Chapter

Telemedicine in Africa: Applications, Opportunities, and Challenges

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Abstract

Telemedicine is the delivery of healthcare services remotely through information and communication technology (ICT) devices. Telemedicine offers a promising solution to address unmet healthcare needs across the African continent. This review explores the current state, opportunities, and challenges of telemedicine in this context. While growth has been significant in recent decades, access remains limited in many rural and underserved regions due to numerous barriers. Despite these limitations, telemedicine has demonstrated its great potential to improve healthcare delivery, particularly in primary care, chronic disease management, specialist consultations, and remote education and training. As new technologies emerge, the scope of services will expand. When used effectively, telemedicine not only improves patient outcomes and healthcare efficiency but also enables collaboration among healthcare professionals, fostering knowledge sharing, and capacity building across geographical barriers. To increase effective utilization across African states, access barriers such as limited internet connectivity, inadequate infrastructure, regulatory hurdles, cultural beliefs, and individual (patient/provider) concerns must be addressed. This requires a multifaceted approach involving various stakeholders supporting healthcare service delivery in the continent.

Keywords: telemedicine, telehealth, e-health, healthcare access, Africa

1. Introduction

Throughout the history of mankind, people have used various tools such as drums, smoke, and horns to communicate over considerable distances [1]. In the 1700s and 1800s, various groundbreaking electrical inventions such as telephones and telegraphs allowed for almost instantaneous communication over long distances and gave birth to the information and communication age [1]. Information and communication technologies are increasingly being used across all facets of our lives today. These technologies have great potential to address some of our pressing healthcare needs, particularly in Africa and other developing countries.

The word 'telemedicine' is derived from the Greek word 'tele,' meaning 'at a distance,' and the word 'medicine,' which has its roots in the Latin word 'medicina,'

meaning 'to heal.' This translates to 'healing at a distance' [2]. Telemedicine is both the art and science of diagnosing, treating, and managing patients and providing healthcare services over a distance using information and communication technology.

2. History of telemedicine

Telemedicine's history stretches back over a century ago. As early as 1879, an article in The Lancet envisioned the use of telephones to decrease unnecessary hospital visits, foreshadowing telemedicine's potential to improve healthcare accessibility [3]. The invention of the electrocardiogram (ECG) in 1906 enabled the transmission of medical data across distances in the Netherlands, and by the 1920s, radio consultation centers had sprouted across Europe [4]. In the 1940s, Pennsylvanian cities successfully transferred radiographic images by telephone, showcasing the increasing possibilities of remote diagnosis and consultation [4].

The United States has played a key role in telemedicine's evolution and expansion through supporting innovation in telemedicine. In 1960, the National Aeronautics and Space Administration (NASA) pioneered using telemedicine technologies to monitor astronauts during space missions [5, 6]. Use of such technologies allows physicians to monitor and manage astronauts through Mission Control, and the scope has expanded due to advancement in satellite communications and connectivity. Soon after NASA piloted the use of telemedicine, its application spread quickly to other areas beyond space science. In the Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC) project, two-way radio, television, and telemetry to provide care to remote regions over 100 miles away in Southern Arizona [7], greatly increasing access to care for rural communities in the served areas.

Concurrently, between the 1950s and early 1960s, closed-circuit television facilitated psychiatric consultations between the Nebraska Psychiatric Institute and Norfolk State Hospital [8]. Technological advancements continued to propel progress in telemedicine, particularly in teleradiology, which has gained widespread global adoption. Radiologists were early adopters and embraced standards like the Digital Imaging and Communications in Medicine (DICOM) for efficient transmission and storage of medical images worldwide, allowing for connectivity, interoperability, and scale-up [9, 10].

The past three decades have seen a surge in telemedicine adoption, fueled by the rise of the internet and mobile technologies. The COVID-19 pandemic further accelerated its growth, highlighting its critical role in maintaining healthcare access while safeguarding safety [11–13]. By necessitating social distancing measures, the pandemic drove healthcare providers to utilize telemedicine to ensure continuity of care while minimizing the risk of coronavirus transmission. Governments relaxed regulations, insurers expanded coverage, and healthcare systems invested in telehealth infrastructure to meet the increasing demand for remote healthcare services [14–16]. Telemedicine is undergoing continual evolution, marked by the expanding application of technologies like artificial intelligence, wearable devices, cloud computing, blockchain, 5G networks, remote monitoring devices, and numerous others. These technological advancements hold the potential to enhance access to quality healthcare, improve patient outcomes, and hopefully reduce healthcare costs.

3. Definitions

In 2007, The World Health Organization (WHO) defines telemedicine as '*the delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities*' [17]. The WHO also specifies that for a service to qualify as telemedicine, it must have four key features, namely offering clinical support, overcoming geographical barriers, or being delivered remotely, utilizing information and communication devices, and increasing accessibility, utilization, efficiency, and effectiveness of healthcare services and a reasonable or affordable cost [18].

While many authors use 'telehealth' and 'telemedicine' interchangeably, others distinguish them by defining telemedicine as a specific subset of telehealth focused on direct clinical care delivery through telecommunications technology. This contrasts with the broader definition of telehealth, which encompasses all uses of telecommunication technology in healthcare such as prevention, diagnostics, treatments, and healthcare administration including information sharing and education between patients and providers [19].

Telemedicine employs a variety of information and communication technologies, such as phone calls, virtual video-based communication platforms, smartphone applications, wearable technologies, remote diagnostic devices, and telehealth carts that bring mobile clinics to underserved areas. Additionally, dedicated platforms integrate various tools like video calls, messaging, appointment scheduling, and electronic health records (EHR) management. Newer technologies such as chatbots, Internet of Things (IoT), Virtual Reality systems, ultrafast connectivity, computer vision, machine learning algorithms, and natural Large Language Models (LLMs) such as ChatGPT will support a wider scale and scope of applications in telemedicine and beyond [18, 20]. Increased integration of artificial intelligence (AI models) into healthcare systems will support patients and clinicians, allowing for more personalized patient care, increased access, and better population health, while hopefully with affordable costs.

4. Types of telemedicine

There are three main types of telemedicine, categorized by the timing of information exchange:

1. Store-and-forward: patient data is stored before transmitting it to a healthcare provider for later review. There is no simultaneous interaction between sender and receiver.

2. Remote monitoring: this method employs various technological devices to remotely track a patient's health and clinical signs. This is frequently utilized in management of chronic conditions like cardiovascular disease and diabetes.

3. Synchronous/real-time interactive services: this telemedicine approach features live, face-to-face communication between patients and healthcare providers. It encompasses activities like taking medical history, consultations, discussing treatment plans, and offering counseling.

5. Disease burden in Africa

Compared to other world regions, Africa's healthcare system faces numerous challenges and lags behind other continents on almost all health indicators [21]. The African continent also lags in human development partly due to high disease burden. With an increasing population (11–13%) and high disease burden of disease contributing to 25% of global disease burden, Africa's spending is less than 1% of the global budget for health, shows the need for further investment to improve access [21]. The high burden of infectious diseases like HIV/AIDS, malaria, and tuberculosis, coupled with significant maternal, neonatal, and childhood illness and mortality and the rapid rise of chronic non-communicable diseases, severely strain African healthcare systems. Urgent action is needed to bridge care gaps across the continent and reverse these negative health trends, aligning with the United Nation's (UN) Sustainable Development Goals (SDGs) launched in 2015.

The 2022 WHO survey revealed a region-wide average of only 1.55 health workers per 1000 people, far below the recommended 4.45 [22]. This translates to just 2.3 healthcare workers per 1000 in Africa compared to 24.8 in the Americas, leaving only 1.3% of global health workers to shoulder 25% of the global disease burden [21]. Many countries do not meet the WHO's recommended density of 2.5 per 1000, with half having fewer than 10 physicians per 100,000 people (compared to 250 or more in developed nations). These gaps significantly hinder essential healthcare delivery and achieving universal health coverage across the continent.

With the increasing adoption and use of technological devices around the world, the use of telemedicine has the potential to revolutionize healthcare delivery in Africa and other low- and middle-income countries (LMICs) and bridge the healthcare gap. Telemedicine can offer a wide range of services, including preventive/health promotive, curative, diagnostic, monitoring, and health educational services. In this chapter, we will explore the application/opportunities and barriers to telemedicine in Africa.

6. History of telemedicine in Africa

Although telemedicine is considered to be in its infancy in Africa, it is not new in the continent. Africa's adoption of telemedicine has been marked by innovation, but uneven infrastructure and resource limitations have made progress slow and geographically patchy. Despite these challenges, several countries have pioneered successful telemedicine programs, offering hope for the future of healthcare delivery on the continent.

The early 1980s saw Ethiopia and, later, Sudan in the 2010s, take the first tentative steps, using telecommunications to bridge the gap between remote communities and healthcare specialists in areas like obstetrics, pediatrics, and family medicine [23, 24]. These pilot projects offered hope for the continent but also brought forth the harsh realities that exist in the diverse continent of Africa. Below are some of the successful telemedicine projects across the continent:

6.1 Gezira family medicine project

One of the earliest telemedicine projects was in Sudan. This explored the use of telemedicine and e-learning in a primary care context. Over 3800 online

consultations and 165,000 new patient records were created by doctors enrolled in the program. Participants found both telemedicine and electronic medical records (EMRs). Nearly all participants emphasized the value of telemedicine and electronic records, and trainees highly appreciated the great value of online learning despite logistical challenges. This study demonstrates the potential of information and communication technology (ICT) for both training and healthcare delivery in primary care settings [24].

6.2 RAFT

In 2001, the Réseau en Afrique Francophone pour la Télémédecine (RAFT) network was established by the University Hospitals and the University of Geneva in French-speaking Africa. Initially targeting 15 countries and focusing on medical education, the project faced challenges with high operational costs. However, it successfully connected hundreds of healthcare professionals, offered teleconsultations, implemented clinical information systems, and even deployed mHealth projects. Since 2010, RAFT has expanded its reach to Bolivia and Nepal [25].

6.3 iPath

Launched in 2001, the University of Basel's iPath telemedicine platform was a point-to-point telepathology system. This web-based platform facilitated online case discussions, real-time telepathology, and case repository access. Within 4 years, the network boasted over 700 users and diagnosed over 6300 cases, transforming into a global pathology network [26].

6.4 African teledermatology project

This collaboration between various institutions, including the University of Pennsylvania and African universities, used store-and-forward telemedicine to provide consultations for dermatological conditions in 13 Sub-Saharan African nations including Uganda, Botswana, Malawi, Swaziland, Burkina Faso, and Lesotho. From 2007 to 2009, it processed over 345 consultations, addressing various skin concerns like adverse drug reactions and HIV/AIDS-related diseases [27, 28].

6.5 The Swinfen charitable trust network

This innovative telemedicine system employed a low-cost, store-and-forward approach to connect healthcare workers in developing countries with a global network of volunteer consulting specialists. Launched in 1999, the program had grown to encompass over 163 hospitals across 60+ countries. Communication initially relied on email but later transitioned to a secure, web-based messaging platform accessible through any internet connection, eliminating the need for specialized software. Central to the program was a secure, centralized system where healthcare workers share anonymized clinical case details when requesting specialist advice. These volunteer specialists would offer their expertise free of charge. Despite its success, the network faces some challenges, including outdated equipment, unreliable internet access in some regions, navigating medicolegal considerations, and ensuring consistent specialist quality. Additionally, the network's rapid expansion has presented sustainability concerns [29–32].

6.6 Pan-African E-network

This ambitious project, a collaboration between India and Africa, aimed to build capacity through quality education and tele-expertise. It provided consultations by Indian medical institutions to African Union member states. While it successfully delivered degrees, telemedicine consultations, and continuous medical education sessions, the project was discontinued in 2017, with the infrastructure handed over to the African Union Commission [33].

These are just a few examples of the many telemedicine projects that have shaped the landscape in Sub-Saharan Africa. While challenges remain, such as digital divides, data security, and skilled personnel, the potential for telemedicine to revolutionize healthcare access and quality in the region is undeniable. With continued collaboration, innovation, and clear strategies for integration and sustainability, this technology can truly bridge the gap and bring vital healthcare services closer to those who need them most.

7. Application of telemedicine technologies in Africa

Telemedicine offers a variety of technologies, like video conferencing, mobile health apps, remote monitoring devices, electronic health records (EHRs) and wearable technologies. These technologies allow healthcare professionals to remotely consult with patients, manage and monitor their health, and manage records effectively. In Africa, mobile health applications have seen particular growth due to the continent's widespread smartphone use and expanding cellular and connectivity networks. As reported by GSMA Intelligence, 46% of the population in Sub-Saharan Africa were mobile phone subscribers in 2024, with smartphone adoption reaching 64%. GSMA predicts that Africa will gain 120 million new mobile subscribers by 2025, bringing the total to 615 million [34]. These applications empower patients to consult healthcare providers, schedule appointments, and access medical information directly from their mobile devices, offering convenient and accessible healthcare solutions.

Below are some of the applications of telemedicine in the continent:

7.1 Remote/virtual consultations

Remote or virtual consultations emerged in the 1980s and 1990s as a powerful tool connecting patients in remote locations with healthcare providers [1]. These consultations served as valuable tools in expanding and improving healthcare access, especially for patients with limited mobility or residing in resource-limited, geographically isolated areas. Remote consultations enabled consultations, diagnoses, and follow-up appointments, leading to improved access and outcomes [35]. The coronavirus pandemic further accelerated the adoption of remote consultations, normalizing their use and demonstrating their feasibility, safety, and effectiveness through initiatives like the Cabo Verde Telemedicine program [36], Réseau Afrique Francophone de Télémédecine (RAFT) [37] and REaCH studies in Tanzania and Nigeria [38]. Remote consultations can be used to support primary care providers by linking hospital-based physicians, enhancing integrated healthcare service delivery over a distance.

While ethical considerations regarding high-risk conditions, vulnerable populations, and technology access require careful attention, many regulatory bodies, such as the General Medical Council (GMC) in the United Kingdom, Health Education,

and Improvement Wales, and the Health Professions Council of South Africa, recommend healthcare providers adopt the following high-level principles when conducting remote consultations. These principles ensure patient safety and quality care in a virtual or remote setting [39–41]:

1. Healthcare providers (HCP) must always prioritize patient safety. Concerns should be raised if the platform or system lacks adequate safeguards, including secure patient identification and verification protocols.

2. HCP should be capable of identifying vulnerable patients and taking appropriate steps to ensure their safety and well-being during the consultation.

3. Both the HCP and patients and others present should introduce themselves and their roles/titles at the start of the consultation. The HCP should explain the remote consultation process and address any concerns the patient may have.

4. Obtain informed consent from the patient, adhering to relevant mental capacity laws and applicable ethical codes.

5. The HCP should conduct a comprehensive clinical assessment, utilizing available or previous medical records and, if necessary, performing virtual examinations or requesting additional tests as required.

6. HCP should clearly explain all available options, including the right to decline treatment, in a language understandable to the patient.

7. The HCP should summarize the agreed treatment or action plans, highlighting any timelines and opportunities for further questions.

8. The HCP should update patient records accurately and immediately after the consultation.

9. The HCP should arrange for appropriate aftercare and, with the patient's consent, share relevant information with other healthcare providers involved in their care.

Table 1 shows some of the potential benefits and limitations of using telemedicine for remote or virtual consultations. Adopted from Khanji et al. [42].

7.2 Chronic disease management

Africa's healthcare systems, already grappling with infectious diseases like malaria, HIV/AIDS, and tuberculosis, face a growing threat from chronic illnesses like diabetes, heart failure, COPD, and autoimmune diseases [43]. In Tanzania, for instance, the prevalence of diabetes is on the increase, straining an already understaffed healthcare system with an 87.5% and 67% doctor shortage in the private and public sectors, respectively [44]. In SSA, about 24 million people were living with diabetes in Africa in 2021, predicted to increase by 129% to 55 million by 2045, according to the World Health Organization [45]. The same reports also note that more than half (54%) of people living with diabetes in the African Region remain undiagnosed.

	Potential benefits of remote consultations	Potential limitations of remote consultations
Patient	Real-time interaction over a distance	Inability to express symptoms or problems effectively, Limited access to technology, and internet connectivity
	Enhanced access to specialist expertise	Language barriers and cultural differences
	Convenience (e.g., for those with children elderly, immobilized, or those with disabilities etc.)	Privacy and data protection breaches
	Save travel costs	Reduced satisfaction from less clinical interaction (physical contact, body language, examination, clinic investigations, etc.)
	Saves time since no need for travel	Inability to conduct physical examination, Challenges with accurate diagnosis and treatment without physical examination
	Greater access to services	Peri-visit tests less readily available (blood, X-ray, ECG, etc.)
	Reduced risk of exposure to infectious diseases	Lack of trust in remote consultations
Healthcare system	Greater flexibility in service delivery models	Limited ability to provide urgent prescriptions
	Reduced requirement for hospital waiting areas	Need for staff training for effective delivery
	Increased efficiencies in cost	Potential for clinical risk from reduced ability to identify deteriorating patient's need for appropriate training and support for healthcare workers
	Reduced risk of nosocomial infection	Need for robust, potentially costly, clinical governance and local data protection systems
Other (environment/ societal)	Reduced pollution from vehicle travel	Higher energy consumption from internet data use/ storage with potential impact on environment and climate change
	Potential for innovation and software development	High cost of technology, interoperability challenges between different applications

Table 1.
Potential benefits and limitations of remote consultations.

Traditional healthcare delivery models struggle to keep pace with this rising burden, potentially leading to poor health outcomes. Innovative solutions are urgently needed. Telemedicine offers a promising approach to managing chronic diseases and alleviates pressure on healthcare systems. By enabling remote monitoring, medication reminders, and virtual support groups, among other telemedicine applications, it empowers patients to actively participate in their health management.

In Rwanda, a telemedicine program for diabetes patients using smartphones in primary health care settings showed a significant reduction in blood sugar levels compared to traditional care [46, 47]. During the COVID-19 pandemic, many providers across Africa adopted mental health tech startups like Wazi (Kenya), PsyndUp (Nigeria), MindIT (Ghana), and the MEGA project (South Africa and Zambia) to offer free virtual consultations, thereby facilitating easier and quicker access to mental

health services [13, 48]. In Cameroon, TELEMED-CAM study assessed the role of telemedicine in controlling hypertension in rural villages. Cardiologists at a central hospital remotely connected with rural healthcare workers (nurses). After 24 weeks of follow-up, patients receiving telemedicine support, especially those at high risk, saw significantly better blood pressure control. This suggests telemedicine could be a valuable tool to improve chronic disease management in resource-limited regions [49].

Such programs not only free up healthcare workers for critical tasks but also improve patient engagement and access to specialist care and form part of an integrated healthcare delivery ecosystem. Investing in telemedicine technologies can significantly enhance existing healthcare systems and optimize the utilization of their limited workforce. This can also reduce travel costs by reducing the need to travel to seek specialist care and help break geographical barriers to access. Patients can also benefit from second opinions that were previously hard to obtain and make informed decisions about their health.

7.3 Medical education

Across Africa, a critical need exists to bolster human resources for health (HRH) to keep pace with growing demands. Advances in technology affect healthcare delivery and healthcare education in equal measure. With rapid advances in technology, we need to constantly evolve, adapt, and incorporate new and emerging technologies into the future healthcare worker. Medical institutions can leverage the power of technology to train, connect, and upskill healthcare professionals more effectively to meet pressing needs. Though new technologies are still emerging and evolving, changes such as asynchronous, 'on demand educational content,' learner-directed content, humanistic educational methods, use of artificial intelligence and large language model, and globally diverse learning communities with greater diversity are anticipated [50]. Newer technologies can offer more opportunities for distance learning in a more collaborative and personalized learning environment.

The coronavirus disease pandemic (COVID-19) pandemic served as a catalyst for technology adoption, demonstrating its crucial role in ensuring uninterrupted learning, fostering innovation, and wide-scale technology diffusion [51]. The rapid spread of coronavirus around the world and the need for social distancing coupled with the need to continue learning and carrying out required tasks enabled rapid adoption of technologies at an extraordinarily rapid pace. Experiences from the COVID-19 pandemic showed that telemedicine and tele-education offer scalability and overcome geographical barriers, minimizing the need for physical travel, though initial capital costs can be prohibitive. Further complicating the issue are reduced funding, budget cuts in medical education, and 'brain drain.' Embracing cutting-edge technologies like 3D printing, virtual reality, and real-time video simulations is crucial for driving innovation and tackling these challenges [52].

However, several hurdles need to be addressed:

1. Africa's ICT infrastructure lags behind, limiting access to technology.

2. Limited Internet speeds: poor download speeds hinder online learning

3. Unreliable electricity: erratic electricity supply disrupts technology-based learning.

4. High Internet COSTS: EXPENSIVE internet access creates another barrier.

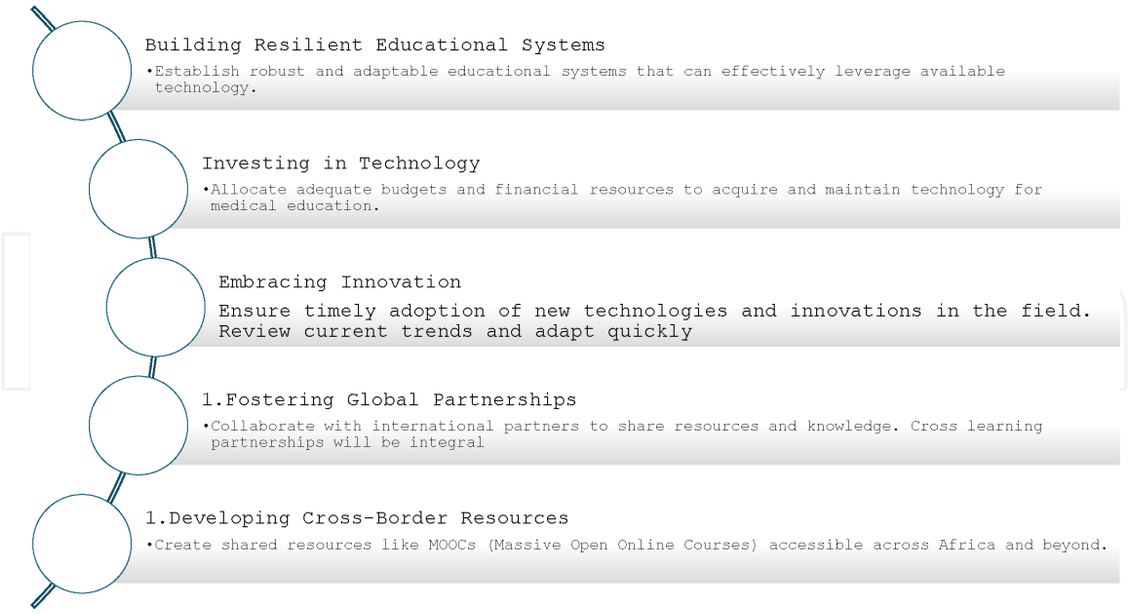

Table 2.
Multi-pronged approach needed to unlock telemedicine's potential in medical education across Africa.

To maximize the future of medical technology and education in Africa, a multi-pronged approach is necessary, as shown in **Table 2**.

8. Telemedicine: bridging the gap in healthcare access

Advancements in technology offer significant opportunities to revolutionize healthcare delivery in Africa. In many developing countries, both within and beyond the continent, these technologies can bridge the gap between existing services and unmet healthcare needs [4]. With rising disease burdens and growing populations amidst constrained healthcare budgets, technology offers a cost-effective solution to address these challenges**.** Increasing internet connectivity and mobile phone penetration across Africa empower individuals to actively participate in health promotion activities [34]. Access to tertiary medical care in underserved regions, made possible by telemedicine, allows scarce medical specialists to reach a wider patient population, improving quality of life and disease management. Telemedicine fosters continuous learning and skill development for both patients and healthcare providers [9, 50]. Additionally, it reduces the need for long-distance travel to access specialist care, saving valuable time and resources for patients and healthcare systems. By enabling simultaneous consultations across multiple regions, telemedicine further optimizes efficiency and resource utilization [10]. With the increasing use of mobile telephone devices, it is possible to provide care even in conflict zones or disaster hit areas where access to care may be difficult or unavailable in a timely manner [3]. If implemented well and supported, telemedicine programs may have far greater impact and success in Africa and other developing countries than in developed countries.

8.1 Benefits of telemedicine

See **Table 3**. Advances in technologies offer great opportunities for the advancement of healthcare services in Africa. In many developing countries in Africa and

Table 3.
Investment in telemedicine brings numerous benefits to all stakeholders in the healthcare sector, including patients, providers, systems, and governments. Various stakeholders can collectively work toward achieving the shared vision of improving healthcare access, enhancing patient outcomes, and building more resilient and sustainable healthcare systems for the future.

beyond, technologies offer opportunities to bridge the gaps and fulfill the unmet healthcare needs of their citizens. With increasing disease burden and growing population amidst meager or reducing healthcare budgets, efficient application and use of technology may bridge some of the unmet health needs around the world.

Increased investment in internet connectivity through 4G, 5G, and cable connections coupled with increased smartphone penetration in many countries in Africa will provide opportunities to utilize these emerging technologies to reach millions of people across Africa [34]. With reduced end to end latency, faster bandwidths and reduced congestion will enhance seamless connectivity will enhance user experience and increased adoption [53–55]. Access to tertiary medical care in underserved regions in Africa providing opportunities for very few medical specialists to serve deserving patients overcome physical and geographical barriers [14]. Access of specialist services through telemedicine also reduces the need for patients to travel over long distances for the search of specialist care, hence saving valuable time and money.

9. Telemedicine barriers

Successful implementation and utilization of telemedicine in Africa depends on understanding and addressing its various barriers. Here are some of the most common barriers faced in Africa:

9.1 Infrastructure technology

Limited access to electricity and unreliable grids in many regions frequently disrupt vital telemedicine communications due to power outages. Additionally,

across much of Africa, internet connectivity is either absent or slow, hindering the quality of services offered. The high cost of equipment and software creates a significant barrier to entry, as highlighted in a recent Kenyan survey [56]. A functional telemedicine unit requires various functional equipment, including video conferencing rooms, video cameras, and electronic stethoscopes, which may not be readily available or accessible, particularly in rural Africa, where these services are urgently required [57]. Fortunately, increasing Internet and grid connectivity across many parts of Africa promises to break these access barriers. However, it is important to note that these changes remain unevenly distributed across the continent, with remote and rural localities experiencing the most need and often the least progress.

9.2 Organizational barriers

Organizations play a crucial role in shaping culture and societal norms, including in areas related to healthcare. However, the widespread adoption of telemedicine in Africa faces challenges due to limited expertise and experience within both staff, who ultimately shape organizational culture across the continent. This limited knowledge and inadequate training can lead to reduced professional competency in using or applying available telemedicine applications and technologies [58]. Such shortcomings can have a negative impact on adoption, restricting the potential benefits of the technology and even fostering negative attitudes. Additionally, a lack of understanding about telemedicine services and their potential impact can exacerbate resistance to this new technology, leading to reduced motivation and delayed adoption. Models such as the Systems Engineering Initiative for Patient Safety (SEIPS) can provide organizations with useful frameworks that help in better adoption of new technologies [59]. The SEIPS model ensures healthcare systems or technologies through multiple lenses, namely person, technologies, environment, tasks, and organization. Such a model can outline various system components and how they interact and ultimately contribute to the successful implementation of telemedicine (**Table 4**).

9.3 Legal and regulatory hurdles

Widespread adoption of telemedicine requires a comprehensive legal and regulatory framework [60]. Governments across Africa are providing the required legal and policy frameworks to support the uptake and growth of telemedicine. Such frameworks facilitate the seamless integration and dissemination of technologies across both private and public sectors. Establishing clear policies and regulations is crucial to ensure meticulous handling of patient data, required security measures, licensures, approved funding models, quality standards, and confidentiality requirements [1, 2, 61]. Implementing robust data protection regulations Health Insurance Portability and Accountability Act of 1996 in the United States of America (HIPAA or the Kennedy–Kassebaum Act) ensures compliance, strengthens patient trust, and fosters an environment of secure and responsible data handling, protection of individual's health records and continued medical care [62]. It is also important to emphasize that the legal and regulatory landscape should be adapted to local context for ease of adoption and to serve local needs. Successful policies from the West may not be effective in Africa [53].

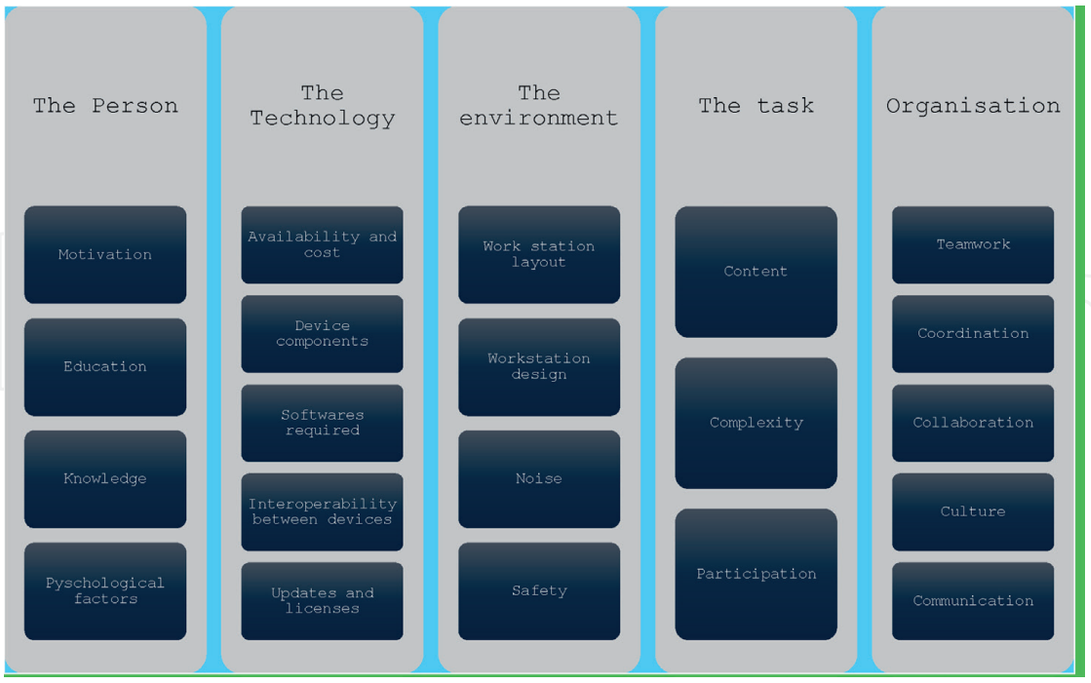

Table 4.
Illustrating the SEIPS model highlighting the key to successful telemedicine implementation and the role of understanding the interconnectedness of patients, technologies, networks, practices, and healthcare institutions, modified from T. Zhang et al. [59].

9.4 Individual barriers to telemedicine

These barriers encompass various factors affecting both patients and providers. Healthcare providers may perceive telemedicine as a threat to their professional autonomy due to fears of misdiagnosis, litigation, and loss of control over patient care.

This resistance to change can stem from concerns about conflict of interest, increased workload, limited information and technology infrastructure, technophobia, difficulty understanding the technology, and anxiety about using new technologies [63, 64]. Limited or lack of integration of telemedicine services into daily workflow and low motivation for compliance can affect adoption by healthcare providers. Lack of physical examination or face-to-face contact with patients diminishes the personal touch, leading to some physician skepticism toward the effectiveness of telemedicine [63]. This can make healthcare providers fear litigation for fear of misdiagnosis. Clear guidelines for prompt referral to a hospital need to be provided to ensure the risk of adverse events is minimized.

Both healthcare providers and patients may have concerns regarding the secure handling of sensitive medical information and the protection of data privacy and confidentiality during telemedicine consultations. Clear communication of data protection mechanisms in place in telemedicine platforms should be emphasized. Factoring the recent adoption of new and emerging technologies in telemedicine in the continent, digital illiteracy presents as an important barrier for both patients and providers. Digital illiteracy can hinder their ability to effectively engage with telemedicine platforms and technologies [56, 57]. Poverty and low socioeconomic status significantly limit access to technology gadgets such as mobile phones and internet connectivity, creating substantial barriers for patients seeking to utilize telemedicine services. Moreover, lack of

insurance coverage and inadequate reimbursement from governments and other payers exacerbate these disparities in access even further [56]. Traditional beliefs, religious restrictions, and gender norms can influence attitudes toward telemedicine and limit access for certain demographic groups such as women and elderly.

9.5 Financial barriers

Limited budget allocation for health infrastructure and telemedicine support remains an important barrier [63]. While some African nations have increased healthcare spending, it often falls short of addressing the required needs of widescale telemedicine implementation. The lack of budgetary allocation for training healthcare professionals, developing robust communication networks, and establishing data centers impedes further progress. Additionally, reliance on external funding and grants creates uncertainties, hinders long-term planning, and raises sustainability concerns [65]. High costs associated with equipment and software are a particularly challenging issue in African nations. The continent's fragmented market, with numerous countries and diverse needs, often leads to higher prices for specialized telemedicine technologies. This makes it difficult for healthcare facilities, often already strained with limited resources, to invest in necessary hardware and software. Furthermore, the need for reliable technical support and maintenance further adds to the financial burden. High electricity costs and erratic power supplies often create disruptions and hinder access to telemedicine services. Unequal access to electricity across urban and rural areas exacerbates existing disparities, leaving remote and rural communities further marginalized [63]. While internet penetration is increasing, affordability and reliability continue to be major concerns. Rural areas often lack access to broadband connections, and mobile data costs can be exorbitant for many individuals across many countries. This creates a barrier, particularly for those who could benefit most from the convenience and accessibility of telemedicine. High taxation tariffs on telemedicine equipment, software, and other supplies significantly increase procurement and operational costs for healthcare providers, ultimately discouraging adoption and hindering access to services in Africa.

Increasing telemedicine penetration across Africa requires significant and sustained financial investment. Governments must take the lead by increasing budgetary allocations. Budgetary allocations will support the development of critical telemedicine physical infrastructure, the acquisition of essential equipment and technology, and ongoing training and capacity building for healthcare professionals. Efforts to expand insurance coverage and revise/review reimbursement rates should be supported. Expanding health insurance schemes, particularly for low-income populations, would make telemedicine a more viable option for accessing healthcare. Furthermore, establishing fair reimbursement rates for virtual consultations will incentivize both patients and providers to utilize telemedicine. Exploring alternative financial models should be considered. Public-private partnerships can leverage the expertise and resources of both the public and private sectors to accelerate the adoption and use of telemedicine. This collaborative approach can unlock the potential of telemedicine and expedite its widespread adoption across the continent.

10. Conclusion

Telemedicine, the use of information and communication technologies to provide healthcare services remotely, is emerging as a promising solution to address unmet

healthcare needs in Africa. With the increasing availability and adoption of various mobile and fixed technologies, coupled with growing electrification and internet connectivity across the continent, the potential for telemedicine remains immense. It promises to bridge the unmet healthcare needs in an acceptable, cost-effective, and sustainable manner. While tremendous progress has been made in recent years, accelerated by the 2019 COVID-19 pandemic, several challenges limit access for those in urgent need. These challenges include the persistent digital divide, particularly between rural and urban areas, the lack of comprehensive legal and policy frameworks, provider and patient barriers, cultural beliefs that may hinder adoption, and concerns regarding data protection and safety. Unlocking telemedicine requires a concerted multifaceted approach involving stakeholders across various sectors in Africa to address barriers while nurturing the role of telemedicine across the continent.

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