stigma is still an issue in Africa [56] and a basic one-way SMS may not able to overcome HIV-related barriers. Different types of mHealth interventions that include counseling or two-way SMS, where the receiver can communicate with the healthcare provider, may be more effective. However, it is outside the scope of this review to assess this type of mHealth interventions. Furthermore, a limitation of our subgroup analysis on clinical conditions is that outcomes were measured heterogeneously across trials. Despite our analysis indicating that one-way SMS has an effect on “HIV medicine adherence”, adherence was measured in various ways such as pick-up of medicine, pill counts, self-reported behaviour and automated pill boxes. Hence, these various differential outcome measures may be too diverse to group into one category. Though our analysis showed minor heterogeneity with an $I^2 = 7\%$ (Fig H in S3 File).

In our descriptive assessment of one-way SMS, we have stringently used unadjusted effect estimates and a 5% significance level (Table 1), which at times resulted in different conclusions than what was concluded by the trial authors [16,41]. E.g., a trial from Kenya concluded that one-way SMS improved HIV medicine adherence based on pooling two intervention arms (short/long weekly SMS) compared to controls (53% versus 40%, $p = 0.03$) [16]. However, individually these two intervention arms were not significantly different from the control group, RR: 1.3, 95% CI: 1.0–1.8, $p = 0.07$ (short weekly SMS) and RR: 1.3, 95% CI: 1.0–1.8, $p = 0.08$ (long weekly SMS). Further, if all four intervention arms are pooled (short/long daily/weekly SMS) the effect is not significant either, RR: 1.2, 95% CI: 0.9–1.5. Our analytical strategy is more conservative as some of the strategies employed by trial authors did not seem to be pre-specified. This highlights the importance of transparently reporting the choice of analytical strategy as this affects the overall conclusions of the effectiveness of one-way SMS. Additionally, our assessments showed that few trials were guided by health behaviour theory. Health behaviour theories, such as “The health belief model”, “The theory of planned behaviour”, and “The transtheoretical model and stages of change”, may increase the likelihood of interventions succeeding as they can help understand why people behave as they do, what researchers need to know before developing an intervention, and how interventions can be shaped so that they impact the target group as much as possible [57]. It is plausible that one-way SMS interventions may be more effective if researchers have a theoretical approach to developing the interventions.

The comparability of our findings is limited as other systematic reviews have had more inclusive approaches to mHealth and SMS. A 2013 Cochrane Review on SMS reminders and attendance to healthcare appointments concluded that there was low to moderate quality evidence of reminders increasing attendance compared to no or postal reminders, RR: 1.14, 95% CI: 1.03–1.26 [12]. This finding is in line with our results despite the evidence mainly stems from different settings; only one African trial was included in the Cochrane Review [15]. This was partly due to the Cochrane review excluding trials where the reminder was sent to the caretaker—e.g. in the case of childhood immunization—and partly due to to most African one-way SMS trials being published after the Cochrane Review. A 2015 systematic review on mHealth interventions’ effect on antenatal, postnatal and childhood immunization in LMICs included both SMS and apps targeted pregnant women or healthcare workers. No trials on childhood immunization were included though three observational studies—from Kenya
and Malawi—found that SMS increased immunization rates. However, the quality of evidence was low to moderate. These findings are also in line with the results of our review.

A 2012 Cochrane Review on mobile messaging and HIV medicine adherence included two trials from Kenya and concluded there was high quality evidence of SMS enhancing adherence to anti-retroviral therapy, RR: 1.16, 95% CI: 1.02–1.32 [13]. As the point estimate is similar to ours, this result supports our finding that one-way SMS have modest effect on HIV adherence, yet we did not find high-quality evidence as all four trials on HIV medicine adherence were assessed as overall high risk of bias. A 2018 systematic review on the effect of voice calls and SMS on HIV medicine adherence also concluded that SMS improved adherence to HIV medicine compared with controls, yet the effect estimate is somewhat higher than what we found, OR: 1.59, 95% CI: 1.3–2.0 [61]. This may be due to the SMS trials included in that review mainly involve two-way SMS or one-way SMS combined with co-interventions. Hence, these may be more effective at improving HIV medicine adherence than one-way SMS. No systematic reviews were found on mHealth and adherence to malaria medication.

From an overall global health perspective, it may be argued that future mHealth strategies and policies in Africa should prioritise to establish one-way SMS within areas, such as childhood immunization programs, as it appears more effective than on medicine adherence. However, as most trials had high risk of bias, there is a need for more large-scale high-quality trials in Africa. As mHealth is a heterogenous field and so is the sub-element of SMS, we recommend that scholars’ approach mHealth and SMS more narrowly and clearly distinguish between different interventions in order to provide a clearer overview of what have proven to work in what contexts within what health outcomes.

Conclusions

Despite the intriguing nature of simple one-way SMS and their potential to address global health issues in innovative ways, this review found that there is only evidence for the effect of one-way SMS within some outcomes and clinical conditions in Africa. Overall, one-way SMS improves attendance to healthcare appointments but not medicine adherence, and it has highest impact on attendance to childhood immunization appointments. One-way SMS may have modest impact on HIV medicine adherence and we found no evidence of one-way SMS impacting malaria medicine adherence or HIV appointment attendance. We recommend future mHealth strategies and policies in Africa to prioritise to use one-way SMS within childhood immunization programs and reconsider using it on medicine adherence as there is very minor or no effect within this area. However, more high-quality trials are needed. To clearly understand what type of mHealth works in different contexts, we advocate that scholars start differentiating between different types of mHealth and SMS interventions as well as have a theoretical approach when developing the content of the intervention.

Supporting information

S1 File. Literature search strings.
(DOCX)

S2 File. Subgroup and sensitivity analyses of one-way SMS versus no SMS on healthcare appointment attendance.
(DOCX)

S3 File. Subgroup and sensitivity analyses of one-way SMS versus no SMS on medicine adherence.
(DOCX)
S4 File. Risk of bias assessment. (DOCX)

S5 File. Protocol. (PDF)

S6 File. PRISMA checklist. (DOC)

Acknowledgments
The authors are grateful the for assistance of the librarian at the University of Southern Denmark, Herdis Foverskov, who assisted in developing the search strings for the review.

Author Contributions
Conceptualization: Ditte S. Linde, Vibeke Rasch, Marianne S. Andersen.
Data curation: Ditte S. Linde, Malene Korsholm, Johnson Katanga.
Formal analysis: Ditte S. Linde, Andreas Lundh.
Funding acquisition: Ditte S. Linde, Vibeke Rasch.
Investigation: Ditte S. Linde, Malene Korsholm, Johnson Katanga.
Methodology: Ditte S. Linde, Vibeke Rasch, Andreas Lundh, Marianne S. Andersen.
Project administration: Ditte S. Linde, Vibeke Rasch, Marianne S. Andersen.
Supervision: Vibeke Rasch, Andreas Lundh, Marianne S. Andersen.
Validation: Ditte S. Linde, Malene Korsholm, Johnson Katanga, Vibeke Rasch, Andreas Lundh, Marianne S. Andersen.
Visualization: Ditte S. Linde, Malene Korsholm, Vibeke Rasch, Andreas Lundh, Marianne S. Andersen.
Writing – original draft: Ditte S. Linde.
Writing – review & editing: Ditte S. Linde, Malene Korsholm, Johnson Katanga, Vibeke Rasch, Andreas Lundh, Marianne S. Andersen.

References
1. World Bank. World Development Report 2016: Digital Dividends. Washington DC: World Bank, 2016.
2. Agarwal S, LeFevre A, Lee J, L’Engle K, Mehli G, Sinha C, et al. Guidelines for reporting of health interventions using mobile phones: mobile health (mHealth) evidence reporting and assessment (mERA) checklist. BMJ 2016; 352: i1174. https://doi.org/10.1136/bmj.i1174 PMID: 26988021
3. World Health Organization. Global diffusion of eHealth: Making universal health coverage achievable. Report of the third global survey on eHealth. Geneva: World Health Organization, 2016.
4. Qiang C, Yamamichi M, Hausman V, Miller R, Altman D. Mobile Applications for the Health Sector. Washington DC: World Bank, 2012.
5. Beratarrechea A, Lee A, Wilner J, Jahangir E, Ciapponi A, Rubinstein A. The Impact of Mobile Health Interventions on Chronic Disease Outcomes in Developing Countries: A Systematic Review. Telemed J E Health 2014; 20(1): 75–82. https://doi.org/10.1089/tmj.2012.0328 PMID: 24205809
6. Watterson J, Walsh J, Madeka I. Using mHealth to Improve Usage of Antenatal Care, Postnatal Care, and Immunization: A Systematic Review of the Literature. BioMed Res Int 2015; 2015: 153402. https://doi.org/10.1155/2015/153402 PMID: 26380263
7. Lee S, Nurmatov U, Nwaru B, Mukherjee M, Grant L, Pagliari C. Effectiveness of mHealth interventions for maternal, newborn and child health in low- and middle-income countries: Systematic review and meta-analysis. J Glob Health 2016; 6(1): 010401. https://doi.org/10.7189/jogh.06.010401 PMID: 26649177

8. The World Bank. World Bank Country and Lending Groups. 2018. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (accessed October 23, 2018).

9. de Jongh T, Gurol-Urganci I, Vodopivec-Jamsek V, Car J, Atun R. Mobile phone messaging for facilitating self-management of long-term illnesses. Cochrane Database Syst Rev 2012; 12: CD007459.

10. Gurol-Urganci I, de Jongh T, Vodopivec-Jamsek V, Car J, Atun R. Mobile phone messaging for communicating results of medical investigations. Cochrane Database Syst Rev 2012; 6: CD007456.

11. Vodopivec-Jamsek V, de Jongh T, Gurol-Urganci I, Atun R, Car J. Mobile phone messaging for preventive health care. Cochrane Database Syst Rev 2012; 12: CD007457.

12. Gurol-Urganci I, de Jongh T, Vodopivec-Jamsek V, Car J, Atun R. Mobile phone messaging for communicating results of medical investigations. Cochrane Database Syst Rev 2012; 6: CD007456.

13. Horvath T, Azman H, Kennedy G, Rutherford G. Mobile phone text messaging for promoting adherence to antiretroviral therapy in patients with HIV infection. Cochrane Database Syst Rev 2012; 3: CD009756.

14. Adler A, Martin N, Mariani J, Tajer CD, Owolabi OO, Free C, et al. Mobile phone text messaging to improve medication adherence in secondary prevention of cardiovascular disease. Cochrane Database Syst Rev 2017; 4: CD011851.

15. Odeny T, Bailey R, Bukusi E, Simoni JM, Tapia KA, Yuhas K, et al. Text messaging to improve attendance at post-operative clinic visits after adult male circumcision for HIV prevention: a randomized controlled trial. PloS one 2012; 7(9): e43832. https://doi.org/10.1371/journal.pone.0043832 PMID: 22957034

16. Pop-Elesches C, Thirumurthy H, Habaryarima J, Zivin JG, Goldstein MP, de Walque D, et al. Mobile phone technologies improve adherence to antiretroviral treatment in a resource-limited setting: a randomized controlled trial of text message reminders. Aids 2011; 25(6): 825–834. https://doi.org/10.1097/QAD.0b013e32834380c1 PMID: 21252632

17. Higgins J, Green S. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]: The Cochrane Collaboration, 2011.

18. The Nordic Cochrane Centre. Review Manager (RevMan) [Computer program]. 5.3 ed: The Cochrane Collaboration, 2015.

19. Haij A, Lowther S, Ngan’ga Z, Gura Z, Tabu C, Sandhu H, et al. Reducing routine vaccination dropout rates: evaluating two interventions in three Kenyan districts, 2014. BMC Pub Health 2016; 16: 152.

20. Wanyoro AK, Kaburi EW. Use of Mobile Phone Short Text Message Service to Enhance Cervical Cancer Screening at Thika Level 5 Hospital, Kiambu County, Kenya: A Randomised Controlled Trial. Res Obst Gyn 2017; 5(1): 10–20.

21. Beall J. Beall’s List of Predatory Journals and Publishers. 2018. https://beallslist.weebly.com/ (accessed October 22, 2018).

22. Nsagha D, Lange I, Fon P, Assob J, Tanue E. A randomized controlled trial on the usefulness of mobile text phone messages to improve the quality of care of HIV and AIDS patients in Cameroon. Open AIDS J 2016; 10: 93–103. https://doi.org/10.2174/1874613601610010093 PMID: 27583062

23. Abaza H, Marschollek M. SMS education for the promotion of diabetes self-management in low & middle income countries: a pilot randomized controlled trial in Egypt. BMC Pub Health 2017; 17(1): 962.

24. Linnemayr S, Huang H, Luoto J, Kambugu A, Thirumurthy H, Haberer JE, et al. Text Messaging for Improving Antiretroviral Therapy Adherence: No Effects After 1 Year in a Randomized Controlled Trial Among Adolescents and Young Adults. Am J Public Health 2017; 107(12): 1944–1950. https://doi.org/10.2105/AJPH.2017.304089 PMID: 29048966

25. Reid MJ, Steenhoff AP, Thompson J, Gabaitiri L, Cary MS, Steele K, et al. Evaluation of the effect of cellular SMS reminders on consistency of antiretroviral therapy pharmacy pickups in HIV-infected adults in Botswana: a randomized controlled trial. Health Psy Behav Med 2017; 5(1): 101–109.

26. Rokicki S, Cohen J, Salomon JA, Fink G. Impact of a Text-Messaging Program on Adolescent Reproductive Health: A Cluster-Randomized Trial in Ghana. Am J Pub Health 2017; 107(2): 298–305.

27. Talisuna A, Oburu A, Githinji S, Malinya J, Amboko B, Bejon P, et al. Efficacy of text-message reminders on paediatric malaria treatment adherence and their post-treatment return to health facilities in Kenya: a randomized controlled trial. Malar J 2017; 16(1): 46. https://doi.org/10.1186/s12936-017-1702-6 PMID: 28126262
28. Thomas I, Lawani A, James B. Effect of short message service reminders on clinic attendance among outpatients with psychosis at a psychiatric hospital in Nigeria. Psychiatric Services 2017; 68(1): 75–80. https://doi.org/10.1176/appi.ps.201500514 PMID: 27582239

29. Bobrow K, Farmer A, Springer D, Shanyinde M, Yu LM, Brennan T, et al. Mobile Phone Text Messages to Support Treatment Adherence in Adults With High Blood Pressure [SMS-Text Adherence Support (SATS)]: A Single-Blind, Randomized Trial. Circulation 2016; 133(6): 592–600. https://doi.org/10.1161/CIRCULATIONAHA.115.017530 PMID: 26769742

30. Davey D, Nhavoto J, Augusto O. SMSaude: Evaluating mobile phone text reminders to improve retention in HIV care for patients on antiretroviral therapy in Mozambique. J Acquir Immune Defic Syndr 2016; 73(2): e23–e30. https://doi.org/10.1097/QAI.0000000000001115 PMID: 27632147

31. Hacking D, Haricharan H, Brittain K, Lau Y, Cassidy T, Heap M. Hypertension Health Promotion via Text Messaging at a Community Health Center in South Africa: A Mixed Methods Study. JMIR Mhealth Uhealth 2016; 4(1): e22. https://doi.org/10.2196/mhealth.4569 PMID: 26964505

32. Liu J, Modrek S. Evaluation of SMS reminder messages for altering treatment adherence and health seeking perceptions among malaria care-seekers in Nigeria. Health Policy Plan 2016; 31(10): 1374–1383. https://doi.org/10.1093/heapol/czw076 PMID: 27315831

33. Ungar JA, Ronen K, Perrier T, DeRenzi B, Slyker J, Drake AL, et al. SMS communication improves exclusive breastfeeding and early postpartum contraception in a low to middle income country setting: A randomised trial. BJOG 2018; 125(12):1620–1629. https://doi.org/10.1111/1471-0528.15337 PMID: 29924912

34. Steury E. Mobile Phone Short Message Service to Improve Malaria Pharmacoadherence in Zambia. J Nurs Scholarsh 2016; 48(4): 354–361. https://doi.org/10.1111/jnu.12216 PMID: 27145248

35. Bangure D, Chirundu D, Gombe N, Marufu T, Mandozana G, Tshimanga M, et al. Effectiveness of short message services reminder on childhood immunization programme in Kadoma, Zimbabwe—a randomized controlled trial, 2013. BMC Pub Health 2015; 15: 137.

36. Orrell C, Cohen K, Mauff K, Bangsberg D, Maartens G, Wood R. A Randomized Controlled Trial of Real-Time Electronic Adherence Monitoring With Text Message Dosing Reminders in People Starting First-Line Antiretroviral Therapy. J Acquir Immune Defic Syndr 2015; 70(5): 495–502. https://doi.org/10.1097/QAI.0000000000000770 PMID: 26218411

37. Schlumberger M, Bamoko A, Yaméogo T, Rouvet F, Ouedraogo R, Traoré B, et al. Positive impact of the Expanded Program on Immunization when sending call-back SMS through a Computerized Immunization Register, Bobo Dioulasso (Burkina Faso). Bull Soc Pathol Exot 2015; 108(5): 349–354. https://doi.org/10.1007/s13149-015-0455-4 PMID: 26498331

38. Bigna J, Noubiap J, Kouanfack C, Plottel C, Koulla-Shiro S. Effect of mobile phone reminders on follow-up medical care of children exposed to or infected with HIV in Cameroon (MORE CARE): a multicentre, single-blind, factorial, randomised controlled trial. Lancet Infect Dis 2014; 14(7): 600–608. https://doi.org/10.1016/S1473-3099(14)70741-8 PMID: 24932893

39. Constant D, de Tolly K, Harries J, Myer L. Mobile phone messages to provide support to women during the home phase of medical abortion in South Africa: a randomised controlled trial. Contraception 2014; 90(3): 226–233. https://doi.org/10.1016/j.contraception.2014.04.009 PMID: 24850188

40. Lau Y, Cassidy T, Hacking D, Brittain K, Haricharan H, Heap M. Antenatal health promotion via short message service at a Midwife Obstetrics Unit in South Africa: a mixed methods study. BMC Pregnancy Childbirth 2014; 14: 284. https://doi.org/10.1186/1471-2393-14-284 PMID: 25145970

41. Raftern J, Lanthorn H, Rokicki S, Fink G. The impact of text message reminders on adherence to antimalarial treatment in northern Ghana: a randomized trial. PloS One 2014; 9(10): e109032. https://doi.org/10.1371/journal.pone.0109032 PMID: 25350546

42. de Tolly K, Skinner D, Nembaware V, Benjamin P. Investigation into the use of short message services to expand uptake of human immunodeficiency virus testing, and whether content and dosage have impact. Telemed J E Health 2012; 18(1): 18–23. https://doi.org/10.1089/tmj.2011.0058 PMID: 22150712

43. Gibson DG, Kagucia EW, Ochisi B, Haricharan N, Obor D, Moulton LH, et al. The Mobile Solutions for Immunization (M-SIMU) Trial: A Protocol for a Cluster Randomized Controlled Trial That Assesses the Impact of Mobile Phone Delivered Reminders and Travel Subsidies to Improve Childhood Immunization Coverage Rates and Timeliness in Western Kenya. JMIR Res Protoc 2016; 5(2): e72. https://doi.org/10.2196/resprot.5030 PMID: 27189422

44. Wagner N, Ouedraogo D, Artavia-Mora L, Bedi A, Thomibiano B. Protocol for a Randomized Controlled Trial Evaluating Mobile Text Messaging to Promote Retention and Adherence to Antiretroviral Therapy for People Living With HIV in Burkina Faso. JMIR Res Protoc 2016; 5(3): e170. https://doi.org/10.2196/resprot.5823 PMID: 27535717
45. Rossing E, Rav H, Batista C, Rodrigues A. mHealth to Improve Measles Immunization in Guinea-Bissau: Study Protocol for a Randomized Controlled Trial. JMIR Res Protoc 2016; 5(3): e158. https://doi.org/10.2196/resprot.5968 PMID: 27466046

46. Drake AL, Unger JA, Ronen K, Matemo D, Perrier T, DeRenzis B, et al. Evaluation of mHealth strategies to optimize adherence and efficacy of Option B+ prevention of mother-to-child HIV transmission: Rationale, design and methods of a 3-armed randomized controlled trial. Contemp Clin Trials 2017; 57: 44–50. https://doi.org/10.1016/j.cct.2017.03.007 PMID: 28315480

47. Linde DS, Andersen MS, Mwaiselage JD, Manongi R, Kjaer SK, Rasch V. Text messages to increase attendance to follow-up cervical cancer screening appointments among HPV-positive Tanzanian women (Connected2Care): study protocol for a randomised controlled trial. Trials 2017; 18(1): 555. https://doi.org/10.2196/resprot.3659 PMID: 29162148

48. L’Engle K, Green K, Sucopp S, Laar A, Wambugu S. Scaled-Up Mobile Phone Intervention for HIV Care and Treatment: Protocol for a Facility Randomized Controlled Trial. JMIR Res Protoc 2015; 4(1): e11. https://doi.org/10.2196/resprot.3659 PMID: 25650838

49. Bediang G, Stoll B, Elia N, Abena JL, Nolna D, Chastony D, et al. SMS reminders to improve the tuberculosis cure rate in developing countries (TB-SMS Cameroon): a protocol of a randomised control study. Trials, 2014; 15: 35. https://doi.org/10.1186/1745-6215-15-35 PMID: 24460827

50. ClinicalTrials.gov [Internet]. Bethesda (MD): National Library of Medicine (US). 2000 Feb. Identifier NCT02915367, Monitoring Pre-exposure Prophylaxis for Young Adult Women. 2016. https://clinicaltrials.gov/show/NCT02915367 (accessed August 7, 2018).

51. ClinicalTrials.gov [Internet]. Bethesda (MD): National Library of Medicine (US). 2000 Feb. Identifier NCT02721420, Delivery of Malaria Chemoprevention in the Post-discharge Management of Children With Severe Anaemia in Malawi. 2016. https://clinicaltrials.gov/show/NCT02721420 (accessed August 7, 2018).

52. ClinicalTrials.gov [Internet]. Bethesda (MD): National Library of Medicine (US). 2000 Feb. Identifier NCT03297190, Impact on Nutritional Practices: SMS and Interpersonal Communication. 2017. https://clinicaltrials.gov/show/NCT03297190 (accessed August 7, 2018).

53. ClinicalTrials.gov [Internet]. Bethesda (MD): National Library of Medicine (US). 2000 Feb. Identifier NCT02680613, Pilot Study of a Mobile Health Approach to Reduce Barriers to Cervical Cancer Screening in Tanzania. 2016. https://clinicaltrials.gov/show/NCT02680613 (accessed August 7, 2018).

54. Pan African Clinical Trials Registry (PACTR) [Internet]. South Africa 2007. Identifier PACTR20180200335922, Retention in Care and Adherence to Treatment in HIV/TB Co-Infection. https://pactr.samrc.ac.za/TrialDisplay.aspx?TrialID=3035 (accessed on October 18, 2018).

55. Current Controlled Trials (ISRCTN) [Internet]. London: BioMed Central. [Date unknown]. Identifier ISRCTN70768808, SMS supporting treatment for people with type 2 diabetes. (2015) 2017. http://www.isrctn.com/ISRCTN70768808 (Accessed August 7, 2018).

56. The Joint United Nations Programme on HIV/AIDS. Miles to go–closing gaps, breaking barriers, righting injustices. Geneva: The Joint United Nations Programme on HIV/AIDS, 2018.

57. Glanz K, Rimer BK, Lewis FM. Health behaviour and health education. Theory, Research, and Practice. 3rd ed. Fransico San: Jossey-Bass; 2002.

58. Wakadha H, Chandir S, Were E, Rubin A, Obor D, Levine OS, et al. The feasibility of using mobile-phone based SMS reminders and conditional cash transfers to improve timely immunization in rural Kenya. Vaccine 2013; 31(6): 987–993. https://doi.org/10.1016/j.vaccine.2012.11.093 PMID: 23246258

59. Mbabazi W, Tabu C, Chemirim C, Kisia J, Ali N, Corkum MG, et al. Innovations in communication technologies for measles supplemental immunization activities: lessons from Kenya measles vaccination campaign, November 2012. Health Policy Plan 2015; 30(5): 639–44. https://doi.org/10.1093/heapolicy/czu042 PMID: 24920218

60. Crawford J, Larsen-Cooper E, Jezman Z, Cunningham S, Bancroft E. SMS versus voice messaging to deliver MNCH communication in rural Malawi: assessment of delivery success and user experience. Glob Health Sci Pract 2014; 2(1): 35–46. https://doi.org/10.9745/GHSP-D-13-00155 PMID: 25276561

61. Amankwaa I, Boateng D, Quansah D, Akuoko C, Evans C. Effectiveness of short message services and voice call interventions for antiretroviral therapy adherence and other outcomes: A systematic review and meta-analysis. PloS One 2018; 13(9): e020409.