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A comparative review of mobile health and electronic health utilization in sub-Saharan African countries

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Mobile health and electronic health utilization in sub-Saharan African countries: A comparative review

Abstract

This study distinguished between the application of e-health and m-health technologies in sub-Saharan African (SSA) countries based on the dimensions of use, targeted diseases or health conditions, locations of use, and beneficiaries (types of patients or health workers) in a country specific context. It further characterized the main opportunities and challenges associated with these dimensions across the sub-region. A systematic review of the literature was conducted on 66 published peer reviewed articles. The review followed the scientific process of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines of identification, selection, assessment, synthesis and interpretation of findings. The results of the study showed that m-health was prevalent in usage for promoting information for treatment and prevention of diseases as well as serving as an effective technology for reminders towards adherence. For e-health, the uniqueness lay in data acquisition and patients' records management; diagnosis; training and recruitment. While m-health was never used for monitoring or training and recruitment, e-health on the other hand could not serve the purpose of reminders or for reporting cases from the field. Both technologies were however useful for adherence, diagnosis, disease control mechanisms, information provision, and decision-making/referrals. HIV/AIDS, malaria, and maternal (postnatal and antenatal) healthcare were important in both m-health and e-health interventions mostly concentrated in the rural settings of South Africa and Kenya. ICT infrastructure, trained personnel, illiteracy, lack of multilingual text and voice messages were major challenges hindering the effective usage of both m-health and e-health technologies.

Keywords: m-health, e-health, Sub-Saharan Africa, utilization, healthcare delivery

1. Introduction

The massive use of electronic and wireless technologies to manage, distribute and share health-related information have resulted in new opportunities for patients of both developing and developed countries. This is typically due to the recent movement of healthcare providers towards ensuring sufficient utilization of modern Information and Communication Technology (ICT) for delivering health services to patients with limited access to care. The applications of electronic and mobile health systems (known as e-health and m-health) have been reported by previous studies [1, 2] within the past decade as two key solutions, mainly to aid certain healthcare

practices. This has motivated previous researchers to study the impact of these systems in health-specific contexts as an attempt to increase the quality of healthcare delivery to medically underserved communities such as in Africa, Middle East, South East Asia and some parts of South America [3, 4].

Generally, the use of healthcare technologies in these regions has been broadened from simple notifications and reminders to more efficient usage of health intervention resources. Kiberu et al. [5] highlighted that factors related to the excessive burden of disease in Africa (for instance; the shortage of health professionals; a rapidly growing population; the low median age of people), are the reasons for this expansion. However, as policy makers in the healthcare sector of developed countries are moving towards robotic and tele-surgeries, the developing countries of Africa seem to be lacking directions to effectively deliver ICTs for health-specific purposes [6]. So far, previous reviews on e-health and m-health in Africa have focused on providing insights for enhancing standard care [7, 8], effective implementation of health technologies [9, 10, 8], disease management [11], and policies for implementing technologies [1, 12]. There are relatively fewer reviews that compare the varied purposes of using e-health and m-health across a spectrum of diseases and health conditions in sub-Saharan African (SSA) countries.

According to Gagnon and Scott [13], studies for assessing the suitability of healthcare systems are often criticized for a lack of common outcome indicators of what constitutes success and failure of these systems, in specific context. While health policy makers in Africa have started to recognize the potential of e-health and m-health systems, their usage have been varied across 53 African countries [14]. Thus, tracing the major trend of m-health and e-health systems would unlock new insights, particularly, essential for the development of healthcare services in these countries. This study was conducted to provide an in-depth look at e-health and m-health utilization in SSA countries, together with the opportunities they offer and the challenges in their trends of usage. Outcomes from this review will enrich the current understanding on the dissemination of e-health and m-health in SSA with respect to the country, context of use, purpose/dimension of use, location of use, diseases and health related conditions as well as types of patients or end user beneficiaries.

2. Materials and methods

2.1 Design

This systematic review was conducted during 2017–2018. The study performed a systematic review based on the PRISMA guidelines [15] to discover related research work on e-health and m-health interventions in healthcare service delivery in SSA countries. The taxonomy used in this study was based on previous reviews.

In cases where there was a lack of clarity, researchers agreed on a common taxonomy for a particular study. Our final taxonomy was based on the country, types of intervention (m-health and e-health), users, diseases, dimensions, challenges and opportunities.

2.2 Search approach

Specific criteria for eligibility included studies that were published over the last decade spanning from 2005-2017 based on the search period of the study. This is because the actual e-health and m-health practices in SSA began in 2005. These studies were mainly written in English and focused on the use of m-health or e-health as an intervention for disease prevention, control, awareness, treatment or management etc. The studies must also have some documentation on m-health or e-health intervention results, challenges faced, and opportunities provided. We considered six main databases which comprised Google scholar, Springer, Global health, PubMed, IEEE and Science Direct for our search. Key word combinations such as 'telemedicine' AND 'Use' AND 'Africa'. 'e-health', mobile health, AND 'Use' AND 'Africa' were employed for the electronic search of articles. For example, "the use of telemedicine in Africa" or "the use of e- or m-health in Africa" or "the use of e-health in Africa" etc. Reference search on articles was also used to facilitate the process of identifying relevant articles. Based on the options provided, keywords were sought in the entire text (not only in titles; abstracts; and/or metadata).

2.3 Study selection procedure

By applying the Preferred Reporting Items for Systematic Reviews and Meta-Analyses **(**PRISMA) guidelines, we first identified and gathered all the articles from the six databases. This yielded a total of 1950 published articles. The gathering process was conducted by two researchers and a research assistant, who accessed and assessed the articles simultaneously. Each article selected was based on a recommendation by at least one of the researchers based on its relevance to the study.

Eligibility criteria for inclusion were: (1) research articles conducted in SSA countries; (2) the utilization of m-health and e-health technology for healthcare purposes; (3) peer-reviewed original publications; (4) English-language articles.

After screening the 1950 articles, 1500 articles were excluded because they fell outside the SSA region. The resultant figure was 450 articles left for the eligibility assessment stage. Out of the 450 articles, 384 were further removed. This comprised of 112 studies that were from non-indexed journals; 43 of them not written in English;

and 229 that were deemed not focused on health service delivery or merely looked at health related issues in SSA countries. Out of these 229 articles, 37 studies were basically scoping reviews, 32 synthesis and 40 systematic reviews on specific e-health or m-health technology application for certain diseases. Since the researchers carried out an independent search for the various studies, we further conducted a duplication analysis and removed 40 duplicated studies. After this we further removed 41 articles that focused on technical reports in relation to the development of e-health or m-health systems without their direct usage for health service delivery. Finally, 39 studies that were based on models for adoption or acceptance of e-health or m-health technology were excluded.

At the final stage, the two researchers and the research assistant read through the abstracts and results of the selected papers that satisfied the inclusion criteria.

2.4 Full paper review

After employing the inclusion criteria above, the number of articles that met the standard of inclusion were 66 (34 on e-health and 32 on m-health, see Figure1). Out of the 66 articles, 5 were qualitative and 61 were quantitative. Finally, all the papers were fully read, and assessment made on their quality and appropriateness for the study.

2.5 Quality assessment

Two experts in the field were asked to assess the quality of each article upon meeting the following conditions:

1. Appropriateness of research design.
2. Appropriateness of overall method and analysis procedure.
3. Generalizability of research findings to the target population from which the sample was drawn.
4. Relevance of the study's purpose in addressing questions raised in this study.
5. Trustworthiness of study findings in relation to our research focus.

Agreement for inclusion of the studies was achieved by measuring the interrater reliability between the two experts, and no disagreements occurred. The two experts coded each article independently (categorized into m-health and e-health studies). Interrater reliability for the coding of the quality indicators was established for all the included studies. Based on the recommendation of Cooper et al. [16], the interrater reliability was determined using an item-by-item method and was calculated by dividing the number of agreements by the total

number of agreements plus disagreements divided by 100. Interrater agreement for study features was 95%, with a range from 92% to 98%. The total number of articles that met the standard of inclusion and quality check was 66 (34 on e-health and 32 on m-health, see Figure1).

[INSERT FIGURE 1 HERE]

2.4 Data analysis

The analysis procedure was adapted from Sherifali et al. [17] to serve as a guide to this study.

2.4.1 Coding of papers

The 66 articles obtained were coded using data extraction segments that were developed by considering previous research. They were categorized based on e-health and m-health intervention programmes by means of their functionalities and environmental settings. In addition, dimensions of use, disease or health conditions, and users or beneficiaries of e-health and m-health are presented in Figure 2.

[INSERT FIGURE 2 HERE]

3. Results

Details of the 66 articles selected for the review are catalogued by way of authors, country, e-health or m-health technology, users, disease/health condition, and dimension. Table 1 presents this information while Figure 3 provides a pictorial view of the country distribution by application type and number of studies.

[INSERT TABLE 1 HERE]

[INSERT FIGURE 3 HERE]

Our review of the literature showed that the purpose for utilization of e-health and m-health in SSA countries has been mainly in the dimensions of adherence; diagnosis; reminders; field case reporting; monitoring; training and recruitment; decision making/referrals; disease/condition control and prevention; patients' data acquisition and records management; information provision for treatment/prevention.

With reference to Figure 3, the final 66 studies spanned across 17 countries within the SSA region. Out of these 66 studies, 6 were dedicated to adherence in countries such as Kenya, Nigeria and South Africa. Another 6 studies focused on reminders in Kenya, Zanzibar, Nigeria, Swaziland, Uganda, South Africa. On diagnosis, 12 studies were conducted in Kenya, Zanzibar, Angola, South Africa, Uganda, Botswana and Zambia. Dimensions such as field case reporting, monitoring and decision making were found in three studies based in Malawi, South Africa, Ghana, Mozambique, Botswana and Kenya. In addition, 5 studies showed how e-health and m-health were utilized for training and recruitment in countries such as Mali, South Africa and Malawi. However, in Botswana, Malawi and Kenya, only 3 studies were found to be related to the use of m-health and e-health for decision-making in healthcare interventions. Within the dimension of disease/condition control and prevention, a total of 6 studies were concentrated in countries such as South Africa, Kenya, Ghana, Uganda and Tanzania. The majority of the reviewed studies were focused on data acquisition and records management as well as information provision for treatment and prevention (11 studies for each dimension). These studies were distributed across South Africa, Uganda, Kenya, Ghana, Malawi, Nigeria, Rwanda and Ethiopia. In terms of the frequency of studies, South Africa had the highest number of studies (15) on the utilization of m-health and e-health technologies across the various dimensions. This was followed by Kenya with 13 studies in a similar vein. However, countries such as Ethiopia, Mali, Mozambique, Swaziland and Angola had the least number of studies (one study each) regarding either e-health or m-health for different dimensions and diseases or health conditions.

3.1 Dimensions of use

3.1.1 Adherence

According to Osterberg et al. [18], about half of all patients do not adhere devotedly to their treatment prescription routines. In sub-Saharan Africa, Ware et al. [19] provided reasons for non-adherence to be social, cultural and economic tendencies. Issues such as religion, non-privacy conditions during treatment times, fear of

side effects, disappearance of ailment symptoms, distance to treatment centers, affordability of treatment packages etc. [20] formed a greater part of these reasons. In most cases, both e-health and m-health have been used to promote adherence towards healthcare services in SSA countries. Particularly, most adherence interventions have been related to the use of mobile text messaging alerts for Antiretroviral Treatment (ART) programs for HIV patients [21], antenatal care for pregnant women [22], treatment of blood pressure in adults [23], rapid diagnostic test and post treatment reviews for malaria [24]. In the e-health literature, Evans et al. [25] reported the use of electronic patients' adherence monitoring device for the purpose of monitoring ART adherence by HIV patients in South Africa. However, m-health was mostly used for intervention adherence in the sub region. This may be attributed to the wide ownership of mobile phones by inhabitants in the sub region [8] and the cheaper subscription to certain medical services [26].

3.1.2 Diagnosis

Both e-health and m-health were identified to support diagnostic usage in health delivery in SSA. A case in this instance is from Evans et al. [28] who employed an ECG application installed on a mobile phone to detect cases of fibrillations among adults in rural Kenya. In South Africa, abortion patients were provided with an automated, interactive questionnaire on mobile phones that helped them detect complete abortion conditions [29]. Within the same country, Tsai et al. [30] used a mobile phone application for depression screening among pregnant women in a rural province. Other uses of m-health were for HIV testing [31] and malaria importation detection through mobile phone records and spatial data on Plasmodium falciparum endemicity in Uganda [32].

With regards to e-health, the key utilizations were in tele-pathology, digital radiology and electronic hearing diagnostics. For instance, a new approach to diagnosing hearing loss was the utilization of a medical hearing impairment diagnostic device for patients with hearing problems in South Africa [33]. Another case of reference was an internet-based tele-pathology that was employed in Uganda for synchronous diagnostic purposes [34]. More advanced methods of tele-pathology were recorded in countries like Kenya [35], Zambia [36] and Botswana [37] where web-based static imaging systems have been used to conduct tele-cytological diagnosis. In Kenya and Tanzania, the technology facilitated diagnosis while providing an expert exchange and mentorship between pathologists of both developed and under resourced countries [38]. In relation to the predominance of use, e-health technologies in health diagnosis were widely implemented and patronized than that of m-health interventions. Although economically, the usage of m-health interventions in promoting health diagnosis in the sub region seem to be cheaper (in terms of cost implications) than e-health application systems,

the need for e-health interventions in providing diagnosis was imperative in the health sectors of these countries, mainly due to the lack of specialized pathologists.

3.1.3 Reminders

Evidence from the reviewed studies indicates uses of m-health and e-health in the SSA region, particularly to remind patients for antenatal visits, child immunization, HIV counselling and care appointments as well as HIV drug medication routines. For instance, results from the review reveal the potential of mobile phone text messages sent to pregnant women in Nigeria [39] and Zanzibar [22] to remind these expecting mothers on the utilization of healthcare centers and antenatal care visits respectively. In South Africa, Swaziland and Uganda, text messaging services were provided to HIV patients to remind them of their counselling sessions and care appointments [40, 41]. There were other instances where community health workers used both mobile phone calls and text messages to remind patients on their drug treatment routines [42] as well as childhood immunization in Kenya [43]. The use of m-health in terms of serving as care and treatment reminders in SSA seem to be the most dominant, since no record was indicated by the literature on e-health being used in such a dimension.

3.1.4 Field case reporting

Our review of the literature on e-health and m-health applications showed that these technologies have been commonly used among healthcare professionals to report health-related cases on the field. Yet, this was varied across countries and contexts. For example, Joos et al. [44], estimated the occurrence of 45% of under-five deaths at the neonatal period, but most these mortality cases were unreported. This situation may be due to cultural and social norms or unavailability of report mechanisms [45]. Haws et al. [46] indicated that an issue confronting data acquisition has to do with timeline reports. Previous studies reiterated that, the use of mobile messaging has been recommended by other researchers [44, 48] to facilitate timeliness of reporting medical cases by community health workers normally within 48 hours.

Mobile phones have been used to provide timely notification and actions on malaria cases in South Africa [47]. This was very useful in promoting healthcare intervention and follow up services. Other areas of utilization were for antenatal and post-natal purposes. A case in reference was the use of mobile phones in providing timely reports on postpartum cases after patients' delivery in the northern part of Ghana for immediate interventions [49]. In Malawi, the main purpose was to match the data on pregnancy and pregnancy

outcomes [44]. The usage of m-health phones for case reporting can be attributed to the feasibility nature of mobile phones for health communication.

3.1.5 Monitoring

In SSA, the use of Electronic Health Records (EHRs) and Open-Source-based Medical Record System (OpenMRS) as e-health interventions have gained ground over the last decade [53] in providing reliable data to guide patients' monitoring and evaluation. For instance, EHRs and OpenMRSs were primarily used to monitor for HIV/AIDS patients' care and treatment progress as well as mother-child transmission possibilities. Typical cases include the use OpenMRS for patient monitoring in an HIV/AIDS care and treatment in Mozambique [54]. Another report by Wessels et al. [55] provides evidence on the effectiveness of EHRs in promoting monitoring of HIV care that informed the provision of further support to patients in South Africa. Earlier, similar usage of this e-health intervention was recorded in Malawi [56]. However, the use of e-health for monitoring was limited to HIV/AIDS patients (as they were constantly monitored for treatment of tuberculosis as well as other diseases which may affect patients while taking up their ART) as well as antenatal and postnatal mothers for records on neonatal outcomes.

3.1.6 Training and recruitment

Results from this review indicate some uses of e-health in promoting needed medical education. For instance, web-conferencing tools were employed for HIV care training across twelve African countries to provide a generalized HIV care-based curriculum and to promote a uniform health practice in handling of HIV cases across the sub region [57]. It was also to upgrade the training of frontline personnel on their knowledge and skills in providing medical and other health support services to HIV patients.

Apart from directly improving training for medical care conditions, the use of e-health was effective in recruiting and retaining health professionals in rural communities. According to Bagayoko et al. [61], the technology also represents a mechanism for recruiting and retaining health professionals in remote areas and could reduce the isolation of these professionals through networking opportunities. This could be a new possibility in reducing efforts exerted on recruitment and training of health personnel by way of eliminating travelling of long distances for interviews and orientation sessions for post recruitment training. However, no m-health usage was recorded for training and recruiting purposes in this study.

3.1.7 Decision-making/ referrals

Quality data acquisition and record keeping for decision making is often a challenge in rural parts of SSA due to paper-based records which often result in loss of reliable data on patients' health information [62]. In Malawi, Tweya et al. [63] addressed the potential of using a drug-resistant Tuberculosis (TB)/HIV Electronic Medical Records (EMR) system to promote decision-making on patients' care services. On the other hand, mobile telemedicine systems could help referrals in the fields of dermatology, oral medicine and radiology. Evidence in the literature points to the use of telemedicine applications installed into mobile phones in Botswana [64]. Whatever the case, it is still reasonable to say that the utilization of m-health recorded significant gains in terms of effectiveness in patients' referrals in most SSA countries.

3.1.8 Disease / Condition Control and Prevention

For interventions related to m-health, the reviewed studies introduced several applications such as the use of mSpray to improve malaria control efforts and monitor human exposure to malaria control pesticides in the Limpopo region of South Africa [66]. Within the same context of usage, Madon et al. [67] reported that a mobile phone-based management information system was used in Tanzania for the control of neglected tropical diseases where village health workers were given mobile phones with web-based software to test the feasibility of using frontline health workers to capture data at point of source. Similarly, m-health support systems were employed in Ghana to improve control over maternal and neonatal morbidity [68]. Within the context of e-health, internet-based programmes showed positive results in HIV preventing behaviors. A case in point was the use of CyberSenga, an Internet-based, comprehensive sexuality education program for adolescents in Mbarara, Uganda for promoting HIV preventive behaviors [31] and the use of technology-based HIV prevention programming with an interactive functionality among high school students in Cape Town, South Africa [31]. Other usage of e-health was disease surveillance applications technology in controlling for general infectious diseases [69, 70].

The review of the literature showed the role of e-health in promoting disease prevention. An example is the use of surveillance systems for patients and the use of a records management system by health workers, all in the domain of e-health applications. Odero et al. [70] report the application of an electronic injury surveillance system that provides data for improving patient care and monitoring injury incidence in rural Kenya. The system presented a valuable tool for injury surveillance, epidemiology, prevention and control for communities served by a specific health facility.

3.1.9 Data acquisition and records management

Patients' data acquisition and records keeping have been a setback in health records management in the sub region [71, 72]. Inaccurate data acquired from the field and it's handling at health facilities renders it difficult for case referrals, treatment tracking or progress monitoring [73]. In most cases, data are either unreliable or insufficient [73] hindering health condition related decision-making. Thus, Management Records System (MRS) or Open Management Records System (OMRS) were typically used in countries like Uganda, South Africa, Ghana, Malawi, Rwanda, Nigeria, Kenya, Mozambique etc. [74,75, 76] for keeping of laboratory test results, prescription, monitoring, x-rays, pathological specimens and preparations, patient indexes and registers, pharmacy and drug records, nursing and ward records [77].

Although some m-health based applications have also been used in this setting, it is still very limited. This is because, compared to e-health systems, the use of MRS requires database management systems and larger disk space to handle large medical data which is a limitation to mobile phones.

3.1.10 Information provision for treatment /prevention

The introduction of e-health and m-health seems to have contributed much in the sub region in terms of health information dissemination and knowledge provision. A typical case is reported by van Heerden et al. [82] in South Africa and Uganda [83], where mobile text messaging services have been used to provide free HIV/AIDS prevention information for adolescents. This is partly because Ugandan and South African adolescents are more affected by HIV infection than their adult counterparts [83]. Similarly, other countries have been able to use mobile messaging to inform health workers and patients on good health practices, malaria preventive healthcare [66] as well as providing information to rural birth attendants on skilled delivery strategies to reduce maternal and neonatal morbidity cases [22].

We also observed that both e-health and m-health have been utilized in the sub region for case treatment and management. In Kenya for example, mobile text messages on guidelines for the treatment and management of malaria were sent to health workers in rural areas in terms of outpatient pediatric malaria with the recommended artemisinin-based combination treatment-artemether-lumefantrine [85]. This improved how health workers treated and managed child malaria cases. Other uses of m-health in Kenya were in aiding the treatment and management of cervical cancer. In this instance, cervical cancer patients were made to use mobile phone and Internet to access information related to cancer treatment and management [84]. As for e-health

applications, Telemed-ETH was developed and used in Ethiopia for radiology and dermatology consultation services towards treatment and management of skin related diseases as well as cardiology and neurology treatment and management [86].

The results from the dimensional use of m-health indicate that out of the ten dimensions, the dominant have been for provision of information for treatment and disease prevention; as well as for care reminders among target groups. Of secondary importance, have been the dimensions of drug adherence and diagnosis. Occasional usage of m-health was for reporting of health-related field cases and disease control mechanisms. For e-health utilization purposes, the central dimension was patients' data acquisition and records management followed by diagnostic purposes. Other utilization has been for training and recruitment as well as disease/condition control and prevention mechanisms. Decision-making or referral; monitoring and field case reporting constituted minimal dimensions of use. Quality of data acquisition and management of patients' health records constitute a major challenge within the region [71]. The ability of OMRS and EMRs in providing electronic databases for capturing, storing and managing patients' information provided a feasible solution to this challenge.

Figure 4 provides a picture of the dimensions of use of both m-health and e-health applications and their related studies across countries in the sub region.

[INSERT FIGURE 4 HERE]

3.2 Diseases or health conditions

3.2.1 HIV/AIDS

Our review of the literature showed that HIV/AIDS occupied the central focus for both e- and m-health applications in SSA. We found that most studies on HIV were mostly related to adherence and reminders of ART treatment, patients' records keeping and counselling sessions [21, 40, 88]. This is because the rate of HIV infection in the SSA region alone accounts for more than 70% of the total global infection figure. Specifically, the concentration of the disease has mainly been in the Eastern and Southern parts of Africa [89, 90]. For m-health, most African countries, particularly South Africa (with the highest in the region of about 25%), were concerned about promoting adolescent health information on HIV prevention [82] and care appointment reminders [41]. The prevalence of HIV/AIDS in the sub region coupled with the need for treatment, has made the application of mobile phone text messaging and other uses to be important for reminding patients on clinical

attendance, treatment and counselling sessions and adherence to their dosages and time frames for antiretroviral drug treatment. In few instances, mobile health was useful in promoting HIV testing [91] and HIV/AIDS patients' records data collection and management [88]. In the area of e-health, utilization in HIV/AIDS has been principally in the e-health records system application for data entry, update and management of patients' information [75]. This was used to promote updates of new cases [76], monitoring of ongoing treatment and adherence to care attendance as well as for referrals [92, 93]. Occasionally, e-health was used for promoting decision-making and rendering training sessions on HIV/AIDS treatment [57].

3.2.2 Malaria

The use of m-health applications, for example, has been the main technology intervention mode for most countries and project initiatives in the region through text messaging. It has been used for promoting patients' adherence to treatment and post-treatment reviews [24]. In South Africa, the technology has been mostly utilized for malaria control efforts [66]. This is attributable to the prevalence of the disease within the urban slum and rural areas. In Nigeria, technology-health has also been used in advocating for diagnostic tests [96] to promote rapid response to control delayed treatment and subsequent mortality. Cross border malaria infection is one of the key cases of the spread of the disease in the sub region [32]. Thus, the use of mobile health applications to control malaria infection [32, 47] has prevented delays and promoted almost real-time acquisition of data [85]. However, the usage of e-health in terms of malaria management has been very minimal or non-existent in the literature.

3.2.3 Hearing impairment

E-health was commonly used in caring for patients with a hearing impairment. The use of the asynchronous video-otoscopy enabled asynchronous diagnosis of otological status from remote settlements such as the cases in rural South Africa [33] which were later referred to an otolaryngologist online in an urban area for medication. E-health technology could bridge the gap of the uneven ratio (250,000 to 7.1 million people per otolaryngologist [97]) between patients and otolaryngologist in SSA. It is very much unclear the reason why m-health applications have not been utilized in this sphere. Possible reasons could be that the use of the technology in this direction has not been much verified for its feasibility, or cases arising from hearing impairment are not alarming to warrant much attention.

3.2.4 Pathology

Tele-pathology as an e-health application is being used to solve the scarcity of pathologists [98] in rural areas of the sub region. In the case of Uganda, the e-health application has made it possible for physical separation between the sites where the specimen is processed and where the diagnosis or consultation is rendered [98]. Analysis of cytologic specimen via web-based or satellite support media has also been explored in the sub region. Previous studies [35, 36, 38] have provided some evidence of various forms of these technologies supporting surgical pathology and other forms of pathological services in the health sectors of countries such as Kenya, Tanzania and Botswana. From our findings, m-health was not used to support this aspect of health delivery in the sub region. This could be explained by the system requirements needed for tele-pathology that go beyond a simple smartphone or tablet.

3.2.5 Dermatology

An aspect of the use of e-health in dermatology was for training of health personnel in improving their diagnostic acumen, for example in the case of South Africa [59]. In Ethiopia, the main focus of using e-health was for the treatment and management of skin related infections [86]. Within the same health domain, the use of tele-dermatology was also reported as a feasible way of providing diagnosis of skin diseases in Botswana to support patients in low resourced areas where specialists were lacking [37]. The result of the review did not show any usage of m-health in dermatology care services, it was exclusive to e-health.

3.2.6 Oral health

For oral health delivery, mobile oral telemedicine systems were used in rural areas in countries like Botswana [64]. The mobile application enabled clinicians in areas remote from oral maxillofacial surgeons and oral medicine specialists in referring patients with complicated oral lesions for virtual specialist consultation. This form of health delivery combined both m-health and e-health applications. It was concluded that m-health was used for the referrals, while the consultation was done virtually through a tele-health system.

3.2.7 Diarrhea

In Ghana, Friedman et al. [80] used m-health for text messaging of diarrhea management protocols to licensed chemical sellers, providing intervention in treating diarrhea cases in children under five. The management of diarrhea was limited to m-health application usage. The literature did not provide any e-health

interventions in this area of healthcare in the sub region albeit very low usage of ICT–related health practices towards diarrhea treatment.

3.2.8 Postpartum hemorrhage

The review of the literature showed limited evidence about the effectiveness of e-health and m-health in the management of post-partum hemorrhage. The study based in Ghana, focused mainly on the use of cell phones by professional and traditional birth attendants in the rural north for reporting postpartum hemorrhage data [49] for intervention purposes. Not very much usage of m-health has been concentrated in treating and managing this postnatal health condition, and for e-health it is yet to be explored.

3.2.9 Blood pressure

Cases of blood pressure control and management in the reviewed studies were rare. Most of the studies did not focus on this health condition. Only a case [23] reported using mobile phone text messaging to improve adherence to clinic visits mainly by adults, and subsequent treatment for this health condition. The review of the literature showed few studies examining the potential of using m-health services for controlling and managing blood pressure cases in the sub region. This can be due to the fact that raised blood pressure is almost always without symptoms —which limits the prospects for clinical success. For e-health, no utilization was recorded from the countries towards the treatment of blood pressure conditions.

3.2.10 Fibrillation

Fibrillation cases though on the rise in Africa [28] have seen very little usage of m-health for care services. This is indicative of our review results that provided just a study on how an iPad mobile device that had an electrocardiogram recording technology was used for diagnostics in Kenya. According to Evans et al. [28], the m-health intervention was able to detect significant proportion of Atrial Fibrillation (AF) cases that would have otherwise gone undiagnosed. Though positive, m-health interventions are still under-utilized in the sub region for fibrillation diagnosis.

3.2.11 Cervical cancer

In Kenya cervical cancer remains a devastating disease accounting for more than 2000 deaths each year [84]. In trying to keep up with the control and management strategies of the disease, Kivuti-Bitok et al. [84]

investigated how the use of internet-based and mobile e-health tools could increase information access among cervical cancer patients, related to cancer treatment and management. Assessing the internet for such information was underutilized. A primary reason was the lack of internet connectivity. However, the use of mobile phones in providing Short Message Service (SMS) related to managing cervical cancer conditions served as beneficial.

3.2.12 Depression

A case of usage of mobile phone technology in depression screening was recorded by Tsai et al. [30] in South Africa. This was mainly because depression conditions were significant among women in township settings in the country [99]. Mobile technology that used short and ultrashort screening instruments were programmed into mobile phones for screening diagnosis of depression cases among pregnant women in a province with high prevalence of the condition in South Africa. Again, the use of the technology was minimal, since its integration into depression health delivery is very novel in SSA.

3.2.13 Tropical diseases

The use of either m-health or e-health in controlling for tropical diseases in SSA is still to be fully utilized. This is because, for most tropical diseases in the sub region, their control has been neglected [67]. An effort made in Tanzania to control for tropical diseases exploited m-health technology by village health workers to control for the diseases by way of reporting and collecting data for referral and treatment [67]. However, the usage of m-health technology is low due to that fact that the information generated from the mobile was yet to be used to support decentralized decision-making.

3.2.14 Abortion

Evidence from the review suggested an underutilization of e-health and m-health services in abortion cases in SSA. This is because abortion is still considered illegal in most of the SSA countries. However, in South Africa, medical abortion in the first trimester of pregnancy using mifepristone and misoprostol was approved by the South African medicines control council [29]. This could be the reason why a study by Constant et al. [29] was found to utilize an m-health based intervention for medical abortion cases. In one of the provinces (Cape Town) of South Africa, women used an automated, interactive questionnaire on their mobile phones to assess themselves whether their abortion was complete. The study established the feasibility of this m-

health intervention in detecting complete abortion conditions among target groups. For e-health, no such usage dimension was recorded. Reasons could be that the feasibility of the technology for management of such health conditions has not been explored.

3.2.15 Infections

In Ghana, an e-health intervention had been used to collect data in the northern part of the country for recording and controling infectious diseases [69]. According to Adokiya et al. [69] an integrated disease surveillance and response strategy improved the availability of medical reports, but the quality of data reported was not sufficient as inconsistencies were inherent. For control of infectious diseases in the sub region, both the use of e-health and m-health applications are still minimally used. Possible reasons could be the lack of support for communication within the integrated disease surveillance system [69].

3.2.16 Maternal health related conditions

Evidence from the literature reveals that an m-health intervention has been utilized for providing adherence to antenatal and postnatal medication or practices and reminders on antenatal and postnatal care clinic attendance [22, 39, 102]. In SSA, most rural communities lack primary healthcare centers and hence heavily rely on local birth attendants who have been provided some skills by specialist midwives [103]. The m-health intervention has also been useful in reporting antenatal and postnatal cases on maternal health complications such as postpartum hemorrhage and other complications in pregnancy and child delivery incidents [49]. It facilitated immediate responses to birth complications and referrals in countries where they were utilized. However, the use of e-health in maternal health in SSA has concentrated on aiding the provision of accurate information on routine maternal health service data [104].

3.2.17 Infant health related conditions

Infant mortality (especially under five) is a global issue that has attracted attention in the past decade [105]. Typically, m-health has been utilized to provide reminders to health workers on infant immunization [106]. Few cases have also been recorded on the use of mobile text messaging to provide guidelines to pharmacists on first aid for child diarrhea treatment [80]. For e-health in particular, usage has been towards the treatment and management of pediatric related diseases and care management [107]. However, the results depict that utilization of both m-health and e-health have not been predominant in child care health delivery services.

This may be due to the fact that for most cases, the attention has been on maternal health outcomes that have a direct bearing on infant health.

Our results showed that the distribution of studies across various diseases and health conditions was not homogeneous. A review of the 66 studies showed that 21 studies were focused on HIV/AIDS, 10 studies were on health promotion interventions, 8 studies were on maternal health related conditions, 5 studies were on malaria, and 4 studies were on pathological cases. In the case of dermatology, only 2 studies were found in the reviewed literature. In addition, 3 studies were found on infant health related conditions. One study was found for each of the following diseases or heath conditions: hearing impairment, oral lesions/health, diarrhea, postpartum hemorrhage, blood pressure, fibrillation, cervical cancer, depression, tropical diseases, abortion, infections, tuberculosis and hypertension. From these observations, it can be anticipated that the utilization of e-health and m-health technologies may serve as platforms for interaction between patients and healthcare professionals in various situations and conditions.

3.3 Opportunities and challenges of e-health and m-health in SSA

The usage of both e-health and m-health provided some opportunities and challenges towards effective achieving certain health results. The following subsection presents the opportunities and challenges in e-health and m-health usage from the studies registered for this review (see Table I in the supplementary file for more details).

3.3.1 Opportunities of e-health and m-health across dimensions

The usage of m-health and e-health applications in the health sector of SSA countries presented some opportunities for health delivery within the region.

Adherence.

In the adherence usage dimension, m-health applications provided an avenue for assessing the core wording elements of text messages that could be effective in promoting adherence behavior in patients towards primary facility visit or medication routines [23]. It also highlighted the level of willingness of care givers in accepting such a technology to promote their adherence level in meting out treatments [24]. Coupled with this, m-health gave a positive indication of the feasibility of mobile phones in promoting healthcare delivery in rural settings within the region, through simple text messaging [21, 96, 108]. For e-health, the main opportunity

identified through adherence promotion was the positive indication of a possibility for an electronic patient adherence monitoring device to be an effective tool within low resource locations [25].

Diagnosis.

Within the usage dimension of diagnosis, the use of mobile phone-based electrocardiogram technology for AF screening in low-resource settings could detect a significant proportion of AF cases that would otherwise have gone undiagnosed, thus reducing early risk to stroke conditions [28]. It also provided a new way of aiding self-assessment of abortion cases among women to reduce post abortion complications [29]. Furthermore, a mobile voluntary counselling test can also serve as an important link to community-based care and treatment services as they become more widely available [91]. In e-health, the use of tele-radiology showed a possibility of providing an external support on diagnosis and case management [107] as well as the ability of a tele-health facilitator with limited training, to conduct video-otoscopy recordings in children for asynchronous diagnosis [33].

Reminders.

The dimension of reminder use revealed that, opportunities exist in using mobile texting coupled with incentives which could serve to significantly improve immunization coverage and timeliness as well as improved maternal and newborn health which ultimately could reduce maternal morbidity and child mortality [43]. The inclusion of extensions such as using voice SMS and the use of women groups as the community entry point to reach the most vulnerable women by way of distribution of free affordable mobile phones and their usage, could improve maternal health [22, 39]. Previous studies on m-health also provided an avenue for further investigation into the impact of reminder on adherence towards appointments and medications in other settings where buzzing may be an affordable alternative to phone calls or text messaging in substantially improving the clinical management of HIV/AIDS [40, 42].

Field case reporting.

The utilization of m-health technology in SSA has been found to offer convenient way for reporting of pregnancies and pregnancy outcomes among community health workers (health surveillance assistants), particularly in low resource settings. Examples of this include the use of one-way SMS sent by the field

coordinator when conducting field visits [44]. Cell phones can be used to train professional and traditional birth attendants to report health-related outcome data via a specified protocol at real time [49].

Monitoring.

It was also observed that using e-health technology for demonstrating its feasibility for monitoring health related issues provided grounds for others seeking to follow a similar approach [54]. The technology also proved to have a great potential for its adaptation and use for other chronic diseases such as tuberculosis, diabetes mellitus, and hypertension, preparing a foundation for a comprehensive electronic health record system [109].

Training and recruitment.

With respect to training and recruitment, web-conferencing offered opportunity for HIV clinicians from other countries to benefit from expert teaching from leading scientists [57]. The educational benefit of web-conferencing by way of referring primary care physicians could be sustainable and would ultimately enhance the quality of dermatological care [59]. For capacity building, tele-education seems to have been well received and is more successful than the usual clinical telemedicine [60] which could be an additional tool for providing mentorship to company health workers in their routine care of HIV-infected workers and family members [56]. In addition, e-health offered a mechanism for recruiting and retaining health professionals in remote areas, which could reduce the isolation of these professionals through networking opportunities [61].

Decision-making /referrals.

Our review also showed that mobile telemedicine could provide the avenue to optimizing the use of insights and skills of specialists remotely in regions where they are scarce [64]. The use of the EMR system demonstrated the potential to enhance integration of TB/HIV services and facilitate improved decision-making among providers [63-75].

Disease/condition control and prevention.

For disease monitoring purposes, the use of cell phone technology could increase the efficiency of indoor residual spraying for malaria control efforts by mapping spray events in relation to malaria cases [66] while mobile phones again present a unique informational resource for promoting the cause of neglected tropical

disease control in developing countries [67]. Within e-health, the system has the potential of providing surveillance data on various diseases for control and prevention mechanisms in SSA [69]. Furthermore, a greater exploration of applications of technology in delivering HIV preventive behavior in South Africa was proposed in the study of [31].

Data acquisition and records management.

E-health application usage further provided evidence for the use of provider-based EMR in large HIV programs in SSA [76]. In an exceptional case such as Malawi, a moderate number of recommendations from ART guidelines could be used to generate automated guideline adherence feedback using existing EMR data. It could also be used to support workplace learning by increasing healthcare workers' opportunities to reflect on their performance [92]. Additionally, mobile technologies have the potential to reduce the cost associated with manual entry into a computer from a paper form per individual encounter [111]. E-health has also provided an example of the potential to overcome the harsh computing environment in countries like Nigeria to implement e-health systems that will improve the quality of patient care [112]. In the long run, these computer-based systems will be better systems and a cheaper alternative in the long run [113]. Again, there is an indication of great potential for use of m-health in the management of cervical cancer through SMS, without internet connectivity.

Information provision for treatment/prevention.

For HIV/AIDS, there is room for effective HIV prevention programs based on cell phone delivery that could reach a large audience in Africa [83]. This would support the current formation of Malaria control programmes to also consider use of text messaging to improve health workers' case-management practices [85].

3.3.2 Challenges of e-health and m-health

Despite the opportunities offered by e-health and m-health applications within the sub-region, there exist some challenges to realizing the full potential of these applications. In utilizing m-health applications, authors such as Otieno et al. [24] indicated preferences for different text messaging languages in English, Kiswahili or Dholuo to be the main obstacles an individual may experience when using m-health. The multilingual nature of the various settlements serves as a barrier to communication in a country like Kenya where there is the non-existence of just one official language for both rural and urban centers. Other indicator

challenges were the need for testing different wording of the text message to verify which word choices most increase adherence [96]. This makes us wonder how wording of the content of the text message plays a key part in catching the attention and promoting urgency in patients' adherence behavior. Challenges such as indirect and direct costs incurred; and literacy level of patients in understanding the content of the messages were also addressed in the literature [22, 43, 84, 106]. Lester et al. [21] report the loss of mobile phones due to internal displacement caused by political violence in some parts of the region, thus impeding progress of adherence promotion. A problem shared by Crankshaw et al. [41] in addition to switching off phones by patients with varying reasons. Oyeyemi and Wynn [39] on the other hand, associate this to network failure or inadequate power supply for charging phones. In most rural settings of SSA, the customary multiple users of mobile phones raised concerns for confidentiality issues in cell phone interventions especially within the domain of HIV/AIDS drug adherence where stigmatization may be apparent [108].

For e-health applications, the main challenge in usage for adherence provision was the correct use of the adherence device by patients. Correct usage of the device was correlated with drug use [25]. Cost implications especially related to hardware and software equipment involved in the implementation of m-health and e-health was highlighted in some previous studies [28, 107] within the dimension of diagnosis. In terms of disease control, Eskenazi et al. [66] reported issues of cost of cell phones and cellular bundles as a major barrier while Zurovac et al. [85] reiterated cost involved in operational requirements in rolling out a national scale distribution of e-health application in information provision and treatment. The lack of computer literacy formed the main hindrance in utilizing mobile and e-health for monitoring [109], training and recruitment [57], data acquisition and records management [76] as well as information provision and treatment [114]. Furthermore, the general IT infrastructure was of concern especially in delivering e-health interventions. These included internet speed and availability, lack of computers, limited data storage capacity, power supply, data transfer and data security issues [34, 57, 60]. In areas where geographic information surveillance systems were utilized as e-health interventions for disease control and prevention, mapping out demarcations electronically to cover all potential sites of disease outbreak was the main challenge [66, 93]. Human resource wise, the established information technology systems lacked trained personnel to maintain and also offer technical advice and assistance where necessary [75, 93] and in some cases very few practitioners [86] could be utilized for the intervention campaigns.

Finally, the recipients of e-health and m-health had problems of stigma associated with testing positive to HIV status in public (in terms of being unfamiliar or uncomfortable with sexual topics [31], identification and

addressing of value proposition for users [109] as well as new user uneasiness [76] to e-health systems). Professional health workers were not always available on phone or at the health center to address village health team concerns and posed a lack of coordination between village health teams and health professionals [115]. When health personnel such as licensed chemical sellers etc., were involved in specific prescriptions for drug interventions, their perceived consumer demand and profit motives preceded their adherence to WHO standards [80] which may affect genuine supervision and accurate feedback [69].

4. Limitations and Future Works

Despite the inclusion of only ISI/Scopus sources for conducting this review, there may be a bias of not including other papers published in non-ISI/Scopus journals which may add some additional insights to this review. In addition, countries from other parts of Africa especially north of the Sahara were not included in this study. This study did not look at how certain interventions (e-health or m-health) may influence healthcare development in each country using more in-depth statistical methods.

Based on these, it is suggested that future works could consider the inclusion of other articles published irrespective of the status of the journal to provide a comprehensive and unbiased view of the state of e-health and m-health in Africa. Countries in other parts (north of the Sahara) of Africa could be included in the study and even further analysis provided on the differences and or similarities in the state of m-health and e-health utilization between the two parts of Africa. Finally, a meta-analysis could be conducted in future to provide statistical evidence on how m-health and e-health interventions are contributing to healthcare development in countries within the African region.

5. Conclusions

Our review of the literature on e-health and m-health technologies showed how they were mostly distributed within the rural and semi-rural areas of SSA. Initiatives were targeted at locations which were underserved or under-resourced in terms of health personnel or relative to social amenities or resource availability. In most instances, rural case referrals were intervened with telemedicine applications that transmitted patients' diagnostic information to urban health centers for medication prescription or mobile text messaging for case management guidelines. The lack of specialist health personnel in the sub region makes m-health the main tool for providing adherence and remainders related services. This allowed patients and health specialists to customize the SMS intervention in a low-resource operational setting. Yet, some key challenges

from using m-health in information provision and treatment were also addressed with regards to the infrastructure and the literacy level among patients or users of the device. With regards to e-health, it was commonly used by health specialists for data acquisition and records management purposes. The technology enabled them to access EMRs, so they could reflect on patients' performance and prescription history. E-health was more dominated by health specialists in SSA countries for monitoring purposes, mainly because of its role in dealing with large EMRs where they can compare and assess case development under certain prescriptions.

The main subjects or patients who benefitted from e-health and m-health interventions in SSA countries were pregnant women, nursing mothers, HIV/AIDS patients, children, adolescents and adults in general. Of these subjects or patients, the focus of previous studies was mostly on pregnant and nursing mothers (10 studies) as well as HIV/AIDS patients (11 studies). This suggests that, continual development in projects on m-health and e-health interventions are likely to reduce the maternal and infant mortality rates, as well as improved HIV/AIDS awareness, treatment and management in SSA.

Supported by 15 studies, South Africa was the leading country of SSA to implement these e-health and m-health technologies for various health interventions, followed by countries such as Kenya (13 studies), Uganda, Malawi, Ghana, and Nigeria respectively. On the other hand, and due to the minimal number of studies found in the present review (only one or two studies for each country), Zanzibar, Swaziland, Zimbabwe, Angola, Mali, Botswana, Tanzania, Rwanda, Ethiopia, and Mozambique were found to be countries with the least utilization of these technologies. We believe that these countries can greatly benefit from m-health and e-health services to widen community health awareness and increase public access to care, particularly in remote areas or for people with limited access to healthcare facilities. In view of this, health policy makers of such countries are encouraged to extend their current use of e-health and m-health to domains such as adherence, diagnosis, appointment reminders, data acquisition and records management for other diseases where applicable. Additionally, how m-health and e-health could be used to provide health interventions to special needs persons across the dimensions revealed in this study, could also be further explored.

Summary points

What was already known on the topic:

- Utilization of e-health and m-health technologies offer a possibility in promoting healthcare delivery in SSA countries.

- These technologies have been employed for managing some diseases across specific dimensions of use (e.g., adherence, reminder, monitoring, etc.) in some countries in SSA.
- Subsequently, the usage of e-health and m-health technologies have been separately studied in specific SSA countries for managing diseases (e.g., HIV, Malaria, etc.).

What this study adds:

- A comparative review to show the feasibility of using e-health and m-health technologies, based on the country, types of intervention, users, diseases, and dimensions.
- An in-depth understanding on how management and treatment of certain diseases can be achieved with the use of either m-health or e-health technologies across SSA countries.
- Major insights on challenges and opportunities of e-health and m-health technologies, with regards to the dimensions of use.
- Information on how certain SSA countries have been successful or ineffective in using these technologies.

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TABLES

Table 1: Studies on e-health and m-health utilization in SSA countries

No	Study (Author &Year)	Country	E-health/M-health technology	Users	Disease/ health conditions	Dimension
1	Leon et al. [8]	South Africa	m-health	Hypertensive adults	Blood pressure	Adherence
2	Otieno [24]	Kenya	m-health	Health professionals/workers	Malaria	
3	Modrek et al. [96]	Nigeria	m-health	Malaria patients	Malaria	
4	Lester et al. [21]	Kenya	m-health	Health workers & Human Immunodeficiency Virus (HIV) patients	HIV-1	
5	Pop-Eleches et al. [108]	Kenya	m-health	HIV patients	HIV	
6	Evans et al. [25]	South Africa	e-health	HIV patients (Adolescents)	HIV	
7	Gibson et al. [43]	Kenya	m-health	Parents	Infant health related conditions	Reminders
8	Lund et al. [22]	Zanzibar	m-health	Pregnant women	Maternal health related conditions (antenatal)	
9	Oyeyemi and Wynn [39]	Nigeria	m-health	Pregnant women	Maternal health related conditions (antenatal)	
10	Kliner et al. [40]	Swaziland	m-health	HIV patients	HIV	
11	Kanutsor et al. [42]	Uganda	m-health	HIV patients	HIV	
12	Crankshaw et al. [41]	South Africa	m-health	HIV patients	HIV	
13	Evans et al. [28]	Kenya	m-health	HIV patients	Atrial fibrillation	Diagnosis
14	Constant et al. [29]	South Africa	m-health	Adolescents	Abortion	
15	Tsai et al. [30]	South Africa	m-health	Pregnant women	Antenatal depression	
16	Tatem et al. [32]	Zanzibar	m-health	Health professionals/workers	Malaria	
17	Morin et al. [91]	Zimbabwe	m-health	Adults	HIV	
18	Zennaro et al. [107]	Angola	e-health	Health professionals/workers	Infant Health Related Conditions	

19	Biagio et al. [33]	South Africa	e-health	Health professionals/workers	Hearing impairment	
20	Kumar et al. [35]	Kenya	e-health	Health professionals/workers	Pathology (cell-related conditions)	
21	Sohani and Sohani [38]	Kenya & Tanzania	e-health	Health professionals/workers	Pathology (skin, blood, cell, bone, and soft tissue)	
22	Wamala et al. [34]	Uganda	e-health	Health professionals/workers	Pathology (fever and blood related conditions)	
23	Tsang et al. [37]	Botswana	e-health	Health professionals/workers	Dermatology (skin related conditions)	
24	Pagni et al. [36]	Zambia	e-health	Health professionals/workers	Pathology	
25	Joos et al. [44]	Malawi	m-health	Health professionals/workers	Antenatal Outcomes	
26	Quan et al. [47]	South Africa	m-health	Health professionals/workers	Malaria	Field Case Reporting
27	Andreatta et al. [49]	Ghana	m-health	Health professionals/workers	Postpartum hemorrhage cases.	
28	Manders et al. [54]	Mozambique	e-health	Health professionals/workers & HIV patients	HIV/Acquired Immune Deficiency Syndrome (AIDS)	
29	Douglas et al. [109]	Malawi	e-health	Health professionals/workers & HIV patients	HIV (Antiretroviral therapy)	Monitoring
30	Wessels et al. [55]	South Africa	e-health	Health professionals/workers & HIV patients	HIV (Highly active antiretroviral therapy)	
31	Bagayoko et al. [61]	Mali	e-health	Health professionals/workers	General Healthcare	
32	Reid et al. [57]	West, East and Southern African countries	e-health	Health professionals/workers	HIV healthcare	Training & Recruitment
33	Colven et al. [59]	South Africa	e-health	Health professionals/workers	Dermatology (Skin related diseases)	
34	Mars [60]	South Africa	e-health	Health professionals/workers	General Healthcare	
35	Clevenbergh et al. [56]	Malawi	e-health	Health professionals/workers	General Healthcare	
36	Tesfalul et al. [64]	Botswana	m-health	Health professionals/workers & Patients	Oral lesions	Decision-Making /Referrals

37	Tweya et al. [63]	Malawi	e-health	Health professionals/workers & HIV Patients	Tuberculosis/HIV	
38	Oluoch et al. [75]	Kenya	e-health	Health professionals/workers	HIV	
39	Eskenazi et al. [66]	South Africa	m-health	Health professionals/workers	Malaria	Disease /Condition Control and Prevention
40	Madon et al. [67]	Tanzania	m-health	Health professionals/workers	General tropical diseases	
41	Adokiya et al. [69]	Ghana	e-health	Health professionals/workers	General infectious diseases	
42	Ybarra et al. [119]	South Africa	e-health	Adolescents & Health professionals/workers	HIV	
43	Ybarra et al. [31]	Uganda	e-health	Adolescents & Health professionals/workers	HIV	
44	Odero et al. [70]	Kenya	e-health	Health professionals/workers	General diseases	
45	Seider et al. [110]	Uganda	m-health	Health professionals/workers & HIV Patients	HIV	Data Acquisition and Records Management
46	Amoakoh-Coleman et al. [104]	Ghana	e-health	Health professionals/workers	Maternal health related conditions (both antenatal & postnatal)	
47	Cline and Luiz [74]	South Africa	e-health	Health professionals/workers	General health	
48	Castelnuovo et al. [76]	Group of SSA countries	e-health	Health professionals/workers	HIV	
49	Lewis et al. [92]	Malawi	e-health	Health professionals/workers	HIV (Antiretroviral therapy)	
50	Were et al. [111]	Kenya	e-health	Health professionals/workers	General health	
51	Waters et al. [121]	Malawi	e-health	Health professionals/workers	General health	
52	Amoroso et al. [122]	Rwanda	e-health	Health professionals/workers	HIV	
53	Thompson et al. [112]	Nigeria	e-health	Health professionals/workers	Maternal health related conditions (both antenatal & postnatal)	

54	Asangansi et al. [113]	Nigeria	e-health	Health professionals/workers	General health	
55	Siika et al. [93]	Kenya	e-health	Health professionals/workers & HIV patients	HIV	
56	Haricharan et al. [120]	South Africa	m-health	Health professionals/workers & Deaf hypertensive patients	Hypertension	
57	Ayiasi et al. [115]	Uganda	m-health	Health professionals/workers & Nursing Mothers	Maternal health related conditions (postnatal)	
58	Friedman et al. [80]	Ghana	m-health	Health professionals (Pharmacists)	Childhood diarrhea	
59	Tumusiime et al. [106]	Uganda	m-health	Health professionals/workers	General diseases	
60	Lau et al. [102]	South Africa	m-health	Health professionals/workers & Pregnant women	Maternal health related conditions (antenatal)	Information Provision for Treatment/Prevention
61	Kivuti-Bitok et al. [84]	Kenya	m-health	Adults (Cancer Patients)	Cervical cancer	
62	Mitchell et al. [83]	Uganda	m-health	Adolescents	HIV	
63	Zurovac et al. [85]	Kenya	m-health	Health professionals/workers	Pediatric malaria	
64	Van Heerden et al. [82]	South Africa	m-health	Adolescents	HIV	
65	Horner et al. [114]	South Africa	e-health	Health professionals/workers	Maternal health conditions (antenatal & postnatal)	
66	Shiferaw and Zolfo [86]	Ethiopia	e-health	Health professionals/workers	General Health	

FIGURES

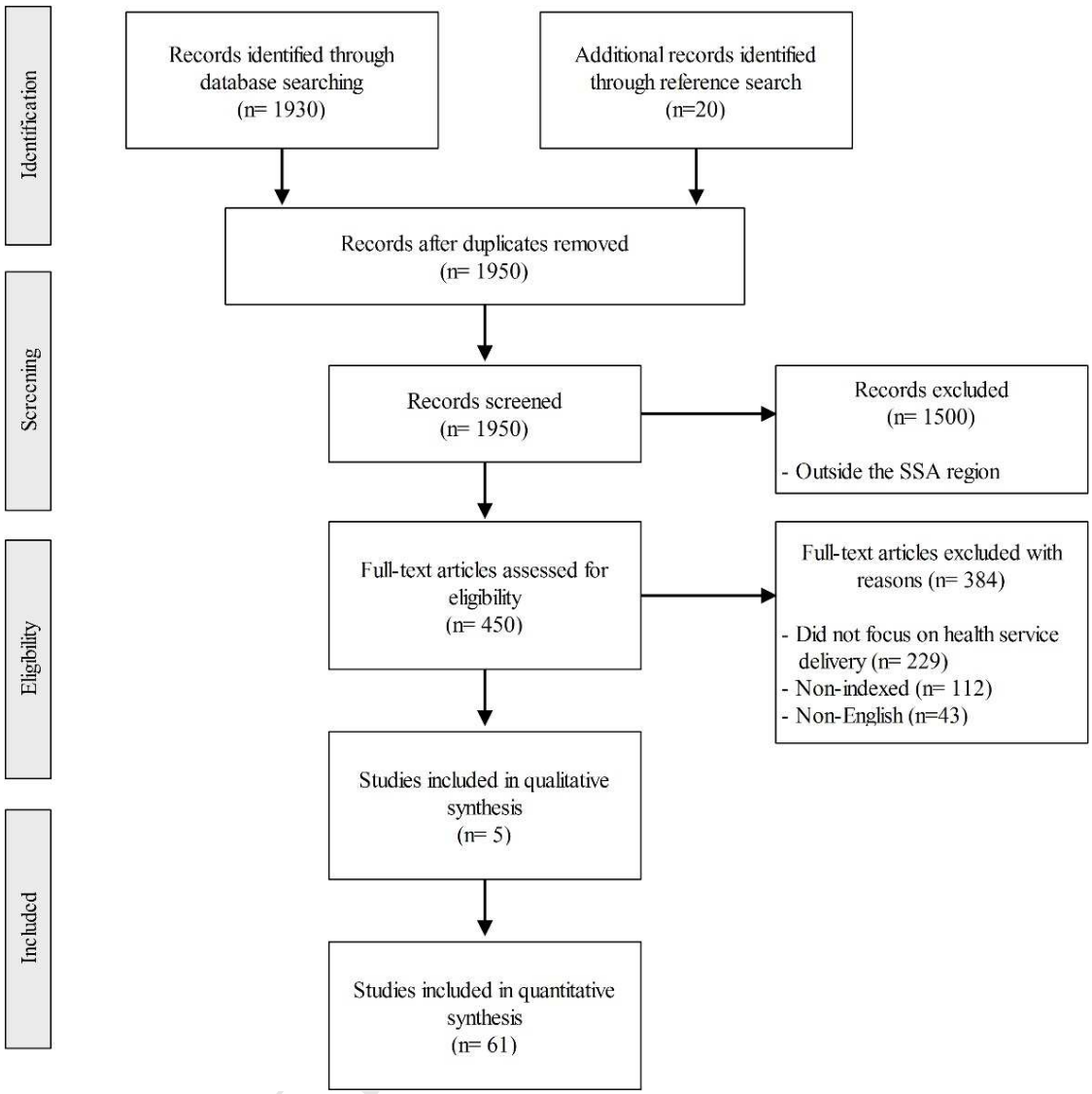

Figure 1: Article selection procedure

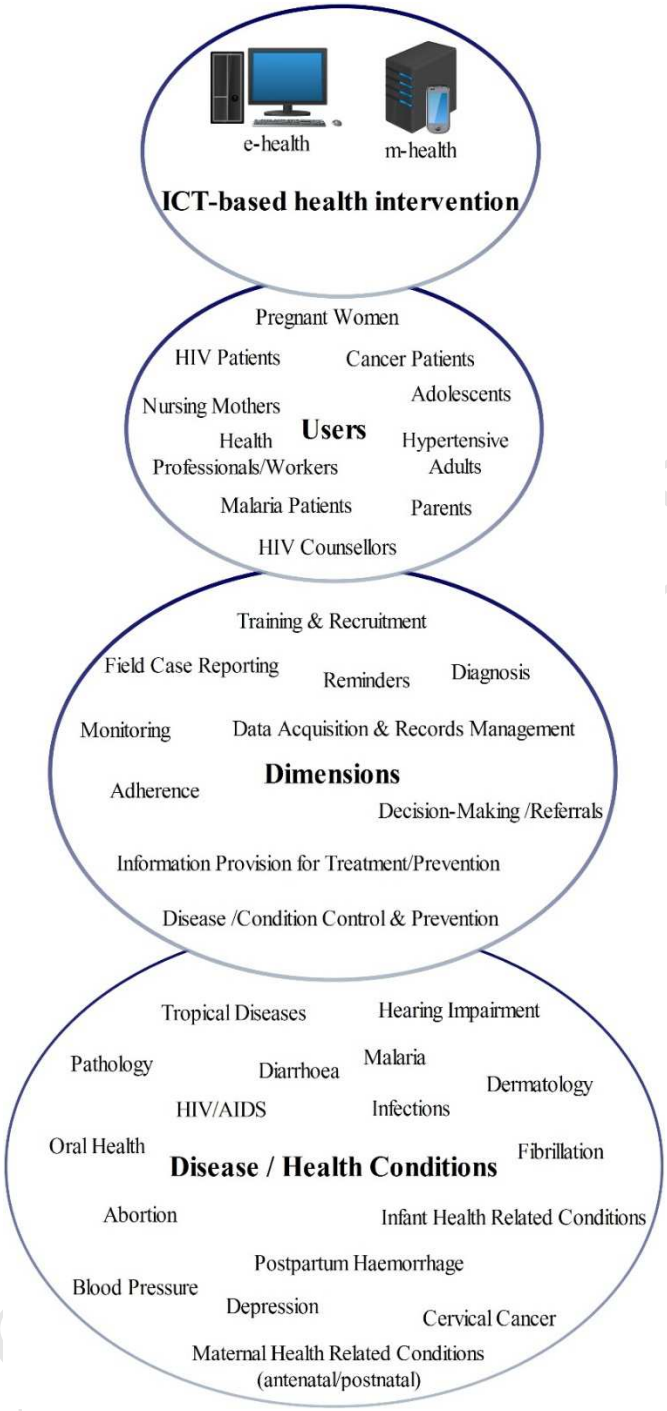

Figure 2: An illustration of the context of the study

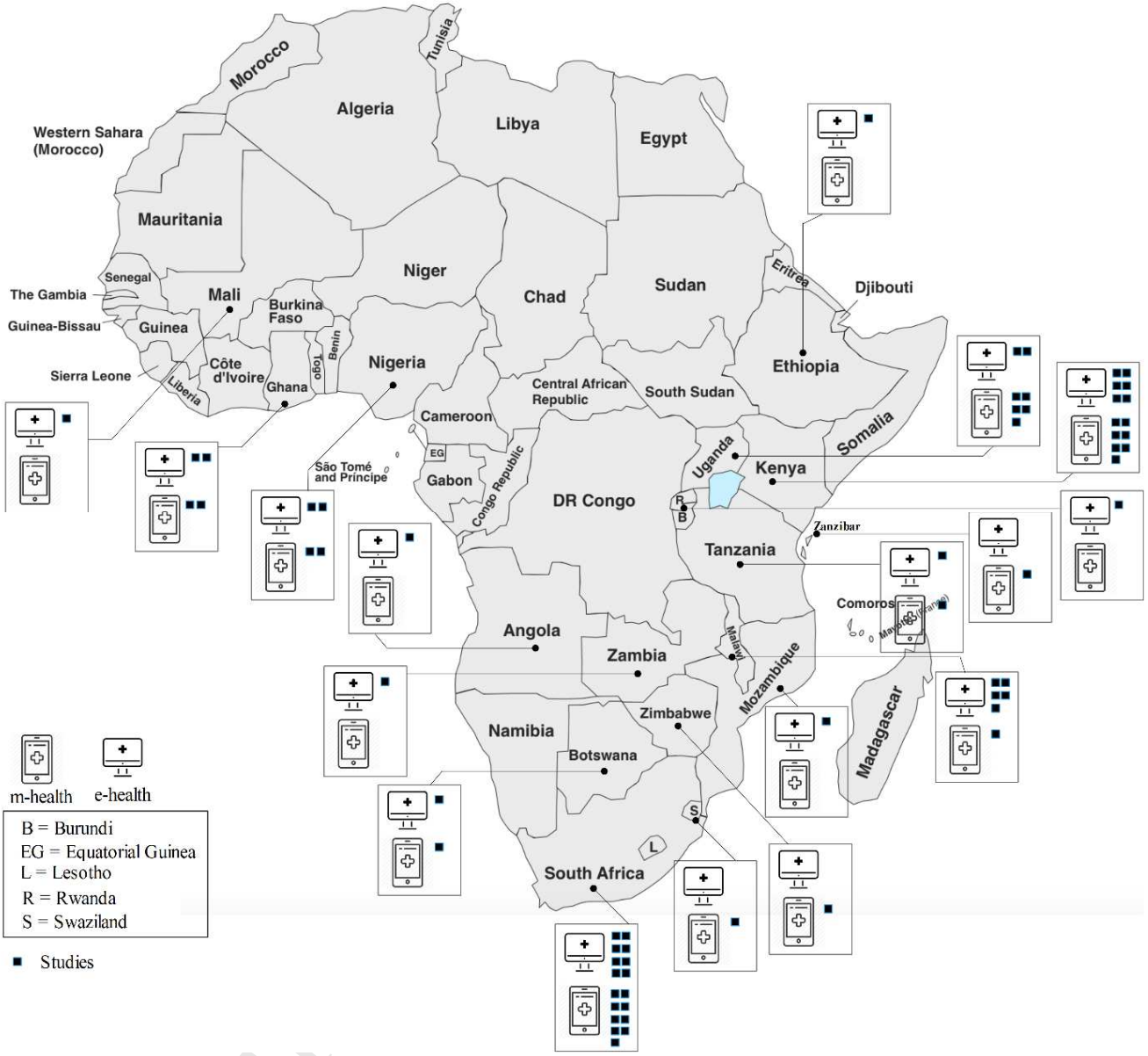

Figure 3. An illustration of m-health and e-health utilization across SSA countries

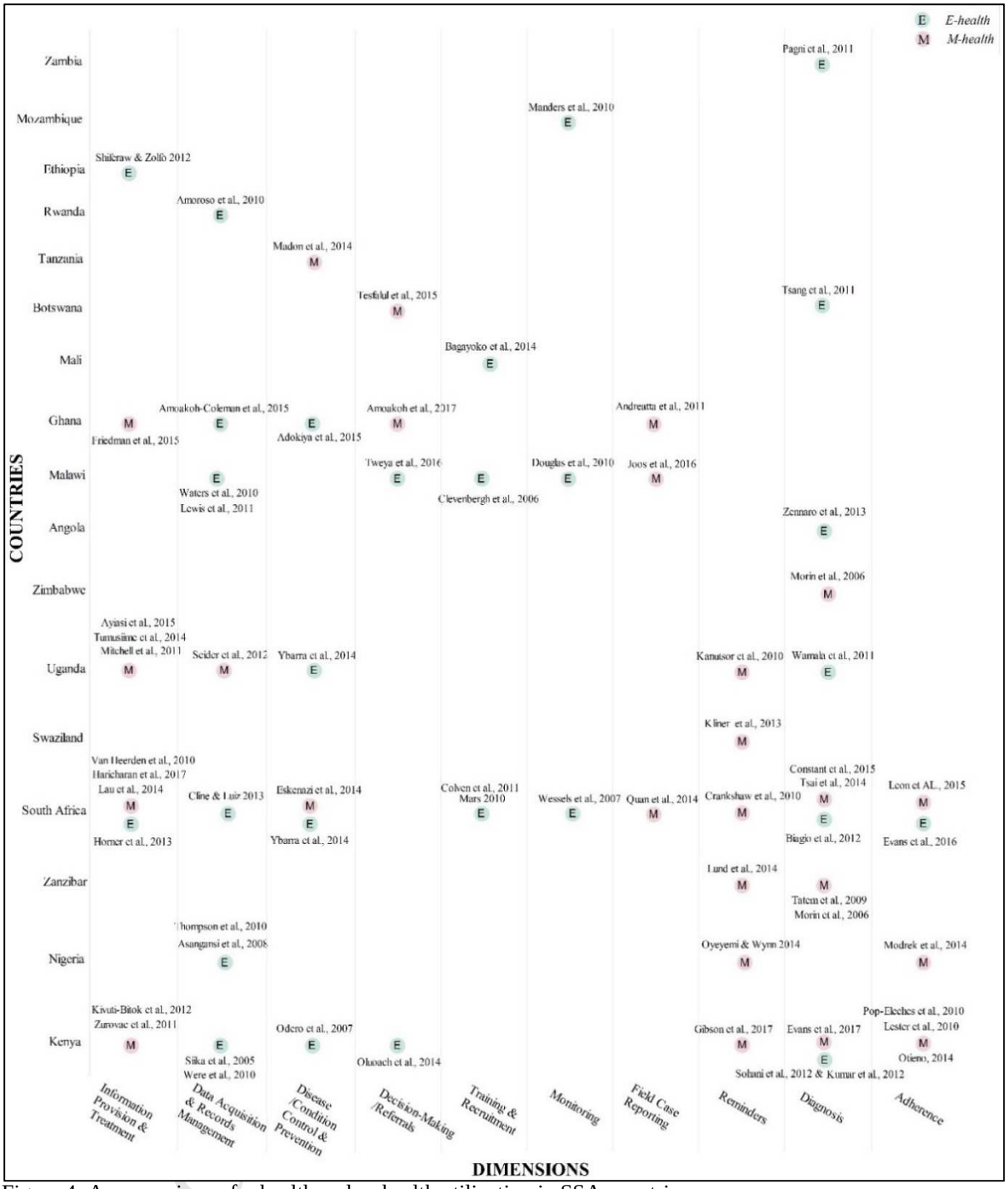

Figure 4: A comparison of e-health and m-health utilization in SSA countries

Highlights

- A comparative review of m-health and e-health in sub-Saharan Africa was conducted.
- The key opportunities and challenges of using these technologies were addressed.
- Differences in utilization were found between the two technologies.
- Both technologies were useful for adherence, diagnosis, and disease control.