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Transforming healthcare systems in medically underserved rural areas (Muas) via digital technology

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Abstract

This article reviews the challenges and impacts of digital transformation in the healthcare systems in rural and underserved areas and the possible solution to this menace. In the developed nations of the world, bridging the gap between the poor and the rich has been challenging as a result of the introduction of social health facilities unaffordable for the poor populace. Telemedicine provides an easier and better way of communicating remotely with healthcare providers without having to travel long distances and spend more. It focuses on the introduction of eHealth facilities in rural areas to bring about equal access to healthcare. The obstacles of accessing remote areas through the implementation of various telecommunication networks, and the necessity of telemedicine in the underserved and rural areas in the underdeveloped nations of Africa as a case study.

The necessity of applying telemedicine in solving various health issues has brought about many contradictions that have worsened the situation with numerous viable technologies examined along with the effectiveness of telemedicine in linking access to healthcare disparities.

Appropriate telecommunications networks should be set up in the underserved areas and rural areas of Africa since we have a larger percentage of the populace in this category. Thus, bringing about equality between the rich and the poor and providing all with the appropriate knowledge in telemedicine.

Keywords: Telemedicine; Healthcare; Digital Transformation; Underserved

1. Introduction

Information and Communication Technology (ICT) has taken a new form as a result of its positive impact on various economic set-ups; the health sector is a case study with several innovations (Limnah et al., 2023). The lack of access to specialists and electronic health (e-health) information has resulted in a "digital divide" in healthcare support for rural residents in developing nations because specialists and computerized health information are not widely available (Miah et al., 2017).

The digital divide is the reduced access to information technology for people from lower socioeconomic backgrounds and those living with disabilities. Individuals are vulnerable to healthcare issues for one or more underlying reasons, such as financial circumstances, place of residence, health, age, functional status, ability to communicate effectively, ethnicity, race, and gender, according to the Advisory Commission on Consumer Protection and Quality in the Health Care

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Industry (Chang et al., 2004). The digital divide has been attributed to a number of issues. These include lack of access to technology, illiteracy, lack of interest in or drive to use technology. Since these problems exist in every country, the digital divide is a worldwide problem (Saeed & Masters 2021).

Gopal et al. (2019), explained that global medical and technological advancements are improving healthcare for people on the one hand while rising prices are a major worry for all governments, healthcare providers, and patients on the other. Unfortunately, in many developing nations, the majority of people live in rural areas with little access to specialized hospitals and contemporary general facilities (Miah et al. 2017). Unlike the vulnerable population, which indicates a higher likelihood of healthcare concerns, the underserved are those members of the population who have not gotten the necessary healthcare service.

A key element of the goals for public health is the digital economy, which fosters a nation's financial and economic development. By utilizing cutting-edge digital technology to produce highquality goods and services, the digital economy program seeks to improve people's quality of life (Limnah et al., 2023). Healthcare is just one of many businesses that are successfully embracing AI and machine learning. Automating and standardizing data interchange, detecting medication errors, and analyzing and forecasting patterns in patient data are just a few applications of machine learning (Haggerty E. 2017). The prevalence of common illnesses such as dengue, malaria, infectious respiratory diseases, or diarrheal illnesses calls for the improvement of health information systems (Prieto-Egido et al., 2014).

2. Healthcare delivery through telemedicine

The word "telemedicine" is used to describe the provision of medical care and information remotely (Bashshur et. al., 2000). Telehealth, which is broadly defined as the provision and facilitation of health and health-related services, encompasses digital communication technologies, self-care (such as mental health services) through telecommunications, health information services, and provider and patient education (Haymes et al., 2021).

The inception of modern telemedicine dates back to the 1960s, when two US healthcare initiatives implemented telemedicine concepts into their treatment plans (Mathur et al., 2017). A more advantageous technological advancement that can facilitate people's access to preventive care and improve their long-term health is telemedicine. This is especially true for individuals who cannot afford or cannot access high-quality care due to local circumstances (Haleem et al., 2021).

The first purpose of telemedicine was to treat patients who lived in remote locations. Since then, it has expanded into initiatives at urban medical centers that provide healthcare to marginalized people and medical interventions like treating soldiers on the battlefield (Chen E. 2017). In addition to lowering the need for rural patients to travel for medical treatment, telemedicine can provide access to rare specialist care and improve the standard of care in these locations. The scarcity of doctors may be mitigated by international cross-border services (Mars M. 2013).

A revolution in global healthcare is emerging in telemedicine, the use of ICT to provide medical services remotely. Its importance is multifaceted, helping to address long-standing issues and advance paradigms of healthcare delivery (Ayo-Farai et al., 2023). The developed world's most valuable instrument for the advancement of medical research applications both now and in the future is telemedicine, as demonstrated by the United States, the United Kingdom, Australia, and other European nations (Chowdhury 2009). In comparison to their more financially advantaged peers, research indicates that marginalized populations have notably greater obstacles— technological, social, and economic—when attempting to implement eHealth interventions on an individual basis (Lee et al., 2022).

Telemedicine adoption in Africa is not without difficulties, though. Significant obstacles are posed by infrastructure constraints, such as insufficient Internet connectivity and irregular electrical supply (Ayo-Farai et al., 2023). The term "telemedicine" was defined more broadly by Bashshur et al. (2000) to encompass "telehealth." Due to weak infrastructure and high connection costs, telemedicine is least likely to be available in rural areas, where the poorest of the poor most need it. Furthermore, the patient community and healthcare professionals are not well-informed about telemedicine, and there is a deficiency of government support for it (Mars M. 2013).

However, during the 1960s and 1970s, telemedicine's widespread adoption was hampered by a lack of appropriate technologies, the high expense of operating these programs, a lack of physician interest, and restricted insurance coverage (Chen E. 2017). If used effectively, telemedicine has the potential to significantly improve access to healthcare for millions of people worldwide. While fostering efficiency and expanding access, investing in telemedicine in all of its

forms through technology, software, and regulatory components can supplement the current pool of human resources (Onsongo et al., 2023).

3. Network Installation in Telemedicine

Efforts are underway in several nations' healthcare systems to shift to electronic case records (ECRs), which facilitate data sharing amongst users of disparate systems. Among the advantages of utilizing electronic medical records is that patients and medical specialists can receive accurate and comprehensive medical information (Buldakova et al., 2019). It makes use of the emerging technology known as the Internet of Things, or IoT. IoT is essentially the internet connected to many gadgets, and it has found extensive usage in medicine during the wave of worldwide pandemics (Cruz et al., 2021).

The following tasks must be completed in the case of wireless networks: locating the network's connection points; selecting technologies for the distribution network and internet access; researching local interference; choosing the equipment ahead of time; conducting simulation tests; and executing radio programs (Zambrano et al., 2008). Remote patient monitoring is one of the most important uses of IoT in the healthcare industry. This entails using wearable technology and sensors to remotely monitor patients' vital indicators, including blood pressure, oxygen saturation, and heart rate (Pulimamidi 2022).

In addition to scheduling a doctor's visit, telemedicine services enable patients to access their health records and receive a comprehensive consultation from a distance (Buldakove et al., 2019). Wireless technologies that can be employed in telemedicine include a hybrid network technique for transmitting data and speech over very high fidelity, VHF (Very High Frequency), 802.11/WIFI (Wireless Fidelity), Satellite, and IEEE 802.16/WIMAX (Worldwide Interoperability for Microwave Access). This platform allows for the creation of information sharing and access services, including teleconsultations, remote learning, and computerized systems for epidemiology.

4. Implementation of Advanced Telecommunications Solution

Technological advancement has led to the introduction of telemedicine, and the application of telecommunication solutions in healthcare systems. Certain difficulties have risen especially in the rural areas as a result of a lack of implementation of the appropriate policies, leading to the implementation of required telecommunication solutions in telemedicine. The most appropriate technology to address this communication difficulty seemed to be wireless. Email and other asynchronous (offline) systems with slow data transmission rates might handle most information needs in rural areas.

The term "internet" as defined by Kifle et al., (2008) describes the joining of computer networks through the use of a common packet-switching protocol. Numerous studies have demonstrated that mobile phone technology directly contributes to the decline in poverty levels and plays a larger role in economic development in less developed economies (Prieto-Egido et al., 2014). The disease management model's patient communication tactics have over the years, mostly involved the use of the telephone, Internet communication, Web-based learning materials, electronic data collection, and patient review of self-monitoring data. Thus, there is a chance that telemedicine will be combined or overlapped with other technologies (Shea 2006).

To provide accessibility requirements for web-based material, telemedicine platforms, and eHealth content should be built in compliance with the Web Material Accessibility Guidelines (WCAG), which are issued by the World Wide Web Consortium (Wang et al., 2021). While internet connectivity is now commonplace in the majority of countries worldwide, disparities in access can still be noted based on several factors, including age, gender, race, ethnicity, income bracket, and educational attainment (Halimi M. 2023).

Several data sources could be employed in telemedicine applications. More qualitative and nuanced information is needed in certain situations, such as psychiatric assessments where posture, speech, and mental state observations are necessary (Harnett 2006). The Internet is crucial in allowing telemedicine and other healthcare services to reach remote locations with limited access to medical care. It gives patients' data simple access from anywhere in the world without requiring face-to-face interaction, and in an emergency, it allows quick access to specialists (Hababeh et al., 2015).

The work circumstances of isolated health personnel can only be improved by information and communication technologies and services if they are carefully chosen, developed, adapted, and implemented to meet the demands of the people in their actual context (Martinez et al., 2004). The term "digital divide" refers to the disparities between

different groups in terms of first- and secondlevel usage of digital devices and the internet. Physical access, which includes having access to broadband internet and smartphones, and material access, which is the capacity to sustain services over time by covering maintenance costs, are two other categories into which the first-level digital divide can be separated (Haynes et al., 2021).

Healthcare services can now be accessed in remote and underserved locations because of telemedicine, which has crossed geographical divides. Distant physical barriers no longer prevent patients from accessing diagnostic services, specialized care, and medical consultations (Ayo-Farai et al., 2023). The possible applications of telemedicine that have been adopted in different parts of the world include; services for home health care, programs for telehealth care in rural areas, ongoing medical education, and international medical services, among others.

5. System architecture for internet-based telemedicine in Africa

Africa as a case study comprises a large proportion of vulnerable individuals in its underserved and rural areas facing challenges of poverty, lack of infrastructure, and health facilities. It has therefore been noted that the implementation of telemedicine in Africa has not been firmly rooted due to inadequate training and insufficient personnel resources. The primary goal of this is to offer effective and practical ways for physicians in cities and remote rural healthcare professionals to communicate with each other about patient cases (Chowdhury et al., 2009; Adewale, 2004).

Telemedicine in the ambulatory setting has frequently decreased the requirement for hospital stays and office visits, decreased the number of non-emergency trips to the emergency room, improved parent satisfaction, and improved population health management (Marcin et al., 2016). While 60% of people in Africa live in rural regions, medical professionals typically reside in metropolitan areas resulting in lapses in rural health care (Mars M. 2010). Additionally, telemedicine can help patients become more independent and compliant, as well as more involved in their healthcare plan (Halimi M. 2023).

The potential of telemedicine instruments is especially great in nations with low levels of specialization and where poor transportation facilities and distances hamper patient and/or physician mobility (Bagayoko et al., 2006). In heterogeneous communications environments, different types of patient data, including ECG, temperature, and heart rate, must be accessible by employing different client devices (Hababeh et al., 2015). This system enables easy access to the patient's data through a wireless telemedicine network system enabling consultations to be carried out remotely by medical officers in the urban healthcare centres.

This procedure frequently takes up a significant amount of the practitioner's time, particularly in episodic interactions with patients who may have complicated medical histories (Adewale 2004). The elements consist of self-monitoring and data collection devices, communication tools, and provider software for data collection, display, and modification. They also include service documentation and interaction with other patient data (Shea 2006).

Researchers have tested and created web portals to specifically assist people seeking health information across various populations, thanks to the widespread use of digital tools like computers, laptops, and smartphones as well as recent advancements in cyberinfrastructure that allow for the efficient storage and analysis of big data at scale (Lee et al., 2022).

One of the main issues in the field of web telemedicine data-based systems (WTDS) is designing and creating quick, efficient, and reliable integrated procedures that can handle a high number of medical transactions on a large number of online healthcare sites in almost optimal polynomial time (Hababeh et al., 2015). Mars M. (2010) in his review work explained that many of the world's poorest people live in sub-Saharan Africa, and they are referred to as "the bottom billion." The body of research suggests that telemedicine improves patient and provider access, lowers costs, and has socioeconomic advantages. The main drivers of technology adoption are cost savings and economic gains (Kifle et al., 2008).

The Internet is evolving into our new town square, with computers in every home serving as allpurpose teachers and bridges to other cultures. This will become necessary rather than just a dream. The goal is to create a suitable model that would enhance appropriate networking in telemedicine to achieve an effective healthcare system in the underserved and rural areas of Africa. **6.0 Network Security in Underserved Areas of the Healthcare Sector**

Devices such as Artificial Neural Networks (ANNs) used in the image analysis of the tongue, Integrated Circuits in the detection of circulatory system diseases, Arduino-based pulse detectors for fingernail blood glucose monitoring, and

wavefront technology's development to support eye investigation have been employed in the remote areas in the Philippines (Cruz et al., 2021).

The Internet of Things (IoT) as mentioned earlier, in healthcare, is the real-time collection, transmission, and analysis of health data through the use of linked devices and sensors. Wearable health monitoring gadgets and intelligent medical devices that provide medication are two examples of these gadgets (Pulimamidi, 2022).

Lee et al. (2022), examined information and technologies that can bridge unequal health outcomes between different social groups outlining the relationship between how communication inequalities mediate and moderate the association between social determinants and communication and health outcomes. It will be possible to prevent future telemedicine adoption from unintentionally creating or exacerbating inequities if disparities in telemedicine utilization across demographic groups are understood (Hsaio et al., 2021).

Previous research by Kun L. (2001) proved that attempts were made in the United States by The Federal Computing, Information, and Communications Program (CIC) to develop a computational means of helping the health sector improve health care. It is further opined that this method can be adopted in Africa in training health personnel on telemedicine, thus, expanding their knowledge in the evolving world of technology.

6. Obstacles to Accessing Healthcare in Remote Locations

As earlier stated, it is indeed a huge challenge for individuals living in rural areas to have easy access to healthcare facilities based on their large numbers, especially in the underdeveloped and developing nations of the world. These challenges have posed serious barriers to these individuals' incapacitating them some of which include remote location, lack of medical specialists, and inadequate infrastructure increasing their mortality rate.

In many isolated places, there aren't any clinics, hospitals, or other healthcare facilities, thus getting medical care requires a lengthy commute. People who are elderly, crippled, or unable to travel because of financial restraints may find this particularly difficult (Pulimamidi 2022). While the availability of electronic health records (EHRs) and the integration of artificial intelligence algorithms promise to allow clinicians to anticipate hospital readmissions and mortality, if frequently missed appointments prevent their health records from being entered into EHRs, those from lower socioeconomic categories may not benefit from these (Lee et al., 2022; Cruz et al., 2021).

Rural families are more likely to have less health literacy than their urban counterparts since they often have lower educational attainment. A reduced chance of utilizing preventative health services and generally poorer health status are linked to decreased health literacy (Marcin et al., 2015). Transportation deficiencies, particularly those on access to private vehicles, considerably worsen the problem of a shortage of physicians and other healthcare professionals in rural and highminority communities (Edmiston & Alzubi 2022).

7. The Necessity of Addressing Disparities in Telemedicine

Disparities are described as "differences in treatment between racial, ethnic, or other demographic groups that persist even after socioeconomic factors are adjusted and are not directly attributable to variation in clinical needs or patient preferences." (Saeed & Masters 2021). E-health strategies are being explored as a potential remedy for impediments to transgender healthcare access. They can offer a greater variety of clients adequate mental and physical health care (Renner et al., 2021).

Nonetheless, hard-to-reach populations may benefit most from e-health initiatives. More precisely, trans persons should be able to contact trans-informed HCPs no matter where they live with the support of e-health strategies, such as video consultations (Haggerty E. 2017). Results indicate that the telehealth delivery setting matters when treating acute illnesses. In particular, studies have compared the quality of care provided by medical homes and direct-to-consumer (DTC) telemedicine services (Fikks et al., 2022).

Remote patient monitoring is one of the methods that can be adopted. For a healthcare provider to track patient data, including symptoms, vital signs, and/or laboratory results, remote patient monitoring entails the transfer of personal health and medical data (Marcin et al., 2016). In medicine and healthcare, technology has always been essential, and technological advancement is ubiquitous. However, telehealth technology integration presents several hurdles, and telehealth adoption has not kept pace with the majority of medical breakthroughs in terms of speed (Edmiston & Alzubi 2022).

To promote the redesign of numerous care practices and preventative and chronic illness care management, telemedicine opens up chances for much-needed cross-sector care integration inside healthcare settings as well as between healthcare and others, such as in schools and social services (Fikks et al., 2022). Ensuring that patients receive prompt and appropriate medical interventions regardless of their location or economic situation is possible with the use of electronic health records (EHRs). In neglected rural locations, telemedicine can improve children's access to subspecialty treatment for unique healthcare requirements, leading to high levels of satisfaction among parents and local healthcare providers (Marcin et al., 2016).

Previous study shows that Physicians and patients discussed how certain health systems gave patients mentoring and direction on how to use telemedicine portals authenticating the fact that pre-visit tutoring can help improve the digital literacy abilities necessary for telemedicine (Wang et al., 2021). Chronic condition treatment is another area where virtual care may be especially useful. Numerous studies have been conducted on the clinical outcomes of telemedicine chronic care in both adult and pediatric age groups (Fikks et al., 2022).

Patient satisfaction is enhanced via telemedicine in a variety of ways. Its main benefit is improved access to care. It also reduces stress because there's no longer a need to travel and miss work. Increased patient convenience is another benefit of these components (Haimi M. 2023). Despite its potential, telehealth has not eliminated health access inequities. Some contend that by restricting access to those who can afford the internet and contemporary technological gadgets, telehealth has made the previously noted disparities even more pronounced (Haynes et al., 2021).

Various barriers were overcome during the COVID-19 pandemic, a situation where patients were privileged to monitor their vitals without physically consulting the healthcare professionals due to limited mobility and positive status to the COVID-19 virus. Remote Patient Monitoring (RPM) is being employed in transmitting and evaluating patient data with the aid of wearables and other electronic devices.

Age was inversely correlated with the usage of video visits but positively correlated with the use of telemedicine overall. Even when they had trouble with digital literacy or technological access, older patients might have preferred to avoid the risks of in-person consultations (Hsiao et al., 2021). In addition to providing a plethora of health information at the fingertips of consumers, doctors, lay support groups, and special interests, the Internet has greatly enlarged the prospects for improved access to information and care sources that are not limited by time or location (Bashshur et al., 2009).

A significant portion, if not all, of the opportunity costs associated with care such as travel, missed income, and unnecessary appointments are reduced. Before the cost savings are used to promote structural reforms to address this issue, the uninsured and the underinsured will not directly benefit from the adoption of telemedicine systems (Bashshur et al., 2009).

Table 1 Previous Works on Telemedicine and Their Gaps

Authors	**Previous Review Works**	**Gaps**
Chang et al., 2004	Development of a framework for national agenda in information and communication technology to enhance health	Lack of critical evaluation by relevant agencies and stakeholders
Bashshur et al., 2009	Healthcare reform and the cent rality of information technology in healthcare	The study focuses on acute care resulting in an uncoordinated system
Saeed et al., 2021	Outline the disparities in health outcome	Unique implementation of specific technology in telemedicine was not addressed
Haynes et al., 2021	Review of the various challeng es and achievements of telehealth and its effects on healthcare delivery	The review work did not address broader health equity governmental policies
Hsaio et al., 2021	Understanding of the utilization patterns in telemedicine	Specific international review boards were exempted
Haimi M., 2023	The effectiveness of telemedici ne in bridging access to healthc are	Barriers in using telemedicine were not appropriately addressed

Fiks et al., 2022	To provide a summary of the impact of pediatric telemedicine and the importance	The focus is majorly on the benefits that children can derive from telemedicine exempting the other populace
Bashshur et al., 2000	Review of the past researches on telemedicine	The innovative system of care was not fully realized
Mars M., 2013	Literature review on telemedici ne, obstacles and current telemedicine activities in Africa	Mobile phone devices were the only devices deduced to explore telemedicine
Chen T., 2017	The delivery of modern healthc are through telemedicine inclu ding current issues in telemedicine	The review work concentrates more on patients and not the healthcare providers

8. Conclusion

Restructuring the health sector via digital transformation, telemedicine poses more advantages than obstacles in decentralizing healthcare such that it becomes more accessible to the public irrespective of their background, culture, race, or age. Technological advancement in telemedicine might result in disparities in accessing telemedicine. Provision of Information and Technology support, patient education, training healthcare workers on IT, and advertisements of IT solutions to individuals would be paramount to the delivery of effective healthcare for the underserved and rural areas in Africa and other surrounding nations.

However, many challenges have not yet been identified to create a proper approach to the high level of decadence of healthcare in Africa due to bad governance and poor leadership. This can be properly managed if the government can work hand-in-hand with healthcare workers to achieve a stable healthcare transformation using a digital network.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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