Review Article

Current evidence on the use of mHealth approaches in Sub-Saharan Africa: A scoping review

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ABSTRACT

Background: Mobile health (mHealth) approaches are especially beneficial to Sub-Saharan Africa (SSA), which has a disproportionate disease burden and a scarcity of healthcare workers.
Objective: This study aims to assess the availability, stage, and targeted health issues of mHealth interventions in SSA and to identify the gaps.
Methods: The study employed a scoping review guided by Arksey and O'Malley's framework to explore the use of mHealth in SSA. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) was used to report the review in a transparent and comprehensive manner. Articles published from 2000 to 2021 were searched in PUBMED, IEEE, SCOPUS, and Web of Science and evaluated with set of inclusion criteria. Data from the included publications were retrieved and synthesized.
Results: A total of 1020 articles were found. 59 of these have met the criteria for inclusion. The results show the implementation of mHealth interventions in 21 SSA nations. Only 1 (2%) mHealth interventions used a wearable sensor-based approach. 13 (22%) were SMS text-based interventions, 17 (29%) were app-based mHealth approaches, 18 (30%) were telemedicine-based approaches, and 10 (17%) were mixed approaches. HIV, cancer, and maternal and child health problems are the most commonly discussed health issues. Proof of concept, design and development, a pilot test were the frequently documented stages of mHealth interventions.
Conclusion: Less than half of SSA countries incorporate mHealth platforms, highlighting the need for further development. Integrating wearable based platforms for real-time monitoring of physiological parameters demands careful consideration.
Public Interest Summary: Mobile health (mHealth) technology is believed to be very beneficial for Sub-Saharan Africa (SSA) nations where there is a high disease burden but inadequate healthcare system. Evidence-based data on the use and implementation of mHealth systems is needed to trace implementation and fill existing gaps. We performed a scoping review to determine the current availability, use, and stage of mHealth interventions and targeted health services in SSA. 21 SSA nations made (few) attempts in designing and implementing of mHealth systems. HIV, cancer, and maternal and child health are some of the health services among others. Though few large-scale implementations were reported, most interventions are at an early stage. mHealth solution should be designed to be both economical and simple to use to increase its uptake and incorporate wearables for real-time monitoring of physiological parameters.

Introduction

Through its global observatory report, the World Health Organization (WHO) defined mHealth as "medical and public health practice support by mobile devices such as mobile phones, smartphones, tablets, patient monitoring devices, personal digital assistants, and other wire-free devices" [1]. It has also been alternatively defined as the application of information and communication technologies to health [2]. It embraces wireless health and telemedicine/telehealth approaches. mHealth has the potential to transform health care and supports public

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health and primary healthcare by enabling activities such as disease surveillance, health information provision, primary health data acquisition and analysis, community health worker support, teleconsultation, tele-education, research, and patient management[3–6]. mHealth systems promote communication between healthcare providers and their patients, the sharing of information and knowledge among providers, and the establishment of better healthcare for patients [7]. The internet's use as a communication tool has also aided in disease management [8]. Patients with various medical conditions can access treatment plans and individual medical records, as well as consult with specialists, at their convenience. A telemedicine system, one type of mHealth technology, is being used in various parts of the world to provide healthcare than transporting a patient long distances or transporting a doctor to a remote area [9]. Despite accounting for 25% of the global illness burden, WHO estimates that Sub-Saharan Africa has only 1.3% of the world's trained health personnel [10]. There are only 0.2 physicians per 1000 people, according to the most recent World Bank data [11]. mHealth has the potential to address issues such as insufficient human resources (doctors, nurses), poor health resource allocation, lack of access to healthcare, high disease burden, non-use of evidence-based interventions, and slow technological advancement [12].

Additionally, it has demonstrated a crucial role in addressing healthcare services during the COVID-19 pandemic, when face-to-face counseling was prohibited because of the disease's high contagiousness [13]. COVID-19 has an impact on healthcare spending and the economy, which has an impact on the quality of healthcare services and their high cost [14–16]. Massive healthcare issues that are already present in developing nations have been made worse by the COVID-19 pandemic [17]. Mobile health (mHealth) technology becomes more and more widely available and used, which offers a great opportunity for its integration into clinical services to promote high-quality medical care.

Recent data on mobile phone penetration in Sub-Saharan Africa (SSA) shows that 51% of residents own a mobile device [18]. With the most current figures showing mobile service subscribers, it is expected that this will increase more. By the end of 2020, 495 million people—or 46% of the population—had mobile service subscriptions in Sub-Saharan Africa. 50% of the population, or 619 million people, are projected to subscribe to mobile services by the end of 2025. The number of internet users in SSA is currently 303 million (28%) and is projected to reach 474 million by the end of 2025. (39%) [19]. Sub-Saharan African nations are adopting mHealth as a way to increase accessibility to high-quality, egalitarian healthcare, particularly for underprivileged and vulnerable people, in order to take advantage of the aforementioned potential [20]. Apps, online media, radio, landlines, television, telemedicine, SMS text, wearables, and other text-messaging devices are just a few of the technology tools that are used in mHealth approaches [21,22].

Numerous studies demonstrate the value of mHealth platforms in assisting chronic disease self-management [23]. As a result, mHealth techniques are rapidly being employed in healthcare to promote patient adherence to chronic illness management, patient communication, monitoring, and education. By providing care and information at home in a natural setting, mHealth solutions have the potential to help patients overcome numerous issues related to the cost and complexity of the healthcare system, as well as to support self-management and disease prevention [24]. Additionally, studies have demonstrated the importance of timely informational access, diagnosis, and therapy for patients in the management of diseases.

The following health advantages may arise from the adoption of mHealth: By increasing care, empowering patients, lowering medical costs, and streamlining the use of health resources, mHealth has the potential to enhance the delivery of high-quality healthcare [2,25].

However, for the majority of SSA countries, mHealth has yet to pass the proof-of-concept stage, resulting in only minor demonstrated added value in small pilot projects [20,21,25]. To map the implementation and

understand the gaps, evidence-based information on the use and implementation of various mHealth approaches in the SSA region is required. The goal of this scoping review is to determine the availability of mHealth interventions in SSA, the stage at which the interventions are available, and the main health services by these interventions.

Methods

Study design

In the present study, we employed a scoping review to explore the current evidence on the use of mHealth approach in SSA using Arksey and O'Malleys [26] methodological framework. The Arksey and O'Malley scoping review framework, is a widely recognized and commonly used approach for conducting scoping reviews in research. It consists of six iterative stages, the sixth being optional, which provide a systematic and transparent process for conducting a scoping review. These stages are (i) Identifying the research question, (ii) Identifying relevant studies, (iii) study selection, (iv) charting the data, (v) collating, summarizing and reporting the results, and (vi) consultation exercise (optional). We opted for scoping reviews as they facilitate the exploration of existing literature pertaining to a particular subject. Moreover, they have the potential to guide future research endeavors and systematic reviews focused on that subject. Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [27] was used to report the search results. This research serves as a first step toward a more extensive investigation into mHealth strategies and the conception and creation of mHealth platforms.

Stage 1: identifying the research question

The review aims to gather comprehensive insights and knowledge regarding the current state of mHealth practices in the region. The overarching research question of this scoping review is:

> What is the existing evidence pertaining to the utilization of mHealth approaches in Sub-Saharan Africa (SSA)?

The sub-questions are:

(i) What kind of mHealth approaches are available in SSA?
(ii) What kind of health issues are addressed by the mHealth approaches implemented in SSA?
(iii) What are the stages of mHealth interventions implemented in SSA?

Stage 2: identifying relevant studies

The search strategy and databases were determined, and subsequently, the inclusion and exclusion criteria were established. The keywords as shown in table 1 were checked for comprehensiveness to ensure that they covered all aspects of the mHealth definition. The following databases were used for searching articles: Scopus, IEEE, Web of Science, and PubMed. The year of publication was used as a primary filter. The last date each database was searched was on November 2021.

Table 1

Key words used for each database search.

("Mobile health" OR mHealth OR telehealth OR telemedicine OR "Wearable devices")	AND	("Sub Saharan Africa")	AND	(Use* OR Practice OR Implementation* OR Enactment OR Application OR Operation OR Employment OR Execution OR Development OR Growth OR Expansion OR Advance OR Progress OR Change)

Stage 3: study selection

Studies obtained from the databases were imported to a reference manager and screened for eligibility against the inclusion criteria. Studies were included if (i) the articles were published between 2000 and 2021 and if they met one of the following criteria: (ii) mHealth was addressed as a primary issue; (iii) the paper discussed mHealth implementation and feedback; (iv) the mHealth approach was used to solve a human health issue; (v) the paper described the development and design of mHealth technology, and (vi) the mHealth approach was not used to educate health professionals for various qualifications (as a form of online education). The following papers were excluded: (i) papers describing electronic medical records, (ii) papers describing general IT and ICT technology for health data collection, (iii) papers providing or advocating policy framework input, (iv) articles describing barriers and enablers to mHealth use, and (v) review papers. There were no limits regarding the health issues that the mHealth is addressing.

Stage 4: charting the data

We created a data charting sheet and conducted initial testing to ensure that it includes all the relevant variables necessary for our study. For ease of manipulation and data integrity, the studies were divided into five categories of mHealth approaches: SMS-based, App-based, Telemedicine-based, wearable sensor-based, and mixed mHealth. Appendices I-V contain extensive tables summarizing the main information of the articles that have been included. All relevant data from the included articles were extracted using a data charting form as shown in (Table3), and analysis was performed using the extracted data.

Stage 5: collating, summarizing, and reporting the results

The data was summarized by the stage of mHealth intervention, health issues addressed, country of intervention, goal of the mHealth use, aim of the article, Information provided to the patients, Information provided to the healthcare professional, and results obtained from the study. The variables for which the data were sought are shown in Table 2.

Results

The four database searches yielded a total of 1020 papers, 189 duplicate records were discovered and eliminated. Two separate reviewers performed title screening on 831 articles and 593 were excluded. Finally, the remaining 238 articles were subjected to full-text screening. Four duplicate articles with the same mHealth interventions but different objectives were discovered and deduplicated. Finally, 59 articles were studied that met all the inclusion criteria. There were no non-English papers found. Fig. 1 shows PRISMA chart reporting literature search and selection of studies.

Study characteristics

A variety of study designs/methodologies was reported in the included studies. The employed study designs include retrospective

Table 2
The variables for which the data were sought.

The variables for which the data were sought
First Author
Stage
Health issues addressed
Country
Study characteristics
Goal of mHealth use
Aim of the article
Information provided to the patient
Information provided to the health professional
Results

cohort studies [28], cluster randomized control trials [29], focused group discussions [30], iterative designs [31], multicenter controlled randomized trials [32], observational study [33], qualitative In depth-interview and focused group discussion [34], qualitative research in a phenomological approach(35), quasi-experimental studies [36], randomized control trials [37–41], surveys [42,43], 2- stage Blinded validation studies [44], cross-sectional studies [45], experimental [46–48], human centered iterative designs [49], hybrid effectiveness studies [50], mixed method [51,52], prospective study [53,54], randomized control trial [39], randomized control pilot studies [55], retrospective analysis of cases [56], semi structured interviews and focused group discussions [57], case reviews [58], case studies [59,60], experimental studies [61], prospective cohort studies [62–64], prospective interventional studies [65], retrospective studies [66], action research [67], cluster randomized trials [68], observational prospective pilot studies [69], and prospective observational studies [70].

Overall distribution of mHealth approaches by type, quantity and year across the ssa countries

In this section, we present the summarized distribution of mHealth approaches across the SSA countries in terms of the type of the mHealth system (Fig. 2), country of the mHealth implementation (Fig. 3) and year of the mHealth approaches implementation (Fig. 4). In terms of type of mHealth approaches, they are categorized as SMS based, App-based, Telemedicine-based, wearable-based, and mixed mHealth approaches. SMS based mHealth approaches refer to the use of Short Message Service (SMS) or text messaging as a means of delivering healthcare interventions or services through mobile devices . App-based mHealth approaches involve the use of mobile applications (apps) to deliver healthcare interventions, services, or support through smartphones or other mobile devices. Telemedicine based mHealth approaches involve the use of mobile devices, such as smartphones, tablets, or computers, and tele-communication to facilitate virtual consultations between healthcare providers and patients. Wearable-based mHealth approaches often involve the integration of sensor-based wearable devices with mobile applications or online platforms. Finally, mixed mHealth approaches is the combination of one or more mHealth approaches discussed above.

SMS based mHealth approaches

From the identified mHealth interventions 22% or ($n = 13$) mHealth interventions were based on using SMS text. As shown in (Fig. 5), the health services were HIV [31,33,34,37,38,71], diabetes [32,35], child health [28], maternal and newborn health [30], maternal health [29], Tuberculosis (TB) [36], and other clinical cases [42].

Countries where the SMS based mHealth interventions designed for and implemented were Botswana [42], (Ghana, Rwanda, Senegal, and Uganda) [28], Kenya [34], Malawi & South Africa [32,35], Mozambique [37], Rwanda [30], Uganda [31,36,71], Zambia [33], and Zanzibar [29].

App based mHealth approaches

29% (17 /59) were identified as mobile app based mHealth approaches. As illustrated in (Fig. 6), the health services with this approach were HIV [39,55,57], child health [72–74], maternal health [45,50], cancer [49,53], fracture management [56], maternal and child health [75], dementia [44], women health [76], hypertension [52], Sexually Transmitted Disease (STD) [47],and rehabilitation [46].

Countries where mobile app based mHealth interventions were designed for and implemented are Kenya [55,74,76], Kenya & Mozambique [57], Madagascar [45], Nigeria [52,72,75], South Africa [39,56], Tanzania [44,46,49,53], and Uganda [50,73].

Table 3

Sample of data charting table for included articles. For the complete data charting tables, see appendices I-V.

S/n	First Author and citation	Stage	Health issues addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Results
1	R. S. Morse [49]	3	Cancer	Tanzania	Human-centered iterative design framework	Providing symptom assessment and care coordination and control to decrease burden of pain to cancer patients.	To discuss on the design and development mobile-Palliative Care Link (mPCL), a web and mobile app to support outpatient symptom assessment and care coordination and control, with a focus on pain.	SMS to complete the POS (African palliative care outcome score)	POS responses from the patient to the specialist Task order from the specialist to the LHW	All users were able to successfully navigate the app, and feedback suggests that mPCL has clinical utility. further improvement in app navigation, simplification of patient and caregiver components and language, and delineation of user roles improvement is recommended.
2	K. Winskell [55]	3	HIV	Kenya	Randomized control pilot study	Increasing age for first sex and culture of condom use by increasing knowledge about sexual health and HIV.	To present a pilot-test result of the theory-based, empirically grounded smartphone game aiming to establish directionality of effects on behavior change.	Knowledge related with puberty, the reproductive systems, HIV, STIs, and condom use.	N/A	The participants were able to acquire increased awareness regarding safe sexual practice and HIV risk factors.
3	H. H. Lund [46]	3	Rehabilitation	Tanzania	Experimental	To improve the rehabilitation activity of stroke patients and other injuries by motivating patients to perform rehabilitative actions	To report on the co-design, adaptation, demonstration and validation of modular ICT solutions for rehabilitation	Feedback shown visually and sound as notes, spoken words, etc	Easily adaptable to feedback and app which allows for customization for each patient	The partners contextualize the eHealth solution to fit the needs in urban, rural and deep rural areas.
4	T. Thompson [47]	2	STD		Design	To diagnose STD anonymously without exposing the details of the patient.	To present an expert system design procedure which helps to diagnose STD anonymously.	Diagnosis result and drug prescription for patients	N/A	The designed system is able to diagnose a number of STDs such as syphilis, chlamydia etc
5	E. G. Vilaplana [45]	4	Maternal health	Madagascar	Cross sectional study	To collect patient pregnant woman information (medical, clinical and personal) during their ANC visit.	Describing the maternal morbidity rate by employing already developed mHealth system called PANDA (pregnancy and newborn diagnosis assessment) system, that incorporates the WHO recommendations for antenatal care (ANC).	N/A	Routine patient clinical, medical and personal data.	Data, including personal and medical information, but also clinical data such as hypertension, anemia or HIV were collected from more than 1000 women attending ANC using the mHealth platform, PANDA. The system allows for a better clinical follow up and for population level data collection,

Table 3 (*continued*)

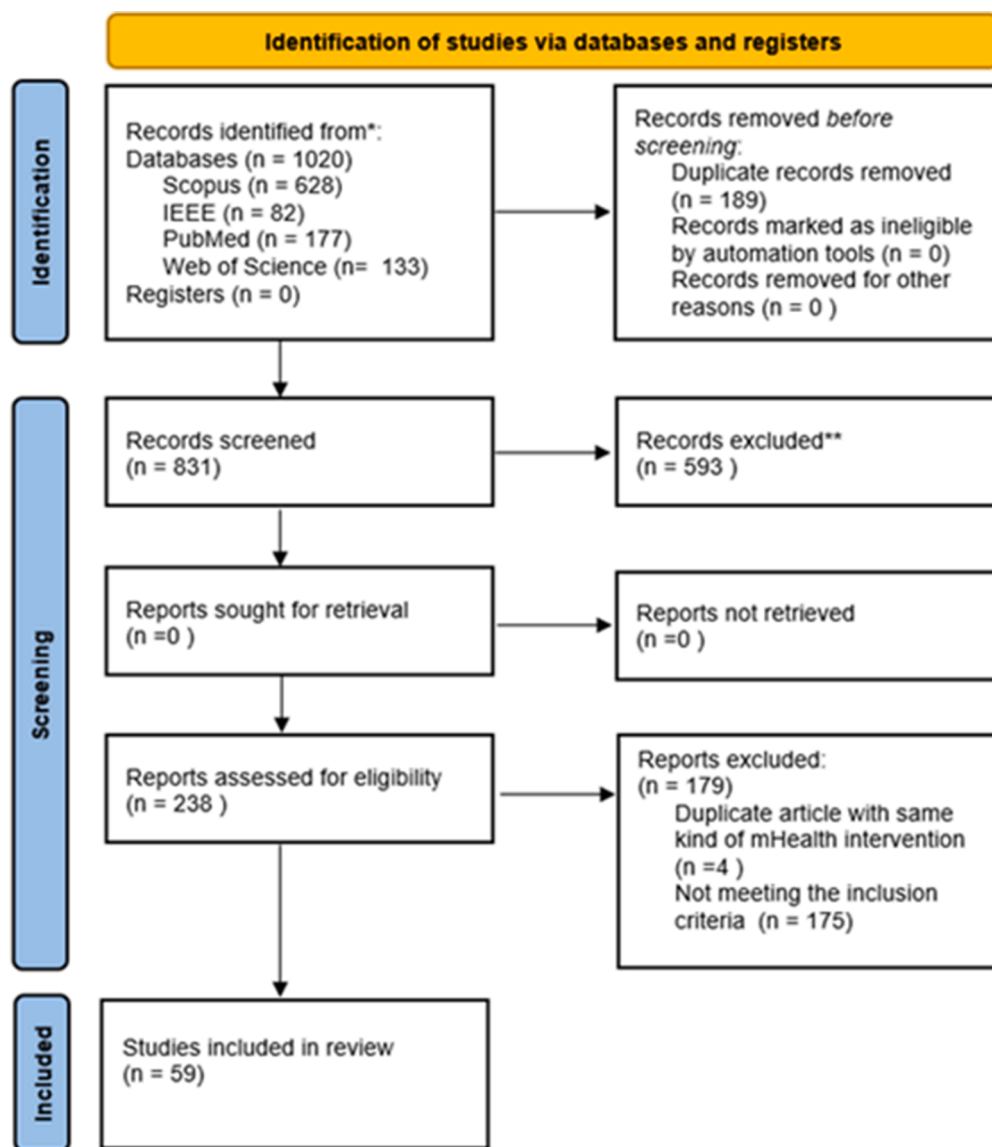| S/n	First Author and citation	Stage	Health issues addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Results
										and to have reliable routine data.

Fig. 1. PRISMA chart showing literature search and selection of studies.

Telemedicine based mHealth approaches

30% (18 /59) reports were identified as telemedicine-based projects. (Fig. 7) shows the health services reported with this mHealth approach. These are cancer [63,66,77], dermatology [78–80], clinical services [81](82), specialty services [54,58], imaging [83,84], maternal health [62,85], Ophthalmology [60], psychiatry [59], HIV [43], and hypertension [65].

Countries where the telemedicine projects were designed for and implemented were (Namibia, Uganda, Nigeria, Zambia) [63], Benin [66], Cabo Verde [54], Cameroon [65], Ethiopia [60], Gambia [62], Kenya [43,59], Mali [78], Nigeria [58], South Africa [84,85], Tanzania [79], Uganda [80,83], and Zambia [77,82] .

Wearable sensor based mHealth approaches

In this systematic review, we were able to identify only one mHealth intervention which incorporates the use of wearable sensor for stroke and rehabilitation [48]. This intervention approach was designed and tested to measure the kinematics of upper body movement for stroke patients in Ethiopia. Further in [61] they integrated the sensor to application and telemedicine platform.

Mixed mHealth approaches

17% (10/59) reports were identified as using mixed approaches of the above platforms. The health services reported were stroke [41,61,
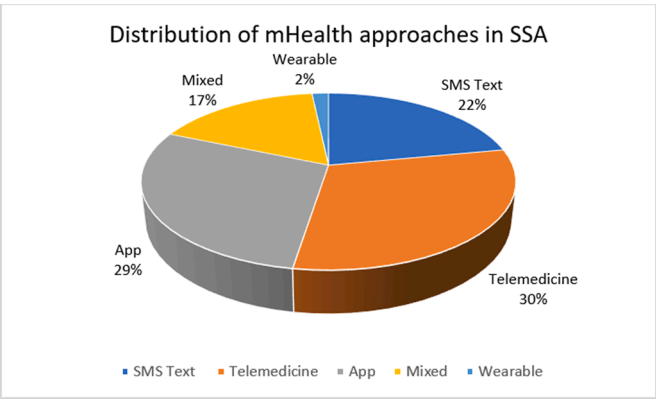
Fig. 2. Overall distribution of mHealth approaches in SSA (in type).

69], cancer [64], cardiac and medical [86], health behavior [40], health information [67], HIV [68], injury [70], newborn and child health [51]. Fig. 8 demonstrates health services by applying a combination of various mHealth approaches.

Countries where these interventions were designed for and/or implemented were (Namibia, Nigeria, South Africa, Uganda, and Zambia) [64], Cameroon [70], Ghana [41,69], Kenya [68], Malawi [51], Nigeria [86], South Africa [67],Uganda [40], and Ethiopia [61].

We found a variety of mixed approaches in mHealth intervention such as app mixed with telemedicine [64,67,69], SMS mixed with phone call (telemedicine) [41,51,68,70,86], mobile app with SMS [40], wearable sensor mixed with app and telemedicine [61].

Stage of mHealth development

For clarity of explanation, the stages of the intervention development were classified into 5 general classes, namely: Proof of concept stage (Stage 1): if the work is on idea stage; Design and development stage
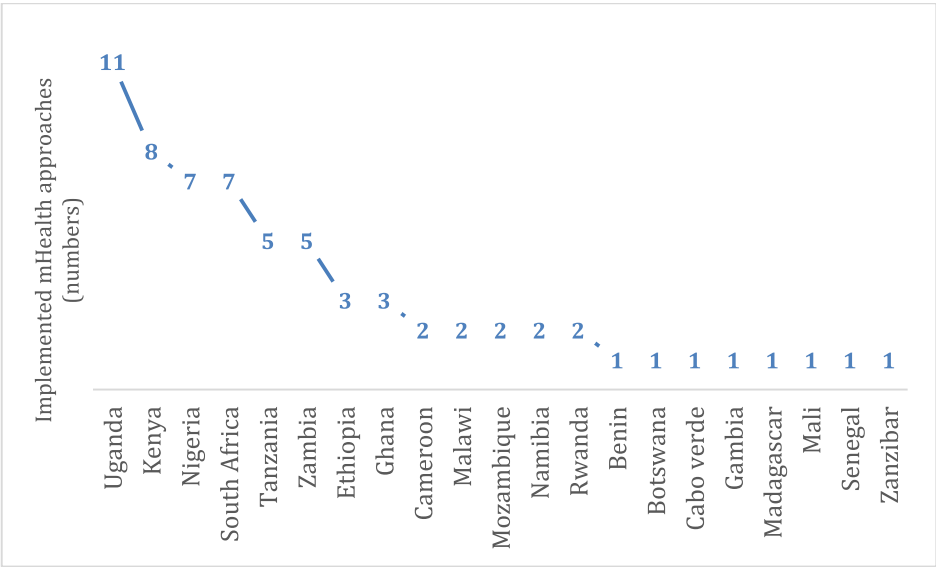

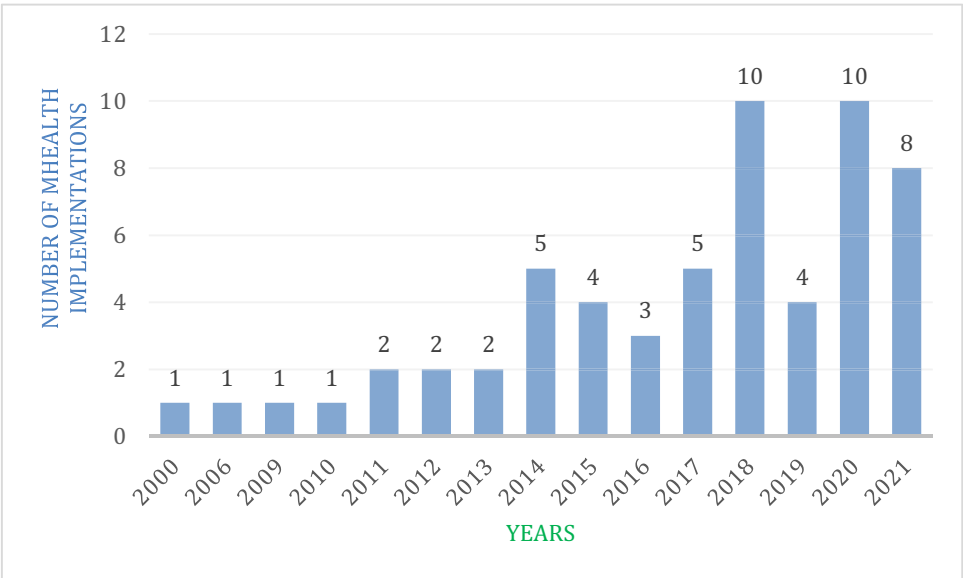Fig. 3. Overall distribution of mHealth approaches in SSA (In quantity).

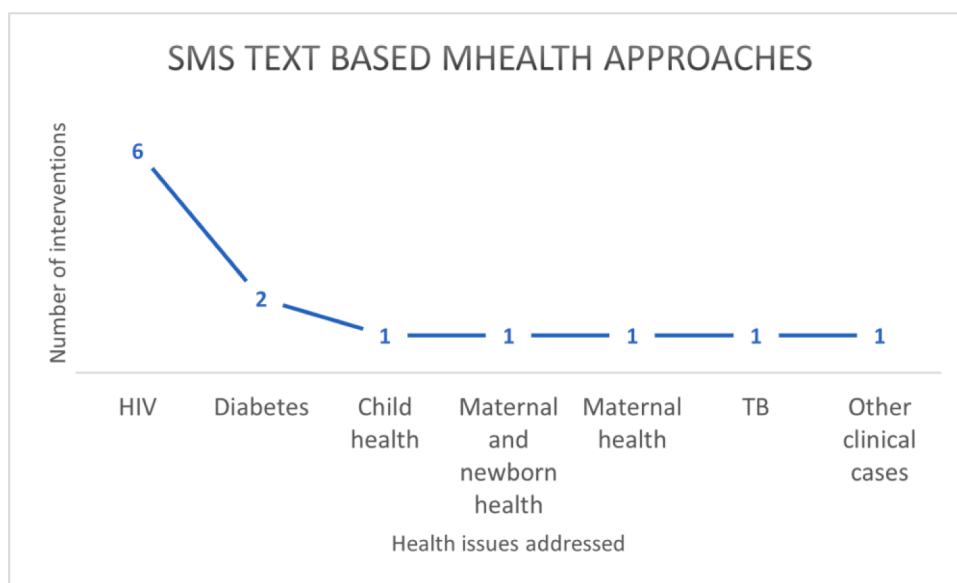Fig. 4. mHealth implementation distributed in years.

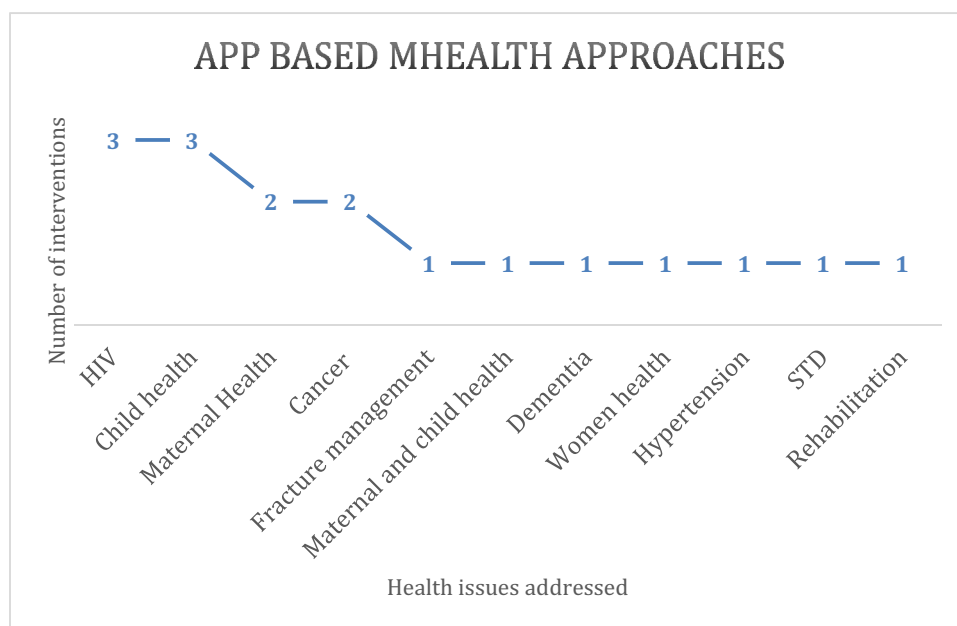**Fig. 5.** Health services with SMS text based mHealth approaches.

Fig. 6. Health services with App-based mHealth approaches.

(stage 2): if some kind of prototype is built; Pilot tested (stage 3): if the prototype is tested in small population(i.e. < 50); Large scale implementation (stage 4): if tested in larger sample population (i.e. >50), and Scaled up projects(stage 5): if nationwide implementation of the intervention is reported.

Looking at the overall stage of mHealth interventions, most SMS based interventions are pilot tested (stage 3) [31,34,37,38,42,71] or at large scale implementation stage (stage 4) [28–30,32,35]. In contrast, mobile app based mHealth interventions [47,72,74–76] are mainly in the design stage (stage 2). Only one article [45] reports large scale implementation of mobile app based mHealth intervention. Articles [39, 44,46,49,52,53,55–57] is on pilot test stage. In contrast, widely held telemedicine based mHealth interventions show large scale implementation (stage 4) [43,54,60,63,65,66,77,79,82]. The pilot test stage telemedicine based mHealth approaches are [58,59,62,78,80,83–85]. Only one article [81] reports telemedicine based mHealth approach that

is in design and development stage. Of the mixed approach of mHealth interventions all, except [51,64] which are large scale implementation, are on pilot test stage. The other category of mHealth approaches which is based on wearable sensors [48] is on pilot test stage

Discussion

This study presents a scoping review to obtain a comprehensive evidence in use and availability of mHealth approaches in SSA. Various approaches and implementations of mHealth interventions across SSA were elucidated in this systematic review. When compared to the five mHealth intervention approaches namely SMS text-based, App-based, telemedicine-based, wearable sensor-based, and mixed approaches, the majority of mHealth intervention approaches are found to be based on telemedicine, and the majority of these telemedicine projects have large scale implementation in which the intervention is tested and/or
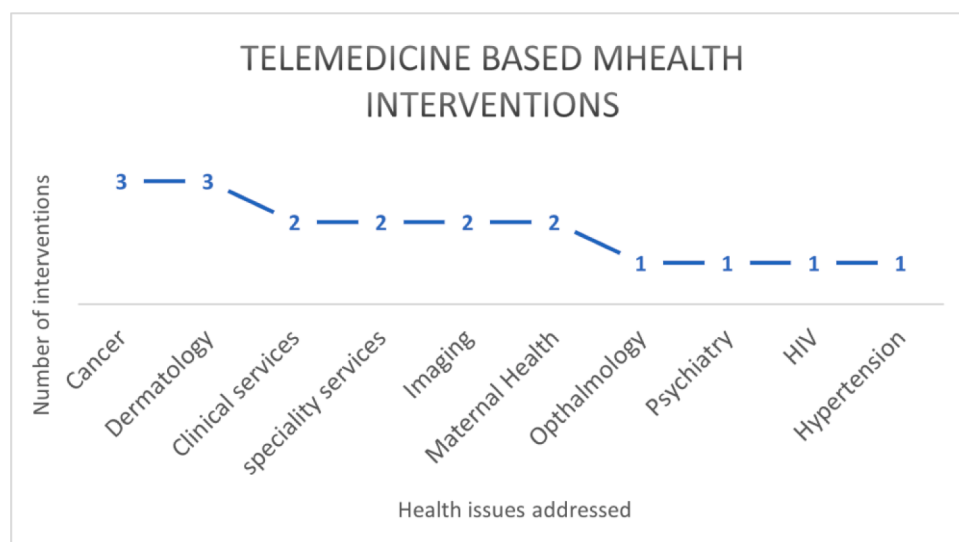
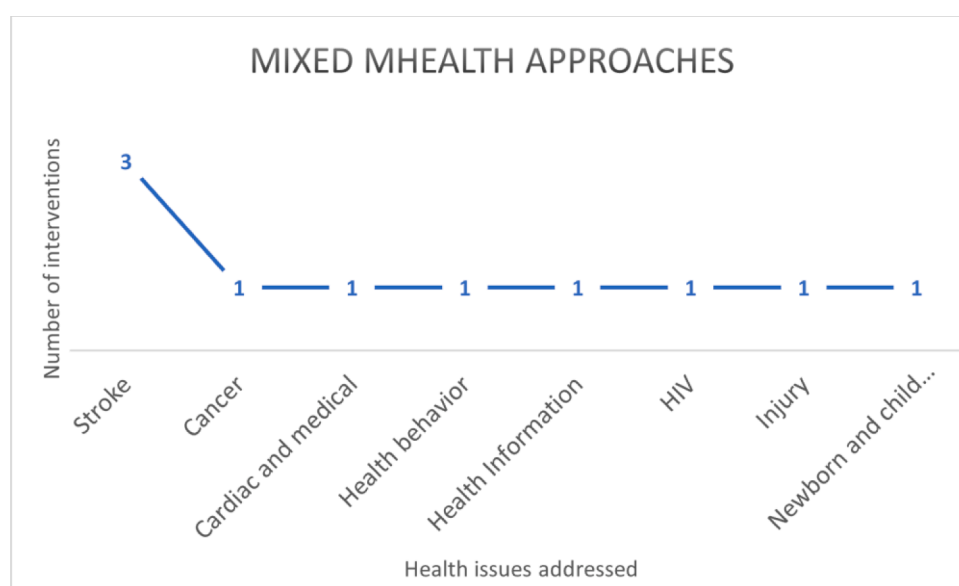**Fig. 7.** Health services with telemedicine-based mHealth approaches.

Fig. 8. Health services with mixed mHealth approaches.

implemented in a larger community. Some mHealth interventions necessitate the use of additional software, hardware, and/or communication platforms, but the majority of other approaches make use of the user's already available mobile phone. Patients, caregivers, and healthcare workers appear to be the typical end-users across the reported studies.

According to the World Bank, SSA consists of 48 countries [87] . Only 21 of these have integrated a mHealth platform into their healthcare system. When examining the distribution of mHealth strategies among countries in the region, Uganda stands out as having the highest number ($n = 11$) of mHealth initiatives, followed by Kenya ($n = 8$), Nigeria ($n = 7$), and South Africa ($n = 7$). Among the other countries in this group of 21, each country has five or fewer mHealth initiatives. Countries involved in mHealth are still in the early stages, and much input from governments, researchers, and innovators is still expected and needed. When examining the years of implementation, the majority ($n = 49$) of the initiatives were published between 2014 and 2021. Only 10 mHealth initiatives were reported between 2000 and 2013. Prior to the year 2000, no mHealth initiatives were identified in this review, indicating

that the adoption and spread of mHealth is a relatively recent development. This suggests that mHealth is a relatively new phenomenon that has been gaining attention in recent years. The various mHealth interventions implemented in the SSA region addressed a wide range of health issues, from non-communicable to communicable diseases. Despite the fact that the extent of mHealth technology is insufficient for the disease burden that the SSA region is experiencing, the start is encouraging. HIV was the most frequently mentioned health issue in the literature, followed by cancer and maternal and child health. Diabetes, tuberculosis (TB), psychiatry, sexually transmitted disease (STD), imaging, and dementia were among the other topics covered.

The findings of the reports demonstrate that mHealth approaches have the potential to transform the way healthcare services are delivered to patients by creating the opportunity to deliver healthcare services at a lower cost without being hampered by geographical distances. It is obvious that mHealth approaches can reduce healthcare costs when compared to traditional methods [88]. This is because of the costs associated with long-distance travel to health facilities, complications that arise due to patients' lack of knowledge about a disease or

condition, and limited patient-provider communication can be solved by incorporating mHealth approaches into the healthcare system. Health service consultations from expert specialists to rural and underserved areas in SSA are becoming possible through the integration of wearables in health platforms to monitor patient status without being concerned about the patient's and/or the health professional's whereabouts.

However, across the inspected literature, the design and development of wearable sensors based mHealth approaches is only reported in [48,61]. The first paper [48] discusses about the design of a wearable sensor based mHealth system, whereas the other one reports the implementation of this wearable sensor based mHealth system in a mobile application and tele rehabilitation service(61). More efforts are required to innovate and incorporate wearables in the mHealth approaches to compete with the rapidly evolving nature of the technology worldwide. If taken seriously and scaled up to cover larger populations, those initiated mHealth approaches have the potential to revolutionize the healthcare arena by improving health service provision which is being impeded by the shortage of healthcare workers [10,11].

Because integrating continuous physiological parameter measurements is critical for monitoring various health issues, researchers and relevant stakeholders should devote significant attention to developing and testing mHealth approaches incorporating wearable sensors. This will aid in the continuous monitoring of human vital parameters, which will aid in the self-management of a wide range of chronic and other noncommunicable diseases.

Opportunities for future research

As with the other developing nations worldwide [89], SSA is experiencing the double burden of communicable and non-communicable diseases. With the rapid penetration rate of mobile phones and the internet in the SSA region, it is expected that mHealth systems will significantly contribute to the highly challenged SSA healthcare system. The study results covered in this literature review suggest green light for the SSA region to start adopting this technology. Sending medication adherence, lifestyle advice, appointment reminders, and other interventions based solely on SMS text or apps is insufficient for efficient chronic disease self-management and cannot fully solve the problem. A system that measures and evaluates the vital parameters which are directly altered/affected by the disorder/disease is key to optimize the output /use of mHealth interventions.

According to the reports, the intervention's response/output is retained and can only be accessed by the patient or a health care worker separately depending on the approaches. It would be better if a direct data transmission from the patient to the attending healthcare worker is available. Due to the lack of adequate health care workers and convenient transportation, it is not obvious to travel for health professionals to remote locations and/or patients to urban areas for diagnosis, treatment and monitoring. Telemedicine-based mHealth approaches are being evaluated and implemented and positive implications are obtained with some limitations. These limitations can be alleviated by integrating wearable sensors into the system. The main limitations are: (i) intermediate medical personnel is required to send the sample to the experts, (ii) the samples may not be adequate (because continuous data is lacking which is hampering effective chronic disease self-management and diagnosis and monitoring of some complicated cases) and (iii) there is no direct communication between the patient and the physician.

The integration of wearable sensors and mobile phones holds promise for mobile health technologies enabling health care that is much less obstructed by physical limitations [90]. Integrating wearable sensors for real-time measurement of vital parameters to develop a care plan and track progress toward a better health outcome will be advantageous.

Reviewing health policies to transform healthcare services is crucial for achieving cost-effective measures in reducing healthcare expenses, as evidenced by studies conducted in BRICS nations, for instance

[91–95]. Transitional health-care changes shifted the emphasis from hospital-based to outpatient-centered care, laying the groundwork for healthcare digitalization including mHealth [96]. SSA stands out as a region with an alarming shortage of healthcare professionals in proportion to the patient population. In this context, mHealth presents itself as a promising solution due to its extensive reach, offering the potential to deliver high-quality healthcare services in a cost-effective manner. Given the region's disproportionate disease burden, dense population, and inadequate healthcare resources, implementing mHealth initiatives becomes even more imperative.

Limitations of the study

We only used the published articles in four databases to ascertain the availability and utilization of mHealth systems in SSA. Other databases and registrations may have other interventions reported and also there might be mHealth intervention initiatives that have not published yet.

Conclusions

The introduction of mHealth approaches into the healthcare system for SSA is at its infancy. However, besides its early stage and implementation at smaller scales in SSA, promising progress is made in this region. Globally, we are witnessing the rise in digitalization and large efforts are made by relevant stakeholders, such as governments, researchers, software developers, internet providers, etc. to enable the implementation of digital health services. The start of mHealth deployment in SSA is positive. A variety of health issues were attempted to be addressed in the reviewed articles at various stages of the mHealth intervention. Despite the fact that there has been some progress in bringing the importance of this mHealth approach to resource-limited settings in SSA, there is still a lot to be expected. Most reviewed articles discuss SMS text-based, app-based, or telemedicine-based mHealth approaches, with a tiny portion addressing wearable sensor-based mHealth approaches. As a result, much effort is still required to integrate wearable sensors into mHealth platforms. Designing mHealth systems should be done in a cost effective and easy-to-use way in order to increase the uptake of the system. Scholars have consistently advocated for the adoption of a health policy that mandates the incorporation of accessible healthcare technologies within national healthcare systems. This recommendation holds particular significance for SSA, as it serves as the primary target region for such efforts [89,97]. By leveraging mobile health (mHealth) technologies, countries can effectively extend healthcare services to a broader population, ensuring increased accessibility and inclusivity in the delivery of healthcare. Considerable attention should also be given to integrate wearable sensors into mHealth platforms for monitoring physiological parameters in real-time allowing to provide customized treatment for patients.

Author contribution

Genet Tadese Aboye co-conceived the study with Jean-Marie Aerts and Gizeaddis Lamesgin Simegn, and designed and implemented the search strategy. The title and abstract screenings were performed by Genet Tadese Aboye and Martijn Vande Walle. Genet Tadese Aboye and Jean-Marie Aerts both contributed to the data synthesis and extraction processes. Genet Tadese Aboye drafted the manuscript, which was revised by all authors. Jean-Marie Aerts and Gizeaddis Lamesgin Simegn supervised the review process and critically revised the manuscript for significant intellectual content. At all stages of the manuscript's development, all authors discussed the findings and read and approved the final version.

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Declaration of Competing Interest

None declared.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.hlpt.2023.100806.

Appendix 1. Overview of SMS based mHealth approaches

s/n	First Author and citation	Stage	Health issue addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Results
1	P. Musoke [23]	3	HIV	Kenya	Qualitative In depth-interview and Focused group discussion	supporting women (pregnant and breastfeeding) ART adherence and retention of care. To prevent mother to child HIV transmission	To report the assessment of the effectiveness of a Health Belief Model (HBM)-based text messaging intervention on ART adherence and retention.	Information about birth plan clinic visits couple HIV testing, condom use and medication adherence.	N/A	Most participants accepted the idea of receiving text messages for their own and baby's health and they believe that text messaging is important communication tool. Text messages interventions can improve patients life and healthcare service access
2	P. Mwendwa [32]	4	Maternal and newborn health	Rwanda	Focused group discussion	To conduct routine surveillance of health events during the course of a woman's pregnancy, delivery, and for the first year of her infant's life.	To report the result of assessing whether the RapidSMS fits to the different factors (literacy level and likes) of the CHW.	N/A	For CHW: Appointment reminders that they had, Delivery date and others (not dierectly to the patient) To centeraldatabase: birth, maternal mortality	Contextual fit was found to be poor and impacted unfavorably on user comfort, work- flow, and time criticality fit. Information communication, location, and interaction fit were positively valued.
3	A. Farmer [30]	4	Diabetes	Malawi and South Africa	Multi-center controlled randomized trial	To improve outcomes in adults with type 2 diabetes.	To report on the effectiveness of SMS-text messaging in improving outcomes in adults with type 2 diabetes.	SMS text that encourage people to take their medicine regularly as prescribed, provide advice about healthy lifestyle and enhance well-being To check the date of their next appointment and whether they had sufficient medication.	N/A	Though SMS text messages do not lead to improved glycaemia there appeared to be an impact on blood pressure and achievement of treatment goals. Text messages alone, may be unsuccessful unless accompanied by health system strengthening and other forms of self-management support for type 2 diabetes.
4	A. Farmer [31]	4	Child health	Ghana, Rwanda, Senegal, and Uganda.	Retrospective cohort study	Data collection, reporting, communications, and point-of-care support. Screening is done for under five childs by measuring MUAC and repeated every	To examine whether SMS patient data entry with text message reminders influenced CHW follow-up visits compared with paper data entry.	N/A	patient data	SMS data entry was associated with a higher proportion of timely malnutrition follow-up visits compared with paper forms.
5	D. J. Davey [24]	3	HIV	Mozambique	Randomized control trial	To contribute to an increase in appointment	To demonstrate the impact of SMS messages on HIV	Reminder and information messages to HIV-	Adherence to ART	Many HIV-positive pregnant women and women on HIV

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s/n	First Author and citation	Stage	Health issue addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Results
						adherence (pharmacy and clinical) and the uptake of PMTCT services at ante-natal care visits, institutional births and postnatal care.	treatment and PMTCT	positive pregnant women and ART patients		treatment do not have cell phones or are illiterate.
6	K. Armstrong [35].	3	Clinical cases	Botswana	Survey	To provide evidence based medicine and clinical practice guidelines to improve medical care form PUBMED for clinicians with no or limited access to internet using SMS	To establish and evaluate the utility of the tools (txt2MEDLINE and SMS optimized clinical guideline) for clinicians	N/A	Abstract of clinical practice guideline through SMS and the full article if required through email.	Accessing clinical guidelines and PubMed/MEDLINE queries via text messaging represents an optimal method of evidence-based knowledge communication in countries
7	M. L. Ybarra [25]	3	HIV	Uganda	Iterative design	To increase the awareness of older adolescents in HIV prevention and sex	To report on the iterative design and test result of a mHealth HIV prevention program.	Text messages that helps them in decision and choice making regarding sex	N/A	Text messaging-based HIV prevention programming that is intense (i.e., 5–11 messages per day) , is both feasible and acceptable across sexual experience levels.
8	M. J. Siedner [26]	3	HIV	Uganda		To increase the odds of return to care after normal and/or abnormal laboratory test results for PLWH	To report on the trial evaluated the efficacy of a SMS text messaging app to notify PLWH of their laboratory results and request return to care for those with abnormal test results	Test results of PLWH and request to return to clinics for abnormal test results	N/A	Confirmed literacy at the time of enrollment was a robust predictor of SMS text message receipt, identification, and appropriate response for PLWH.
9	K. Smillie [27]	3	HIV	Kenya	Randomized control trial	To improve the follow up of HIV diagnosed patients for ART initiation	To report on the effectiveness of text messaging intervention to improve clinical outcomes among patients initiating ART	Weekly text messaging sent to HIV patients, Counselling service, support and/or referral	A reply from patients whether they are ok or there is problem with their health	Both people living with HIV and HCP felt that increased communication has the potential to enable early identification of problems, leading to timely problem solving that may improve retention and engagement in care during the first year after diagnosis.
10	S. Lund [33]	4	Maternal health	Zanzibar	Cluster randomized controlled trial	To improve antenatal care visit during pregnancy	To report on the evaluation of the association between a mobile phone intervention and antenatal care in a resource-limited setting.	Health information to pregnant women to improve antenatal follow up	Communication/ information from patient at the time of two way communication	The mobile phone intervention significantly increased the proportion of women receiving the recommended four antenatal care visits during pregnancy and other outcome.
11	N. Leon [29]	4	Diabetes	Malawi and South Africa	Qualitative research in a phenomological approach	To improve clinical outcomes and adherence to refilling medicine, in patients with T2DM	To report on the process evaluation of brief text intervention to improve diabetes treatment	Messages focusing on promoting regular medication refill, medication, and healthy lifestyle changes	N/A	Brief messages delivered by text were acceptable and useful for addressing informational and support needs for participants.

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s/n	First Author and citation	Stage	Health issue addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Results
12	S. M. Hermans [34]		TB	Uganda	Quasi-experimental study	To improve LFU for TB treatment and mediation adherence	To report on a test the effect of a short-message service (SMS) intervention on loss to follow-up (LFU) for TB-HIV co infection	Text messages containing adherence reminder, appointment reminders, and educational quizzes, and a computer generated response with the right answer for the quizes	N/A	The SMS reminder service was highly rated, and there were no breaches of confidentiality, though substantial technological barriers have implications for larger scale implementation.
13	C. G. Sutcliffe [28]		HIV	Zambia	Observational	To improve early infant diagnosis of HIV infection	To assess the feasibility of using mobile phones to contact mothers.	Notification of HIV test result of their baby	N/A	Mobile phone and text messaging technology has the potential to improve early infant diagnosis but challenges to widespread implementation need to be addressed, including low mobile phone ownership, use and coverage in rural areas.

Appendix 2. Overview of App based mHealth approaches

S/n	First Author and citation	Stage	Health issues addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Results
1	R. S. Morse [44]	3	Cancer	Tanzania	Human-centered iterative design framework	Providing symptom assessment and care coordination and control to decrease burden of pain to cancer patients.	To discuss on the design and development mobile-Palliative Care Link (mPCL), a web and mobile app to support outpatient symptom assessment and care coordination and control, with a focus on pain.	SMS to complete the POS (African palliative care outcome score)	POS responses from the patient to the specialist Task order from the specialist to the LHW	All users were able to successfully navigate the app, and feedback suggests that mPCL has clinical utility. further improvement in app navigation, simplification of patient and caregiver components and language, and delineation of user roles improvement is recommended.
2	K. Winskell [36]	3	HIV	Kenya	Randomized control pilot study	Increasing age for first sex and culture of condom use by increasing knowledge about sexual health and HIV.	To present a pilot-test result of the theory-based, empirically grounded smartphone game aiming to establish directionality of effects on behavior change.	Knowledge related with puberty, the reproductive systems, HIV, STIs, and condom use.	N/A	The participants were able to acquire increased awareness regarding safe sexual practice and HIV risk factors.
3	H. H. Lund [52]	3	Rehabilitation	Tanzania	Experimental	To improve the rehabilitation activity of stroke patients and other injuries by motivating patients to perform rehabilitative actions	To report on the co-design, adaptation, demonstration and validation of modular ICT solutions for rehabilitation	Feedback shown visually and sound as notes, spoken words, etc	Easily adaptable to feedback and app which allows for customization for each patient	The partners contextualize the eHealth solution to fit the needs in urban, rural and deep rural areas.

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S /n	First Author and citation	Stage	Health issues addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Results
4	T. Thompson [51]	2	STD		Design	To diagnose STD anonymously without exposing the details of the patient.	To present an expert system design procedure which helps to diagnose STD anonymesly.	Diagnosis result and drug prescription for patients	N/A	The designed system is able to diagnose a number of STDs such as syphilis, chlamydia etc
5	E. G. Vilaplana [42]	4	Maternal health	Madagascar	Cross sectional study	To collect patient pregnant woman information (medical, clinical and personal) during their ANC visit.	Describing the maternal morbidity rate by employing already developed mHealth system called PANDA (pregnancy and newborn diagnosis assessment) system, that incorporates the WHO recommendations for antenatal care (ANC).	N/A	Routine patient clinical, medical and personal data.	Data, including personal and medical information, but also clinical data such as hypertension, anemia or HIV were collected from more than 1000 women attending ANC using the mHealth platform, PANDA. The system allows for a better clinical follow up and for population level data collection, and to have reliable routine data.
6	N. Kawakyu [37]	3	HIV	Kenya & Mozambique	Semi-structured interview and focused group discussion	To provide a systems-level view to track patient flow through the PMTCT cascade.	To report a study aimed at understanding and improving the mPCAT's core usability factors and assessing the health workers' experience with using the mPCAT	N/A	Quick summary of the number of patients and percentage drop-off at each step of the PMCTC care cascade, as well as how many women-infant pairs would be retained if a step was optimized	The mPCAT gave frontline health workers and facility managers an immediate, direct, and tangible way to use their clinical documentation and routinely reported data for decision making for their own clinical practice and facility-level improvements
7	S.-M. Paddick [48]	3	Dementia	Tanzania	2- stage Blinded validation study	An application for dementia screening to replace paper and pen tool	To report on diagnostic accuracy of a brief dementia screening mobile application (app) for non-specialist workers against blinded gold-standard diagnosis of DSM-5 dementia.	N/A	Dementia screening results for three classifications of dementia as probable dementia, possible dementia, or no dementia	The pilot dementia screening app had good sensitivity but lacked specificity for dementia when administered by non-specialist rural community workers.
8	H. Gouse [38]	3	HIV	South Africa	Randmized control trial	To closely follow South African DoH (Department of Health) counselling protocol in the clinics, and To engage counsellors with patients in the delivery of ART adherence counselling	To explore lay-counsellors and DoH perspectives on the utility of a multimedia adherence counselling program in primary health care in this low-and-middle income (LMIC) setting.	N/A	Guidance on HIV counselling for lay counsellors	Masivukeni has potential as a counselling tool in resource-limited settings as it empowers counsellors to provide high quality counselling
9	F. Rubagumya [45]	3	Cancer	Tanzania	prospective study	To improve access to specialist care for skin cancer detection for people with Albinism.	To describe the feasibility of using a smartphone mobile health care (mHealth) application to aid in the detection of skin cancer in People with albinism.	Skin cancer detection and biopsy result	Patient skin lesion pictures from local clinicians to experts and Expert review designation of a lesion from specialists to local clinician	This kind of approach could have a major impact on minimizing diagnostic delay and ensuring presentation to health providers. Most lesion evaluated as

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S /n	First Author and citation	Stage	Health issues addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Results
										malignant using the app were pathologically proven to be cancer
10	J. S. Eyitayo [39]	2	Child health	Nigeria		Registering and health monitoring of children under age five.	To report the development of a mobile application (mHealth tool) which incorporates an extensive registration platform for children under age five.	Register children Set schedule Contact doctors Live chat with medical personnel Children details	View registered children Set schedule Contact doctors Children details	mHealth app named FirstSteps is designed and tested.
11	A. S. Akinseinde [47]	2	maternal and child health	Nigeria		To provide pregnancy and child health related health information and others to pregnant and nursing women	To present an indigenous mobile health (or mHealth) solution design named GRAVID	Due date estimation, baby development and expected milestones, other information related to pregnancy and child health	Track the progress of the women and children especially the high-risk patients.	mHealth app named GRAVID which is supposed to fill the gap of unavailability of context-based nutritional, drug and substance abuse and medical information for women and baby is developed.
12	A. Bebla [49]	2	Women health	Kenya		To educate girls on menstruation and help them manage their period	To present the design of a health education app for girls related with menstruation	Next period date, education regarding period and how to manage it.	N/A	an Android app that both educates girls on menses and helps them manage their period is developed.
13	H. E. Nelissen [50]	3	Hypertension	Nigeria	Mixed method	To connect pharmacy staff and cardiologists a care model for hypertension care	To report on the implementation and pilot test of pharmacy based hypertension care	Counselling and monitoring	Blood pressure measurements	Patients, pharmacists and cardiologists adopted the care model, although with gaps in mHealth data. Mean blood pressure of the patients was significantly reduced.
14	L. L. English [40]		Child health	Uganda		To aid health care workers to identify pediatric patients at high risk of both in-hospital and post discharge mortality	To summarize the usability evaluation of the PARA app among target users and to improve the design based on the feedback	N/A	The probability of in-hospital or postdischarge mortality for children	Based on the feedback the app is improves in many aspects. Users described the usability of the app and agreed to use if it is available in their healthcare facility
15	N. J. Kauta [46]	3	Fracture management	South Africa	Retrospective analysis of cases	For co-management of surgical cases in resource scarce setting	To report on the assessment of the use of WhatsApp as a mobile health platform to support fracture management by non-orthopedic surgeons	N/A	Advice on posted cases	non-specialist doctors were able to manage traumatic through virtual supervision and co-management by an orthopedic team on a WhatsApp referral group. Confidentiality is an issue.
16	A. A. Boatin [43]		Maternal health	Uganda	Hybrid effectiveness study	To detect and alert clinicians of abnormal vital signs in women for 24 h after undergoing emergency cesarean delivery	To report on effectiveness implementation study of using wireless physiologic monitoring system to detect and alert clinicians of abnormal vital signs in women	N/A	Physiologic data (heart rate, respiratory rate, temperature and blood pressure) with alerting notification if abnormal case is there	Insights is offered into use of wireless monitoring systems in low resource-settings, as well as physiologic parameters among women delivering by CS.

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S/n	First Author and citation	Stage	Health issues addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Results
17	P. Francis-Lyon [41]	2	Child health	Kenya		To early identification of developmental delay	Too report on the prototype design of a child cognitive assessment	N/A	Integrated data during children cognitive assessment	The tablet app is designed and developed

Appendix 3. Overview of telemedicine based mHealth approaches

s/n	First Author and citation	Stage	Health issues addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Result
1	O. Faye [56]	3	Dermatology	Mali		To address the problem arise due to lack of specialist dermatologists.	To report on feasibility investigation of teledermatology pilot program focused on primary health centers and its impact on the management of skin diseases.	N/A	Diagnosis result of different skin condition and drug prescription so that they can treat their patients	Slight increase is seen in dermatological activities and a huge decrease in the proportion of patients with unclear diagnosis on all intervention sites
2	M. Solano [65]	3	maternal health	South Africa		To guide midwifes in taking US images and their interpretation through tele consultation and guidance by specialists to detect different pregnancy related problems in order to decrease maternal mortality	To describe the assessment of the feasibility of an electronic medicine system in facilitating consultation and collaboration between specialists in maternal-fetal health and midwives new to obstetric ultrasound	N/A	Annotated maternal ultrasound image and consultation on different cases from specialists.	It is technically feasible to expand routine availability of prenatal ultrasound to populations with restricted access to this service.
3	R. Latifi [61]	4	Speciality services	Cabo Verde	Prospective study		To present the preliminary results of building the Integrated Telemedicine and e-Health Program for Cabo Verde (ITeHPCV), with an emphasis on initial utilization and results.			The ITeHP-CV has been successfully launched, and the initial results are encouraging.
4	G. P. Parham [53]	4	Cancer	Zambia		To assist in cervical cancer diagnosis by creating locally adaptable and sustainable public sector cervical cancer prevention program	To report on the implementation of cervical cancer prevention program by employing widely accessible telemedicine platform.	N/A	Cervical cancer examination, Distance consultation, patients electronic medical record, education	The system facilitated monitoring and evaluation of nurses' performance measures, rapid access to off-site experts, continued education of nurses, and patient education and medical records documentation
5	S. Kingue [70]	4	Hypertension	Cameroun	Prospective interventional study	To improve the outcome of hypertension patients by providing remote guidance and consultation using phone call and voice mail	To report on the implementation and evaluation of the effectiveness of a telecare intervention package for improving outcome of hypertension patients.	N/A	Baseline systolic (SBP) and diastolic (DBP) blood pressure, and treatment consultation	More participants in the intervention groups achieved optimal BP control, High risk participants (hypertension stage III) in the intervention group
6	C. Karari [69]	4	HIV	Kenya	Survey	To provide expert advice for HIV counsellors using	To evaluate the uptake, acceptability, and effectiveness of clinicians HIV hotline	N/A	Consultation from expert HIV clinicians	The platform increased access to current information for quality care in a

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s/n	First Author and citation	Stage	Health issues addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Result
						toll free telephone call				rural and resource limited setting and has potential for scale-up to a national level.
7	M. Foerster [54]	4	Cancer	5 SSA Countries Namibia, Uganda, Nigeria, Zambia	Prospective cohort study	To estimate cancer survival	To report the implementation of active mobile health follow up to decrease loss to follow up	N/A	Vital status and quality of life information	LTFU was much lower and the study enabled estimation of up-to-date and reliable cancer survival.
8	F. Njenga [68]	3	Psychiatry	Kenya	Case study	To provide remote consultation for psychiatric patients during covid-19 pandemic	To report on the challenges and opportunities of implementing remote patient consultation service as a result of Covid-19 outbreak.	Consultation regarding their medical conditions remotely	Information and other related symptom of their patients	This intervention has demonstrated that it is possible in an African country to rapidly shift platforms in a clinic setting.
9	E. A. Olajubu [59]	2	Clinical service			The framework uses mobile devices that can run Light Weight Agents (LWAs) to send consultation requests to a remote medical expert in urban city from the vulnerable interiors.	To propose a telemedicine platform for the vulnerable areas of developing nations.	If test result is ready	Laboratory test request Test result	The simulation result shows the average queue length, the number of entities in the queue and the number of entities departure from the system.
10	J. Frühauf [58]	3	Skin disease	Uganda		To provide mobile teledermatology service	To report the evaluation of applicability of mobile teledermatology service with regard to the impact of remote diagnoses on patient outcomes, and local health workers' perception concerning this mode of dermatology consultation	N/A	Consultation on skin diagnoses results	It is demonstrated teledermatology is applicable in support in auxiliary health workers in LMIC.
11	D. Epstein [63]	3	Imaging	Uganda		To improve access to radiological services for people living in rural area	To report on the clinical work session of testing of POCUS augmented examination	N/A	Support in diagnosis and consultation through telemedicine service	In a variety of medical conditions, these point of care device can be used by physicians with a limited training as a powerful diagnostic tool
12	P. Schmid-Grendelmeier [57]	4	Dermatology	Tanzania		To provide better skin care	To report the first established teledermatologic connection in Tanzania	N/A	Consultation received from expert dermatologists	teledermatology proved to be a highly beneficial and efficient tool
13	E. N. Mupela [60]	4	Clinical service	Zambia		To bring free medical expertise and treatment directly to under-served communities in hard-to-reach areas via telemedicine	To report on the implementation of mobile clinic and telemedicine platform to provide healthcare service to underserved area.	N/A	Consultation from experts from capital city or abroad on complex cases	This overview of the Virtual Doctor Project provides insight into both the potential for ICT, and the barriers that any "real-world" articulation of this technology must confront
14	M. Kifle [67]	4	Ophthalmology	Ethiopia	Case study	To provide remote ophthalmology diagnosis and eyecare service to alleviate the shortage of ophthalmologists and the service	To examine the need and adoption of teleophthalmology service in Ethiopia	N/A	Consultation and/ or second opinion from expert ophthalmologists	This work could be considered as the starting point to investigate telemedicine projects in Ethiopia and other countries.
15	A. L. Azakpa [55]	4	Cancer	Benin	Retrospective study	To alleviate the problem of shortage	To report the experience of	N/A	To experts: demographic data	Telepathology enables a great

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s/n	First Author and citation	Stage	Health issues addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Result
						of pathology services.	telepathology practice in the improvement of cancer diagnosis.		of patients and anatomic site To local health workers: histologic type and histologic grade	improvement in cancer diagnosis
16	R. Griggs [64]	3	Imaging	South Africa		To alleviate problems with shortage of radiologic services	To examine the practicality and sustainability of a pilot pediatric teleradiology project	N/A	Assistance in interpretation/ reading of pediatric radiology image	Although teleradiology is a viable option to alleviate radiologist Shortages, there are many challenges to designing an adequate teleradiology system.
17	J. N. Olayiwola [62]	3	Speciality services	Nigeria	Case review	To deliver high quality specialty consultations to patients and their clinicians in Africa using US-licensed and board certified physician specialists	To assess the impact subspecialty clinician-to-clinician electronic consultations (eConsult), on general practitioners (GPs) serving a diverse patient population	N/A	Consultation on different subspeciality cases	Telehealth/ eConsult has tremendous potential in improving GPd capacity to handel subspeciality s=cases
18	S. Laing [66]	3	maternal health	Gambia	Prospective cohort study	To improve perinatal acre	To report the value of mobile telephone followup	N/A	Birth outcome	Mobile phones can be used as an important follow up tool

Appendix 4. Overview of wearable sensor based mHealth approaches

s/n	First Author and citation	Stage	Health issue addressed	Country	Study characteristics	Goal of mHealth use	Aim of the article	Information provided to the patient	Information provided to the health professional	Results
1	C. M. L. Hughes [71]	3	Stroke & rehabilitation	Ethiopia	Experimental	To enhance stroke evaluation and rehabilitation to enable rehabilitation clinicians to develop patient-specific rehabilitation plans.	To introduce a new low-cost wearable sensor designed to enhance stroke evaluation and rehabilitation to report on validation of its performance	N/A	Quantitative information about upper limb movements	The results of the study demonstrates that wearable sensor systems are capable of accurately measuring upper limb joint angles, joint range of motion, and limb usage

Appendix 5. Overview of mixed mHealth approaches

s/n	First Author and citation	Stage	Health issues addressed	Country	Study characterstics	Goal of mHealth use	Aim of the article	Approaches	Information provided to the patient	Information provided to the health professional	Result
1	J. Coetzer [78]	3	Health information	South Africa	Action research	To support the Sethakeng rural community in obtaining meaningful and dependable access to health services and health information	To present an adaptive, user-centered approach to development of Mobile-Health (M-Health) intervention for a semi-literate rural community	(app and telemedicine)			Improves upon the existing mHealth application which contains SMS based and telemedicine by employing human centered design approach such as anthropomorphism and affective design.
2	V. McCormack [75]		Cancer	(Namibia, Nigeria, South Africa, Uganda,	Prospective cohort study	To track the survival rates of patients diagnosed with breast cancer.	To provide survival estimates in women in SSA and apportion the survival gaps.	(app and telemedicine)	N/A	Smooth data collection and tracking.	There is large variation in breast cancer survival. This also indicates that improvements are possible

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s/n	First Author and citation	Stage	Health issues addressed	Country	Study characterics	Goal of mHealth use	Aim of the article	Approaches	Information provided to the patient	Information provided to the health professional	Result
				and Zambia							
3	O. N. Mgbemena [76]	3	Cardiac and medical	Nigeria		To provide specialist medical care for patients through telemedicine.	To report on a pilot trial of telemedicine platform in order to doctors to reach out to patients for cardiac and medical service via website and SMS. It has also incorporated for physician to physician consultation in case if the patient requires specialized service.	(SMS and telemedicine)	Diagnostic requests and prescriptions	Patient waiting list Patient history, signs and symptoms, Diagnosis results	There is huge potential of telemedicine in improving health care service delivery to patients in developing countries. The service was free of charge.
4	S. A. Christie [80]	3	Injury	Cameroon	Prospective observational study	To provide further care for discharged injured patients	To establish the feasibility of a mobile health follow-up program after injury	(phone call (telemedicine) and SMS)	Request to comeback to hospital for follow up by licensed Physician	N/A	There is considerable under treatment of injury and mobile telephone follow-up demonstrates potential as a feasible tool for screening discharged patients who could benefit from further care
5	L. K. Beres [77]	3	Health Behaviour	Uganda	Randomized control trial	To improve health related behaviors	To advance the evidence base for mobile health (mHealth) interventions in LMICs	(App and SMS)	Behaviorally responsive interventional health messaging (EMAI)	Daily reports on 5 different health behaviors (fruit consumption, vegetable consumption, alcohol intake, cigarette smoking, and condomless sex with a non–long-term partner)	Preliminary estimates suggest that EMAI may be a promising strategy for promoting behavior change across a range of behaviors.
6	F. S. Sarfo [73]	3	stroke	Ghana	Randomized control trial	To improve medication adherence and lowering BP after stroke	To report on a test whether mHealth enabled nurse led intervention improves blood pressure	(telemedicine and SMS text)	Motivational text messages based on their status/ adherence	BP measurements and summary reports	It is claimed effective to implement task shifting,from doctors to nurses, such system for chronic disease management.
7	F. S. Sarfo [74]	3	stroke	Ghana	Observational prospective pilot study	To provide tele rehabilitation service for stroke survivors for improved outcomes	To report on the assessment of the feasibility and outcome of mobile assisted physical exercises for stroke rehabilitation	(App and telemedicine)	Standardized rehabilitation program which has four categories of physiotherapy components	Video recording of the patient performing the exercise and data review	It is feasible to administer an m-health delivered physical therapy intervention in SSA, with high user satisfaction
8	J. C. Fotso [81]	4	Newborn and Child health	Malawi	Mixed methods	To improve MNCH outcomes through improved access to timely and accurate health information	To report on the assessment of the impact of a (mHealth) project on uptake of home-based care for newborn and child health	(SMS and telemedicine)	Protocol-based health information, advice and referrals, and automated tips and reminders	N/A	It is demonstrated that a toll-free hotline and messaging service could reduce the workload of facility staff for conditions that can be treated at home.

(*continued*)

s/n	First Author and citation	Stage	Health issues addressed	Country	Study characteristics	Goal of mHealth use	Aim of the article	Approaches	Information provided to the patient	Information provided to the health professional	Result
9	T. A. Odeny [79]	3	HIV	Kenya	Cluster Randomized Trial	To improve uptake of infant HIV testing and maternal retention in postpartum HIV care in a high–HIV-burden setting.	To report on the implementation text message intervention	(SMS AND CALL (telemedicine))	Customized messages based on the recipient's gestational age, language preference, due date, baby name and others	N/A	The text improves testing intervention
10	C. Hughes [72]	3	Stroke	Ethiopia	Experimental	To deliver personalizable upper extremity stroke assessment and rehabilitation for patients	To report usability study to assess the usability of developed upper extremity rehabilitation app which comprises of different functionalities	(Wearable+ app + telemedicine)	Access daily exercise videos, educational materials, report impaired arm use and quality of movement, view their progress, and upload personal query video	Enter, access, and modify patient baseline data, primary and secondary outcome data, document patient's assessment progress, and record tele-consultations between the clinical team and patient/caregiver.	This mHealth platform has a potential to improve how stroke rehabilitation is delivered in countries with there is a deficit of experienced health professionals

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