

Mapping Evidence of Mobile Health Technologies for Disease Diagnosis and Treatment Support by Health Workers in Sub-Saharan Africa: A Scoping Review

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Abstract

Background: The rapid growth of mobile technology has given rise to the development of mobile health programmes aimed at treating and preventing a wide range of health conditions. However, evidence on the use of mHealth in high disease burdened settings such as SSA is not clear. We systematically mapped evidence on mHealth for disease diagnosis and treatment support by health workers in SSA.

Methods: We conducted a scoping review study guided by the Arksey and O'Malley's framework, Levac et al recommendations, and Joanna Briggs Institute guidelines. We thoroughly searched the following databases: MEDLINE and CINAHL with full-text via EBSCOhost; PubMed; Science Direct and Google Scholar for relevant articles from inception to July 2019. Two independent reviewers screened abstracts and full-text articles using the eligibility criteria as reference. This study employed the mixed methods appraisal tool version 2018 to assess the methodological quality of the included studies.

Results: Out of the 572 articles identified, only 10 published articles presented evidence on mHealth for treatment support by health workers in SSA since 2010. No studies reported evidence on mHealth for disease diagnosis by health workers in SSA. Of the 10 studies, four studies were conducted in Kenya; one in South Africa; one in Malawi; one in Zimbabwe; one in Mozambique; one in Nigeria and one in Lesotho. Of the 10 studies: three reported the use of mHealth to manage HIV; two on the management of HIV/TB; two on treatment of malaria; one each on the management of hypertension; cervical cancer; and one was not specific on any disease condition. All the 10 included studies underwent methodological quality appraisal with a score between 70 and 100%.

Conclusions: The study shows that there is limited research on the availability and use of mHealth by health workers for treatment support in SSA. This study also shows there is no literature on the availability and use of mHealth by health workers for disease diagnosis in SSA. We, therefore, recommend primary studies focusing on the use of mHealth by health workers for disease diagnosis in SSA. **Keywords:** Mobile Health; Disease diagnosis; Treatment support; sub-Saharan Africa

Background

Globally, there is tremendous growth in mobile technology which has given rise to the development of mobile health technology (mHealth) programmes for managing a wide range of health conditions (1). Health-related programmes using mobile communication technologies are evolving to help strengthen healthcare systems and deliveries (2–4). The Joint United Nations Programme on HIV/AIDS (UNAIDS) and World Health Organization (WHO) have jointly included wireless mobile communication as part of their strategic plans in implementing health policies and programmes (4, 5). Globally, smartphones usage have been estimated to be about 60% according to the Global Special Report for Mobile Association (GSMA) 2018 report, and this is projected to increase to almost 79% by 2025 (6). In 2018, the estimated smartphone users in Sub-Saharan Africa (SSA) was nearly 36%, and this is predicted to rise to about 66% by 2025 (7). In view of this high mobile phone penetration rate and its uniqueness, it has become a compelling tool for promoting healthcare delivery and bridging the gaps in accessing quality healthcare (8–10). Mobile phone text-messaging component has also changed from the normal global communication and is being utilized to support healthcare delivery and prevent diseases (11).

Mobile health technology can be defined as the use of mobile devices, their various components as well as other related technologies in healthcare delivery (12). Mobile health is an emerging and a promising way to improve disease prevention, diagnosis, treatment compliance, medication adherence and honouring clinic appointments thereby enhancing health outcomes (13). Mobile phone technology allows easy remote communication between health workers and their patients in hard-to-reach communities with poor access to healthcare due to deplorable roads or transportation challenges (14–16). Previous studies have demonstrated that mHealth technologies have the capacity to improve healthcare outcomes such as health workers adhering to case management standards and guidelines (11, 17–19). One main application of mHealth intervention that has the capacity to improve health workers performance is to send these health workers short message prompts, educational materials on new diagnostic and treatment procedures of cases, clinical guidelines and others (11, 17, 20, 21). In SSA, where healthcare systems continuously face problems like inadequate infrastructure, shortage of resources, and an increasing burden of communicable and non-communicable diseases such as HIV, tuberculosis, hypertension, diabetes, among others (22). To this end, mobile health technology is useful to support disease diagnosis and treatment of such diseases in SSA.

Mobile health technology also helps health workers to support their patients and prevent late disease detection, reduce mortalities, improve poor treatment outcomes, and many others (23). In SSA, people in limited-resource settings may have poor access to quality healthcare due to poor road networks, long distance travel, lack of trained or skilled health professionals, lack of health facilities, among others (16, 23, 24). In the light of these healthcare challenges and the potentials of mHealth for improving access to healthcare, mHealth could be adopted by health workers and policy-makers to support the provision of quality healthcare to people living in hard-to-reach communities. Despite this, no study has mapped literature on mHealth in SSA to the best of our knowledge. Hence, there is an urgent need to explore the role of mHealth for disease diagnosis and treatment support by health workers and identify gaps for future research. Therefore, this present study mapped evidence on mHealth for disease diagnosis and treatment support by health workers in SSA.

Methods

This study is part of a large study aimed at examining the accessibility of mHealth technologies for disease diagnosis and treatment support by health professionals in Ghana. This scoping review was guided by the 2005 Arksey and O'Malley's framework (25), Levac et al. 2010 recommendations (26) and the 2015 Joanna Briggs Institute (27) guidelines. The results of this review were presented in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis: Extension for Scoping Review (PRISMA-ScR) guidelines (28).

Identifying the research question

Research question: What are the evidence on the availability and use of mHealth for disease diagnosis and treatment support by health workers in SSA?

The Population, Concept, and Context (PCC) framework developed by Joanna Briggs Institute (27) was used to determine the eligibility of our primary research question as illustrated in Table 1.

Data sources and literature search

A systematic literature search was conducted from MEDLINE and CINAHL with full-text via EBSCOhost; PubMed; Science Direct; and Google Scholar databases. The search from the databases occurred in July 2019 using the following keywords: “mHealth technologies”, “mobile health”, “disease”, “diagnosis”, “treatment” “support” and “accuracy” (Additional file 1). Boolean terms (AND / OR) were used to separate our keywords. Medical subject headings (MeSH) were also used in the electronic database search. Date, language and study design limitations were removed to widen the scope of the conducted search to help capture almost all the full range of literature on mHealth for disease diagnosis and treatment support. The year of publication was from inception in order to identify the pattern of reports on mHealth for disease diagnosis and treatment support by health workers in SSA. Reference lists of the included articles were also searched thoroughly to source for relevant literature.

Study selection

Our study selection was conducted in three stages. At the first stage, EO conducted the electronic database search and screened titles of articles with guidance from the eligibility criteria. After the title screening, two reviewers (EO and VNP) independently screened the abstracts and full articles in parallel. Discrepancies in the reviewers’ responses at the abstract stage were resolved via a discussion until an agreement was reached. Discrepancies at the full article screening stage were resolved by a third reviewer (DK).

Eligibility criteria

Inclusion criteria

The following were included:

- Articles that reported evidence on Health Workers
- Articles that presented evidence on mHealth (text message, voice calls, multimedia messaging, mobile apps, emergency toll-free telephone services, among others)
- Articles that reported evidence on the availability of mHealth for disease diagnosis
- Articles presenting evidence on the availability of mHealth for treatment support
- Articles reporting evidence on the use of mHealth for disease diagnosis
- Articles that reported evidence on the use of mHealth for treatment support
- Articles presenting evidence from sub-Saharan Africa

Exclusion criteria

We excluded the following:

- Articles that reported evidence on patients
- Articles that reported evidence on eHealth
- Articles that presented evidence on mHealth for surveillance
- Articles that presented evidence on mHealth for health/medical education
- Articles that reported evidence on mobile clinics
- Articles that reported evidence on mHealth for communication
- Articles that presented outside sub-Saharan Africa

Data charting

The included selected articles were comprehensively read for data extraction using a standardized data extraction tool. We extracted data on the following: author and year of publication, country of the study, geographical setting (rural/urban/semi-urban), study setting and study design. Other information such as target population, type of technology, type of mHealth intervention, the purpose of mHealth, disease diagnosis and treatment support were also extracted as shown in table 2. NVivo version 12 was then used to help extract the themes from all the included primary articles.

Quality assessment of the included studies

We used the mixed method appraisal tool (MMAT) version 2018 (29) for methodological appraisal of all included primary studies. The included primary articles were appraised using the appropriate study designs as stipulated by the MMAT. The percentage quality score of all the included primary articles was then calculated for each and interpreted as $\leq 50\%$ -low quality, 51–75% -average quality, and 76–100%-high quality (30).

Collating, summarising and reporting

The study findings from the existing literature were presented using thematic content analysis. Our narrative literature was then structured around the themes derived from the study results or outcomes. The themes emerged from the articles were: availability of mHealth, use of mHealth in terms of treatment, prevention and management of HIV, TB, hypertension, cancer, malaria, pneumonia and diarrhoea conditions, use of mHealth for disease diagnosis, and acceptability of mHealth.

Results

Screening results

Seven hundred and twenty-five (725) eligible articles were identified from a total of 31,281 articles from the initial search. Of these, 153 duplicates were removed leaving 572 articles eligible for abstract screening. A total of 477 articles were excluded following abstracts screening, and 95 were found eligible for full article screening. Subsequently, at the full article screening stage, 88 articles were excluded as in shown Figure 1 which demonstrates the PRISMA-ScR flow chart of literature search and selection of studies. Reasons for excluding 88 articles after the full article screening are as follows: twenty-four articles were conducted outside SSA (31–54), fifteen articles presented evidence on patients (55–69), ten articles presented evidence on mobile clinics (70–79), eight articles presented evidence on mHealth for data collection (80–88), four articles reported evidence on mHealth for disease tracking and surveillance (89–92) and seven articles presented evidence on perceptions and adoption of mHealth (22, 87, 93–97). Others included: three articles presented evidence on mHealth for communication (98–100), five articles reported evidence on mHealth for health education (23, 89, 101–103), five articles presented evidence on mHealth development and framework (104–109), six articles presented evidence on mHealth for evaluation and assessment (110–115), and one article presented evidence on mobile phone ownership (116). A total of 10 included primary articles met our eligibility criteria with three other articles identified through additional search were included for data extraction. The level of agreement between the reviewers' response following full article screening was 73.68% versus 59.72% as expected by chance which represents lack of agreement (Kappa statistics = 0.35, and p-value <0.05). In addition, the McNemar's chi-square statistic suggests that there was a statistically significant difference in the proportions of yes/no answers by the reviewers with p-value <0.05 (Additional file 2). Discrepancies between the reviewers' responses at the full article screening stage were resolved by involving a third reviewer.

Characteristics of included articles

Out of the 10 included studies, three studies reported on the usage of mHealth for treatment support of the following disease conditions: HIV/AIDS (4, 117, 118); HIV and TB (1, 14); two on malaria, pneumonia and diarrhoea support (11, 17); one on hypertension (119); one on cervical cancer support (120) and one study did not specify any disease (121). Figure 2 shows the distribution of included studies by diseases. The characteristics of the included articles are summarised in Table 2. The 10 included articles comprised three qualitative studies (1, 117, 118), four cluster randomized control trial (4, 11, 14, 17), one quantitative study (121), and two mixed method studies (119, 120). All the included articles were published in English language from 2010 to 2019. All the included studies presented evidence on mHealth for treatment support by health workers in SSA. None of the 10 included primary studies reported evidence on mHealth for disease diagnosis by health workers in SSA. In terms of geographical settings, five of the 10 included studies were conducted in urban settings (17, 118–121); three studies were conducted in semi-urban settings (1, 14, 117); one study was conducted in rural settings (11), and only one study was conducted in rural, semi-urban and urban settings (4). Figure 3 shows the distribution of included studies by geographical settings. Out of the 10 included studies, four studies were conducted in Kenya (4, 11, 117, 118); one in Malawi (17); one in Zimbabwe (121); one in South Africa (120); one in Mozambique (1); one in Nigeria (119) and one in Lesotho (14).

Quality of the evidence

All the 10 included primary studies underwent methodological quality assessment using the 2018 version of MMAT (29). The ten included primary studies which underwent the methodological quality appraisal scored within the range of 70 and 100%. Out of the ten included primary studies, six studies scored 100% which is the highest quality score (1, 117–120, 122); two studies had an average of 85.7% quality score (4, 121); and the two remaining studies also had the lowest quality score of 71.4% (11, 14) (Additional file 3).

Summary of study findings

All the included primary studies presented evidence on the availability and use of mHealth for treatment support by health workers in SSA. Figure 4 demonstrates the time mHealth for treatment support was first published, countries with mHealth, type of mHealth interventions used and the purpose of the mHealth interventions. The following are the themes that emerged from the included studies: availability of mHealth, use of mHealth in terms of treatment, prevention and management of HIV, TB, hypertension, cancer, malaria, pneumonia and diarrhoea conditions, use of mHealth for disease diagnosis, and acceptability of mHealth.

Availability of mHealth

All the included studies reported on the availability of mHealth (1, 4, 11, 14, 17, 117–119, 121–123). Studies conducted in Kenya reported on the availability of mHealth to support pregnant women living with HIV to comply with antiretroviral drugs medication and improve the prevention of mother-to-child-transmission (118); help HIV/AIDS patients adhere to medication procedures (4, 117); and encourage health professionals to adhere to standard guidelines when treating malaria conditions (11). A study in Mozambique indicated the availability of mHealth for supporting HIV and TB patients to honour their clinical appointments and collect their drugs on time (1). Availability of mHealth was also reported in Lesotho where mHealth was used to help patients reduced the number of missed clinical appointments and collected their drugs on time (14). Kaunda-Khangamwa et al demonstrated the availability of mHealth to encourage health workers to strictly adhere to standard guidelines in the treatment of malaria, pneumonia and diarrhoea cases (17). Nelissen et al conducted a mixed method study which reported on the availability of mHealth to help hypertension patients adhere to or comply with treatment (119). Moodley et al reported evidence on the availability of mHealth for supporting patients to manage their cancer cases (123). Marufu et al conducted a quantitative study which revealed the availability of mHealth to set-up clinical appointments, remote consultation and adherence to medication procedures (121). We found that mHealth for treatment support is available in only seven SSA countries with few diseases which demonstrates a major gap in literature.

Use of mHealth for treatment support

All the included studies reported on the use of mHealth technology for treatment support (1, 4, 11, 14, 117–119, 121–123). Nelissen et al showed that both healthcare providers and patients perceived the mHealth app as supportive and attractive in managing patients' illness (119). Zurovac et al suggested that the text messages helped health workers to improve their quality of disease management skills (11). Their study results further suggested that the proper management of artemether-lumefantrine medications improved the treatment and cure of children suffering from malaria (11). A similar study conducted in Malawi revealed that the SMS intervention assisted health workers to comply with standards and guidelines in treating malaria cases, and improved their case management skills (17). The results of this study further showed that some clinicians used the message received as reference materials to support the treatment and cure of such diseases (17). Other studies conducted in Kenya also reported that mHealth interventions provided by health workers assisted HIV patients to comply with treatment procedures and stick to medication adherence (4, 117, 118). Similar studies conducted in Mozambique and Lesotho showed that the SMS intervention provided by health workers helped HIV/TB patients to stay in treatment and increased treatment compliance (1, 14). The findings presented evidence on the use of mHealth for only malaria, pneumonia, and diarrhoea conditions treatment support demonstrating a gap as mHealth could be used to support the treatment of several other diseases in SSA.

Use of mHealth for prevention of mother-to-child transmission of HIV

Only one study reported on the use of mHealth intervention to prevent the transmission of diseases (118). Larissa et al conducted a study aimed at examining what specific content and forms of mobile communication are acceptable to support the prevention of mother-to-child transmission (118). The results revealed that SMS reminders sent by health workers assisted HIV infected pregnant women to stick to the prescribed antiretroviral medication procedures to prevent their unborn babies from contracting the virus (118). The results also indicated that HIV infected pregnant women had remote access to their healthcare providers and could easily request more antiretroviral drugs via mHealth without travelling to the health facility (118). The findings presented evidence on the use of mHealth to prevent the transmission of only HIV condition but no evidence on the use of this intervention to prevent the transmission of other communicable and non-communicable diseases in SSA.

Use of mHealth for management of diseases

Six studies reported the use of mHealth for the management of disease conditions like hypertension, cancer, HIV and tuberculosis (TB) (1, 4, 14, 117, 119, 123). Nhavoto et al suggested that mHealth reminders provided by health workers assisted HIV and TB patients to comply with treatment procedures, collection of drugs on time and adhering to clinical appointments (1). A randomized control trial study carried out by Lester et al demonstrated that patients who received the SMS intervention adhered to ART medication procedures (4). The results also showed that the SMS intervention helped to reduce viral replication via ART, hence decreasing transmission of HIV1 to new partners (4). Hirsch-Moverman et al also conducted a similar study which suggested that patients perceived their adherence to clinic appointments and medication procedures were due to the SMS received from health workers (14). Their study results further revealed that mHealth can support patients to have remote access to their healthcare providers to report a side effect, seek advice or inform them about potential delays in clinic appointments (14). Moodley et al illustrated that SMS sent to patients by health workers improved the management of cervical cancer conditions and encouraged patients' adherence to clinical colposcopy appointments (123). Nelissen et al revealed that patients' medication adherence and treatment compliance improved significantly due to regular monitoring by health professionals using the mobile app intervention (119). Smillie et. al study showed that the SMS and voice call reminders helped HIV patients to adhere to antiretroviral treatment process, medication procedures as well as honouring their clinical appointments (117). The results of their study further indicated that this intervention helped health workers to better manage HIV cases (117). We found that mHealth was used to manage only few communicable diseases (HIV, TB) and non-communicable diseases (hypertension, cancer), however a gap was revealed as mHealth could be used to manage many other communicable and non-communicable diseases.

Use of mHealth for disease diagnosis

None of the ten included primary studies reported evidence on the use of mHealth for disease diagnosis by health workers in SSA.

Acceptability of mHealth

All the ten included primary studies reported on the acceptability of mHealth by health workers to support quality healthcare delivery. Two studies reported that health workers accepted SMS intervention as a supportive tool to help them improve their clinical management skills in treating disease conditions (11, 17). The results of these studies also demonstrated that clinicians were appreciative of SMS reminders as reference materials to support the treatment of patients suffering from malaria and other diseases (11, 17). Three studies also reported that health professionals expressed interest in using mHealth for clinic appointments; remote consultation; medication adherence reminders and delivery of patients test results (118, 121, 123). Their results again found that medical doctors accepted mHealth as a medium to help them improve service delivery (118, 121, 123). Five studies reported that health workers were excited to use text messages to help patients to reduce the number of missed appointments; improve the collection of drugs on time; comply with dosage instructions; motivational messages and health education information (1, 4, 14, 117, 119). However, three studies also reported that some health workers raised issues over confidentiality and privacy breaches which should be of public concern with regards to mHealth (1, 117, 123). The findings illustrate that there is limited evidence on the acceptability of mHealth for treatment support of malaria, HIV, TB, hypertension and cancer.

Discussion

This scoping review mapped existing literature on the availability and use of mHealth for disease diagnosis and treatment support by health workers in SSA. The findings illustrated that there is limited published research on the availability of mHealth for treatment support in many SSA countries. This is very disturbing and requires immediate action from all relevant stakeholders as SSA seeks to reduce the high disease burdens and improves poor access to healthcare. We also found limited published research on the availability and use of mHealth for treatment support by health workers in SSA. The results further demonstrated limited research on the use of mHealth interventions to manage some chronic disease conditions such as HIV, TB, cancer and hypertension in SSA. Nonetheless, the results demonstrated that these interventions enhanced adherence to treatment and medication procedures, promoted clinical appointments compliance, and improved collection of drugs on time. To this end, we propose that more mHealth interventions should be scaled-up to support the management of many communicable and non-communicable diseases in SSA to enhance quality of health outcomes. The results also revealed that Kenya had the highest evidence on the use of mHealth to support the management of HIV compared to other sub-Saharan African countries. This potentially could help Kenya to improve healthcare access to majority of her population in accordance with the universal health coverage policy (124).

One notable study finding was that no studies reported evidence on the use of mHealth for disease diagnosis by health workers in SSA. This finding is worrying and requires redress considering that WHO is advocating for improving access to healthcare, particularly in resource-limited settings (124). Rural communities in SSA most often have poor roads, lack of transportation, inadequate health infrastructure, and poor access to healthcare. Therefore, we recommend research and implementation of mHealth for disease diagnosis. This will facilitate early detection and treatment of most diseases and improve health outcomes among the general population in SSA.

The limited level of published research on the use of mHealth by health workers to manage communicable diseases like HIV, TB and malaria conditions demonstrates that much effort is still required by SSA towards the achievement of the Sustainable Development Goal (SDG) 3.3 (125) target which advocates that by 2030 the epidemics of HIV, TB, malaria, and other communicable diseases will be ended. This is not good and requires urgent attention from all the appropriate stakeholders to initiate new mHealth interventions and/or scale-up existing ones to manage several other communicable diseases in SSA. Again, the findings showed limited research on the use of mHealth by health workers to manage non-communicable diseases (NCDs) in SSA. This demonstrates that SSA has to do more in order to achieve the SDG 3.4 (125) target which stipulates that by 2030 pre-mature deaths from NCDs will be reduced by one-third via treatment and prevention. This is worrying and needs an urgent redress if SSA wants to achieve this SDG target.

Our review study are partly consistent with other studies carried out in high-income countries (HICs) (38–40, 54) which found the use of mHealth to manage chronic disease conditions like HIV, TB, hypertension and cancer. Similar studies conducted in low-and middle-income countries (LMICs) also agree with the findings of this review study which revealed the use of mHealth improved medication adherence and treatment compliance (41, 46). Other studies conducted in HICs demonstrated a relatively higher level of research on the use of mHealth to support the treatment procedures of many communicable and non-communicable diseases (39, 41, 45, 50, 53) which are at variance with this study. Roesler et al and Ochalek et al conducted studies in Brazil and US which showed limited level of research on the use of mHealth to prevent transmission of diseases from one individual to another (51, 52) which are similar to our findings. In addition, some studies conducted in HICs and other LMICs indicated limited level of research on the use of mHealth interventions for diagnostic purposes (37, 47) which are different from the study findings. Furthermore, there is a higher level of research from some studies conducted in HICs and other LMICs which showed that health workers used tablets, personal digital assistants, handheld devices and mobile phones to support disease diagnosis and treatment procedures (37–41, 45, 47, 52–54) which are not consistent with this study findings.

Strengths and limitations

Our review included studies conducted in different settings (urban, semi-urban and rural) which provides an overview of mHealth for disease diagnosis and treatment support by health workers in SSA. This scoping review study to the best of our knowledge is the first comprehensive study to explore the available evidence in literature on the availability and use of mHealth for disease diagnosis and treatment support by health workers in SSA. This study illustrated a substantial gap in literature on the availability and use of mHealth for disease diagnosis by health workers to guide future research in SSA. The methodology of our review study also allowed us to include different study designs; identifying all relevant articles systematically; data charting and analysing the various study outcomes (25, 126) which may not be performed in review articles. One important strength of our review study was the removal of limitations of date, language and study design. A comprehensive search for available literature used in this reviewed study is another important strength of the study. In spite of all these, it is highly possible that research on mHealth for disease diagnosis and treatment support by health workers in SSA probably existed under different terminologies were not captured in our study. Nonetheless, we included the Medical Subject Heading terms to capture all relevant available literature. This review study was also limited to studies conducted within sub-Saharan Africa and may not be generalised.

Implications for practice

Majority of the studies were conducted in urban settings where access to quality healthcare is mostly available with modern health facilities and highly skilled health professionals. Only a few were conducted in semi-urban and rural settings where access to healthcare or health infrastructure is poorly developed with either no or insufficiently trained health workers. This demonstrates that people in hard-to-reach communities may have to travel long distance with transportation challenges to access healthcare services. This may prevent such people from accessing healthcare which could lead to late disease detection, late detection of drug resistance, poor treatment outcomes and increase in health-related mortalities. The study findings also revealed that in SSA, health workers used only mobile phones with text message reminders intervention to support treatment procedures. This may affect many patients in resource-limited settings who cannot read and write and may not benefit fully from this intervention, hence more voice calls intervention should be encouraged.

Recommendations for future research

Our reviewed study findings demonstrate that there is limited published research on the availability and use of mHealth for treatment support by health workers in SSA. We, therefore, recommend that more primary studies should be conducted in this setting to examine the availability and use of mHealth to support treatment procedures. The findings also show that mHealth for treatment support is available in only few SSA countries. We, therefore, recommend the implementation of mHealth interventions in many countries within SSA to support treatment procedures of diseases. The findings further show that mHealth interventions are mostly found in urban settings in SSA. Hence, we recommend that more primary research should be conducted at primary healthcare clinics to assess the availability and use of mHealth for disease diagnosis and treatment support by health workers. The results also reveal mobile phone text message reminders as the most commonly used mHealth intervention by health workers in SSA. We also recommend that more other forms of mobile wireless devices like personal digital assistants, tablets, smartphones and other wearables with more voice calls, multimedia messaging services and other interventions should be used. Considering that no studies reported on the availability and use of mHealth by health workers for diagnostic purposes in SSA. We recommend future research aimed at exploring the availability and use of mHealth by health workers for disease diagnosis. Randomized control trial studies on mHealth for disease diagnosis and treatment support are also recommended because they are the most appropriate study design for assessing the impact and cost-effectiveness of an intervention.

Conclusion

The study shows that there is limited research on the availability and use of mHealth by health workers for treatment support in SSA. The study demonstrates that mHealth interventions can be used to treat, prevent and manage both communicable and non-communicable diseases effectively in SSA. This study, in addition, reveals the overall acceptance on the use of mHealth by health workers to support treatment procedures in SSA. Finally, our review study shows that there is no published research on the availability and use of mHealth by health workers for disease diagnosis in SSA. Therefore, we recommend that more primary studies should be conducted in this region on the use of mHealth by health workers for disease diagnosis.

Abbreviations

WHO-World Health Organization

UNAIDS- Joint United Nations Programme on HIV/AIDS

GSMA- Global Speciale for Mobile Association

SSA-Sub-Saharan Africa

AIDS- Acquired immunodeficiency syndrome

HIV-Human immunodeficiency virus

TB-Tuberculosis

PRISMA-ScR- Preferred Reporting Items for Systematic Reviews and Meta-analysis: Extension for Scoping Review

PCC-Population, Concept and Context

MMAT- Mixed Method Appraisal Tool

SMS-Short Messaging Service

SDG-Sustainable Development Goal

NCDs-Non-communicable diseases

HICs-High-Income Countries

LMICs-Low-and Middle-Income Countries

Declarations

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Authors' contributions

EO conceptualized and designed the study together with DK and TPM-T. EO, VNP, DK and TPM-T contributed in the abstract, full article screening and the quality assessment of the included studies. DK and TPM-T contributed in the synthesis of data and the design of the sifting and data extraction processes. EO prepared the first draft of the study, and DK and TPM-T critically reviewed the draft. EO prepared the final draft and all authors approved it. All authors read and approved the final manuscript.

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Availability of data and materials

The data supporting the conclusions of this paper are available through the detailed reference list. No original datasets are presented, due to the fact that this is a review of already existing literature.

Ethics approval and consent to participate

This paper is a scoping review study that relied strictly on the review of existing literature, no human participants were involved. Therefore, ethical approval and consent to participate by human participants was not applicable.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests

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Tables

Table 1: PCC framework for defining the eligibility of the studies for the primary research question

Determinants	Description
Population	Health workers- All categories of trained health professionals such as Nurses, Doctors, Pharmacist, Biomedical scientist/Technologist Radiologist, and others working in healthcare facilities located in sub-Saharan Africa
Concept	<p>Disease diagnosis and treatment support</p> <p>Disease diagnosis- Use of mHealth as diagnostic apps to screen or examine patients to identify or detect any form of disease or disorder.</p> <p>Treatment support- Use of mHealth to provide treatment and guiding patients to manage their disease conditions without their physical presence at the health facility.</p>
Context	<p>Availability and use in sub-Saharan Africa</p> <p>Availability- mHealth being accessible, usable and obtainable upon the demand to perform a required function.</p> <p>Use- Process of employing mHealth to accomplish a task such as diagnosis, treatment, control/prevention and management of diseases.</p>

Table 2: Characteristics of the included articles

Author and date	Country	Geographical setting (rural/urban/semi-urban)	Study setting	Study design	Target population	Aim of the study	Type technology	mHealth intervention
Kaunda-Khangamwa et al., 2018 (17)	Malawi	Urban	Government hospitals and Christian Health Association of Malawi hospitals	Cluster-randomized trial study	Health workers	The aim of the study was to assess the effect of mobile phone text message reminders on health workers' adherence to case management guidelines for malaria and other diseases	Mobile phone	Short message service (SMS)
Larissa et al., 2013 (118)	Kenya	Urban	Kendu Bay and Rachuonyo districts hospitals	Descriptive qualitative study	Community health workers	The aim of the study was to examine what specific content and forms of mobile communication are acceptable to support prevention of mother-to-child transmission (PMTCT)	Mobile phone	SMS and voice
Marufu et al., 2017 (121)	Zimbabwe	Urban	District hospital	Quantitative study	Health workers	The aim of the study was to determine the use of mHealth and identifying and describing the opportunities and the challenges faced by the medical doctors in using mHealth at a specific health care facility	Cell phone	Voice and internet-based
Moodley et al., 2019 (122)	South Africa	Urban	Cape Town tertiary hospital	Mixed method study	Primary health workers	The aim of the study was to determine the feasibility of mobile health technology to improve management and follow-up of clients with cervical cancer precursor lesions	Mobile phone	SMS
Nelissen et al., 2018 (119)	Nigeria	Urban	University teaching hospital and Pharmacy-based care model	Mixed method study	Health workers	The aim of the study was to investigate the feasibility of a pharmacy-based hypertension care model using mHealth	Mobile phone	Mobile phone and internet-based calls
Nhavoto et al., 2017 (1)	Mozambique	Semi-urban	Machava II health centre, Matolla I & II health centres, Namaacha health centre and Ndlavela	Qualitative study	Health workers	The aim of the study was to examine patients' and healthcare workers' views on an mHealth intervention aiming to support	Mobile phone	SMS

			Health centre			retention in antiretroviral therapy (ART) and tuberculosis (TB) treatment		
Smillie et al., 2014 (117)	Kenya	Semi-urban	Kibera Community health centre (KCHC) and Research Foundation (AMREF) clinic	Qualitative study	Community health workers	The aim of the study was to explore the experiences of people living with HIV and their perceptions of communicating via text message with healthcare providers	Mobile phone	SMS (Web and calls)
Lester et al., 2010 (4)	Kenya	Urban, semi-urban and rural	University of Nairobi Pumwani clinic, Coptic Hope Centre for Infectious Diseases and Kajiado clinic	Randomized controlled trial study	Health workers	The aim of the study was to assess whether mobile phone communication between health workers and patients starting ART improved drug adherence and suppression of plasma HIV 1	Mobile phone	SMS
Hirsch-Moverman et al., 2017 (14)	Lesotho	Semi-urban	Berea district health facilities	Cluster randomized trial study	Health workers	The aim of the study was to describe the use and acceptability of mHealth by patients with HIV/tuberculosis and health care providers	Mobile phone	SMS
Zurovac et al., 2011 (11)	Kenya	Rural	Rural government health centres	Cluster randomized trial study	Health workers	The aim of this study was to assess whether text-message reminders sent to health workers' mobile phones could improve and maintain their adherence to treatment guidelines for outpatient paediatric malaria	Mobile phone	SMS

Figures

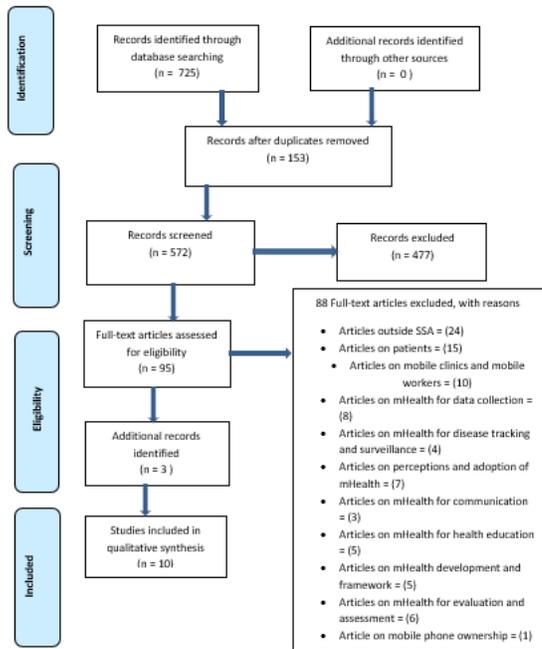


Figure 1

PRISMA-ScR flow chart showing literature search and selection of studies

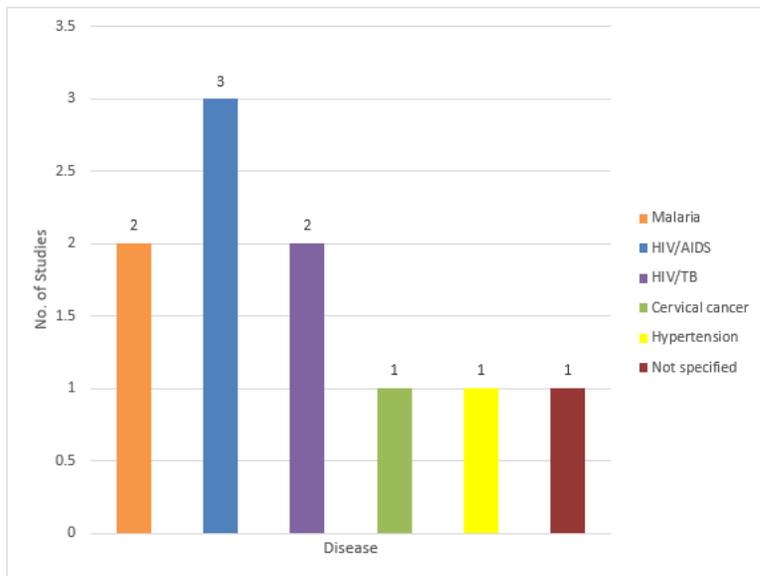


Figure 2

Distribution of included studies by diseases

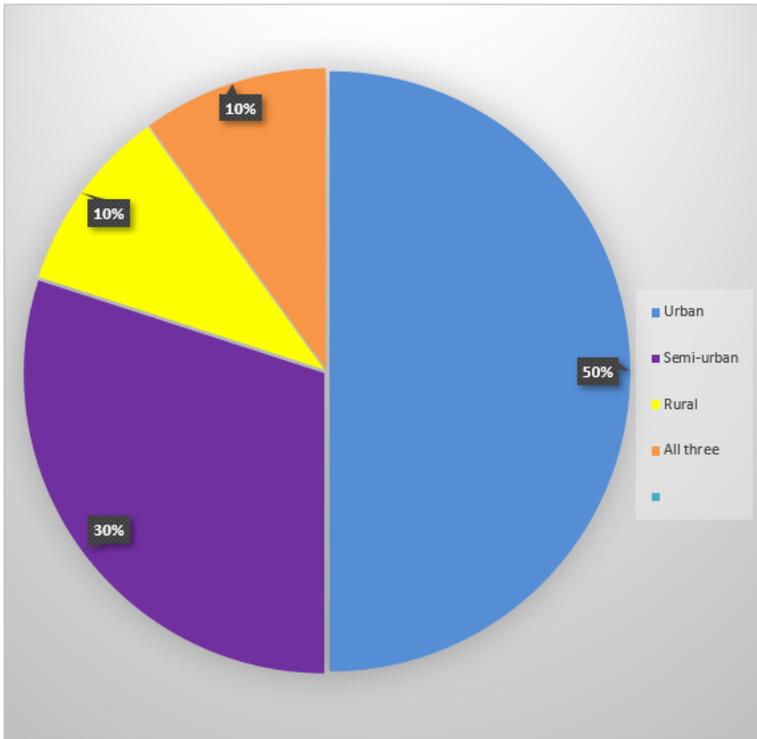


Figure 3

Distribution of included studies by geographical settings

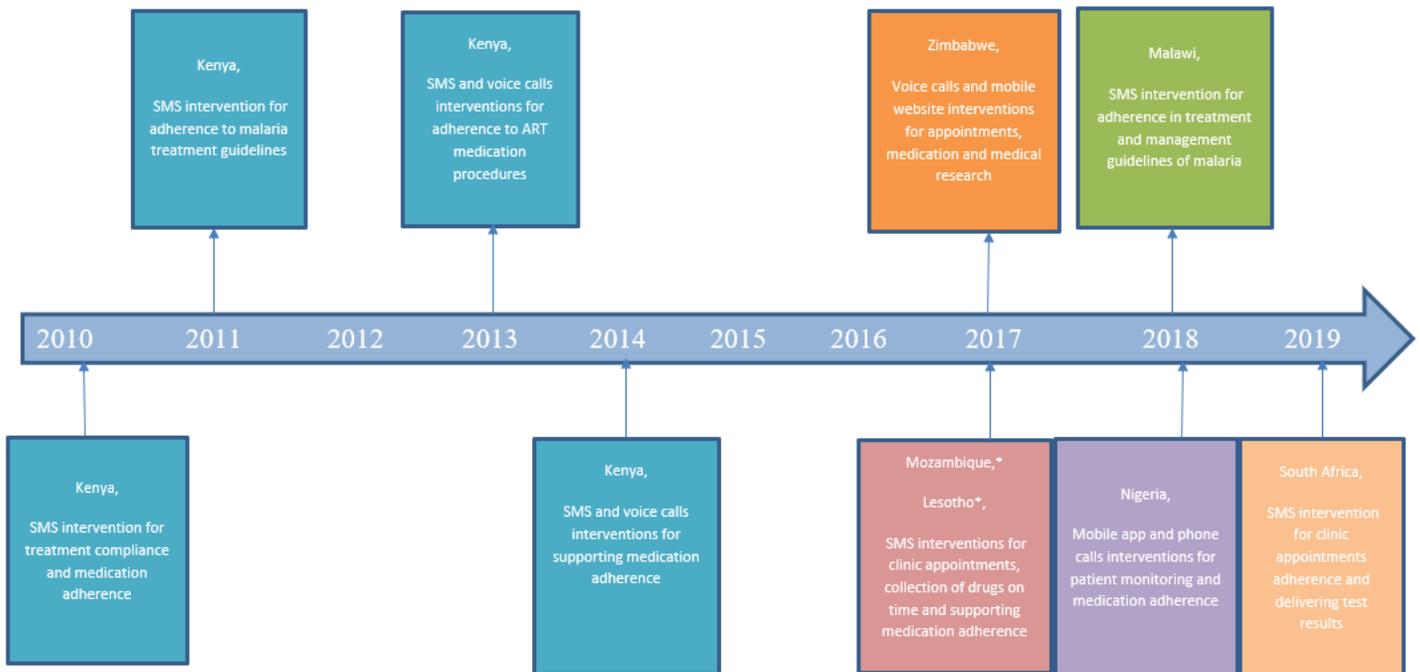


Figure 4

Distribution of studies with countries of publication and the type of mHealth intervention

Supplementary Files

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