

Framework for the adoption and delivery of eHealth for accessible and affordable quality healthcare in in low- and middle-income countries (LMICs) rural areas: A case study of Nigeria

Abstract

In Nigeria, approximately 45.72% of the population resides in rural communities, where access to equitable and quality healthcare remains severely limited. This persistent disparity has contributed to accelerated rural-to-urban migration as individuals seek improved living conditions and health services. Such migration poses a significant developmental challenge, with adverse implications for national agricultural productivity and food security. The present study develops a framework for the adoption and delivery of eHealth for accessible and affordable quality healthcare in rural areas of low- and middle-income countries, using Nigeria as case study. Relevant literature was identified through systematic searches of electronic databases and authoritative reports, including the World Health Organization report, Trading Economics report, and the United Nations report on Sustainable Development Goals, complemented by a review of prior empirical studies on digital health implementation.

Findings highlight critical enablers for effective eHealth implementation in rural Nigeria, structured around three interdependent domains: adequate health financing, encompassing health insurance coverage and sustained government investment in digital health infrastructure; comprehensive digital health literacy and capacity-building programs to enhance adoption and user engagement, supported by the development of intuitive, context-appropriate user-friendly platforms; and robust data privacy, security protocols, and regulatory certification to foster user trust and confidence. These components are integral to driving eHealth adoption and advancing healthcare equity in rural settings. The study advocates for strategic, multi-sectoral interventions to ensure the delivery of accessible, affordable, and high-quality healthcare across LMICs rural communities.

Keywords: eHealth, policies and programs for accessible and affordable quality healthcare, Low- and Middle-Income Countries (LMICs)

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Oyerinde M O,¹ Sowumi O A²

¹Departments of Communication, University Top Gateway, Nigeria

²Departments of Human Nutrition, University of Ibadan, Nigeria

Correspondence: Oyerinde M O, Departments of Communication, University Top Gateway, Nigeria, Tel +2349059445505

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Introduction

Background of the study

Medicine remains a critical sector in every nation and has significantly benefited from technological advancements in the remote delivery of healthcare services. The widespread diffusion of Information and Communication Technology [ICT] across global populations has been pivotal to the expansion of eHealth in recent years.¹ As population growth continues, increased investment in technology that enhances accessibility to quality healthcare is imperative for promoting a healthy nation. Recognizing its benefits, both developed and developing countries, including Nigeria, have embraced eHealth as a proactive strategy to deliver quality healthcare services to their populations.²

The challenges associated with healthcare service delivery are numerous, and eHealth has emerged as a viable solution to address some of these systemic barriers. Consequently, this article examines the challenges affecting the delivery of eHealth in LMICs rural areas using Nigeria as a case study. eHealth represents a field of healthcare that integrates information technology and telecommunication to provide medical assistance across geographical distances. According to the World Health Organization,¹ eHealth is defined as the delivery of healthcare services where distance is a critical factor, whereby

healthcare professionals utilize ICT to exchange valid information for diagnosis, treatment, prevention of diseases and injuries, research and evaluation, and for continuing education of healthcare providers, with the aim of advancing the health of individuals and their communities.

eHealth technologies encompass a broad spectrum of tools, including telemedicine platforms,³ electronic health records,⁴ health information systems delivered through mobile health, email, short message service (SMS), and online chat functionalities,⁵ as well as artificial intelligence technologies such as deep learning and machine learning.⁶

Problem statement

Despite technological advancements, eHealth in Nigeria remains at an embryonic stage, with substantial gaps in accessibility, particularly among rural populations. The COVID-19 pandemic served as an accelerator, prompting many hospitals to initiate dedicated eHealth units.¹ Rural health development constitutes a major public health concern in Nigeria, given that approximately 48.04% of the country's residents still reside in rural areas.⁷ Patients in these areas encounter significant barriers to accessing healthcare services that are predominantly concentrated in urban centers. For patients with critical medical conditions in rural settings, geographical distance to functional healthcare facilities in major cities poses a severe

challenge, with documented cases of mortality attributable to delayed intervention by urban-based providers.³

Although eHealth offers immense potential benefits, its delivery in rural Nigeria is constrained by multifaceted challenges. These include inadequate digital infrastructure, limited internet connectivity, shortage of qualified medical personnel, insufficient government support, and low levels of eHealth literacy and awareness among rural residents.⁸ Furthermore, there is a weak legal and regulatory framework supported by legislation and policies to ensure optimal efficiency of the eHealth system that meets the standards of conventional medicine in the country.⁹

Research aim and research questions

Research aim: To recommend policies and programs for the adoption and delivery of eHealth for Accessible and Affordable Quality Healthcare in in Low- and Middle-Income Countries rural areas.

3Research objectives: To develop framework for the adoption and delivery of eHealth for Accessible and Affordable Quality Healthcare in in Low- and Middle-Income Countries rural areas.

Research significance

As a low- to middle-income country, Nigeria stands to benefit significantly from access to high-quality and affordable healthcare, which would enhance productivity, well-being, and overall economic growth. This study develops a framework for the adoption and delivery of eHealth for quality healthcare in rural areas of low- and middle-income countries, using Nigeria as a case study. The proposed framework is intended to guide policymakers in formulating appropriate policy frameworks to elevate healthcare standards nationally. Consequently, findings from this research can be adopted and implemented by both public and private hospitals in Nigeria. Aligned with the Sustainable Development Goals, technology-driven health initiatives, such as eHealth adoption, can contribute to improved inclusive and equitable quality healthcare.¹⁰

As articulated in the United Nations¹⁰ SDG agenda, good health and well-being are fundamental to economic growth and prosperity. Accordingly, health technologies including telemedicine, electronic health records, and mobile health are pertinent to achieving quality, affordable, and accessible healthcare delivery.¹¹ Therefore, this study aims to explore existing and emerging policies, programs, and support systems required to achieve affordable and accessible quality healthcare delivery through eHealth in Nigeria. Considering Nigeria's physician-to-patient ratio of 1:2,500 and the country's low minimum wage of approximately 70 euros per month, the adoption of eHealth within an appropriate policy and infrastructural framework is crucial for improving both accessibility and affordability of healthcare services.

This study contributes to the body of knowledge on the utilization of eHealth to achieve affordable and accessible quality healthcare, drawing on theoretical models such as the eHealth-enhanced Chronic Care Model and the Digital Health Equity Framework, among others. The framework developed provides a comprehensive solution for delivering affordable and accessible quality healthcare in Nigeria, driven by digital health technologies such as eHealth.

Literature review

Theoretical basis

The eHealth enhanced chronic care model (eCCM): Gee et al.¹² introduced the eHealth-enhanced Chronic Care Model (eCCM), which

illustrates how electronic health technologies contribute to improved clinical outcomes. The model underscores the importance of delivery system design in advancing healthcare, highlighting elements such as care coordination, interoperability, timeliness, policy frameworks, Regional Health Information Organizations (RHIOs), and networking architecture. It also emphasizes the role of eHealth in supporting clinical decision-making through tools such as clinical charts, graphs, protocols, guidelines, information buttons, and clinical reminders, which enhance provider-patient interactions.

The eCCM further demonstrates how eHealth, enabled by clinical information systems including electronic health records (EHRs), patient portals, mobile health applications, internet-based platforms, smartphones, telehealth, and wearable devices, positively influences medical outcomes. Additionally, the model emphasizes the role of eHealth in strengthening self-management support by providing 24/7 access to healthcare services, convenience, automated reminders, communication tools, alerts, patient engagement, care planning, and empowerment.

Furthermore, the model highlights the importance of eHealth education in improving health outcomes. This encompasses training in health education, effective message delivery, technology utilization, eCommunity engagement, information accuracy, system navigation, data security, and usability. By addressing these interrelated dimensions, the model demonstrates how eHealth can transform healthcare delivery and lead to improved patient outcomes (Figure 1).¹²

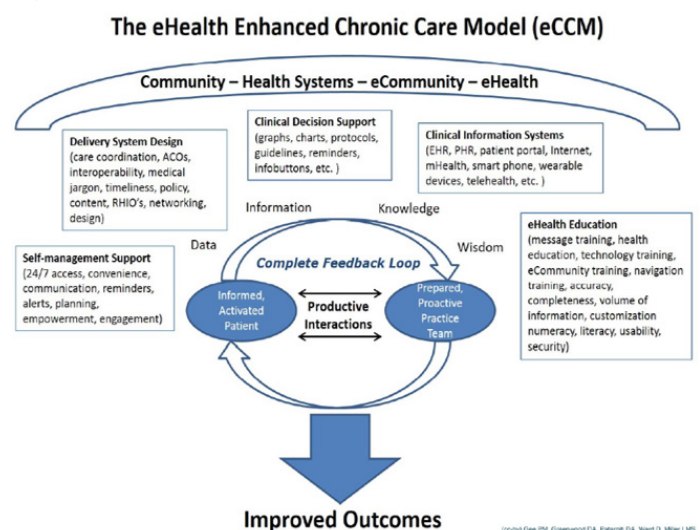


Figure 1 The eHealth enhanced chronic care model (eCCM) source.¹²

Digital health equity model: To achieve affordable and accessible eHealth, the Digital Health Equity Model integrates diverse support systems and activities while considering sociodemographic factors such as gender, age, ethnicity, region, and income. Developed by Crawford and Serhal,¹³ the model emphasizes the influence of socioeconomic and cultural determinants on eHealth adoption, particularly in ensuring equitable access to resources and infrastructure. The framework highlights that affordability of healthcare directly influences its accessibility, underscoring the role of eHealth in advancing equity in healthcare delivery.

The model identifies psychosocial stressors, appraisal and coping mechanisms, health-related beliefs and behaviors, and environmental factors as key determinants shaping eHealth adoption. Consequently, it stresses the need for user education, ensuring that electronic health

technologies are accessible and user-friendly, and providing incentives to promote eHealth uptake among patients. Key recommendations to support affordable and accessible eHealth include ensuring access to digital resources, such as robust health infrastructure, which is essential for successful implementation; utilization of digital resources for health-seeking behaviors; digital literacy; and integration of digital resources into community health systems.

The model asserts that successful eHealth implementation requires addressing critical social determinants, including institutional policies and leadership, healthcare financing mechanisms such as digital health insurance, governance and government support, and health education and training.¹³ The Digital Health Equity Model further emphasizes how eHealth contributes to quality healthcare delivery by enhancing access, ensuring timely care, promoting effective and efficient service provision, safeguarding patient safety, and fostering person-centered, community-centered, and culturally safe care.

According to the framework, addressing social factors, including ensuring equal access to digital healthcare and achieving equitable outcomes regardless of gender, age, ethnicity, geography, or income, can significantly enhance digital health equity. Additionally, the model highlights the importance of healthcare provider competencies, particularly through training in digital health, which improves service delivery. Collectively, these elements work synergistically to improve healthcare quality and outcomes, ensuring that eHealth benefits all individuals equitably (Figure 2).

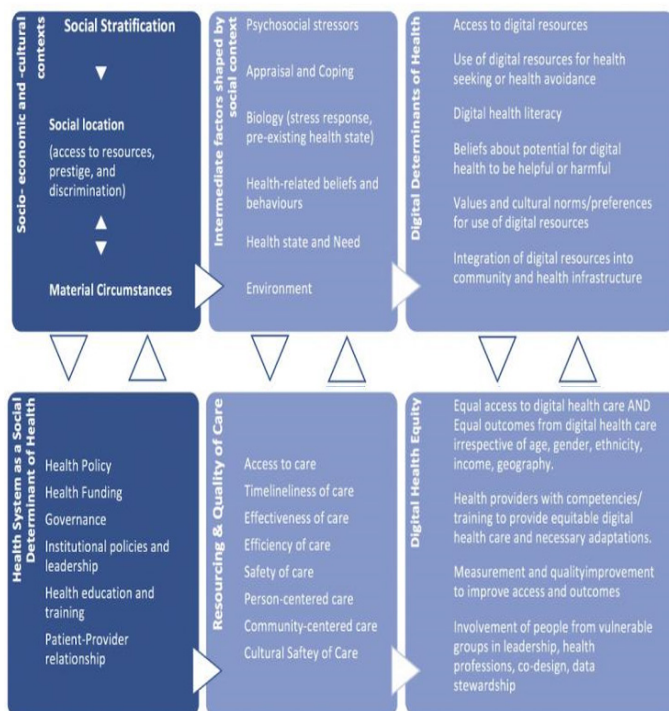


Figure 2 Digital health equity model source.¹³

Benefits of telemedicine

Telemedicine offers substantial benefits; for instance, through telecardiology, medical professionals can remotely monitor patients with pacemakers in rural areas of Nigeria. Similarly, in cases where patients cannot be moved outside the hospital for medical reasons, technologies such as telecardiology enable the transfer of patient information from the hospital to medical laboratories.¹⁴ Telemedicine eliminates geographical barriers, improves access to quality healthcare delivery, and facilitates connections between patients

and healthcare professionals in rural areas to access support and facilities.¹⁵ Consequently, it helps reduce unnecessary travel for both providers and patients, thereby enabling rural populations to access quality healthcare.⁶

Gorman¹⁶ found that telemedicine contributes to saving lives. Rural residents often live hours away from emergency services, placing them at risk of not receiving timely treatment. The study reported that mortality rates among rural residents improved significantly by 36% through the adoption of telemedicine, specifically tele-ICU technology. Furthermore, Anker et al.,¹⁶ in a study on patients with chronic heart failure, found that telemedicine enhanced quality healthcare delivery through the use of technology and communication tools, which consequently helped reduce mortality and morbidity rates. The study further indicated that telemedicine enabled medical professionals to detect medical conditions early and develop intervention plans to mitigate adverse outcomes.²

The challenges affecting delivery of telemedicine in rural areas of Nigeria

The implementation of telemedicine entails substantial costs and training requirements for health professionals serving rural areas. Given that a significant proportion of rural residents in Nigeria live in poverty, affordability of orthodox medicine remains a major concern, resulting in a preference for traditional medicine perceived as more affordable. The perceived high cost of telemedicine coupled with limited awareness of its significance for quality healthcare delivery has negatively affected its adoption among rural populations in Nigeria.¹⁷ Obikunle¹⁸ found that shortage of locally trained experts, inadequate training facilities, high remuneration costs for foreign-trained specialists, and insufficient knowledge of billing mechanisms for services rendered on telemedicine platforms hinder telemedicine delivery in rural Nigeria.

Furthermore, the absence of an institutional framework, legislation, and policies to regulate telemedicine standards and practice constitutes a major challenge in rural areas. This is compounded by limited government support in terms of legal frameworks to promote technology adoption for quality healthcare delivery, inadequate public financing of digital infrastructure in rural communities, and insufficient awareness campaigns to ensure rural residents have access to and understand the importance of telemedicine for quality healthcare.¹⁹

Additionally, weak collaboration among healthcare professionals, agencies, and the three tiers of government — federal, state, and local — affects telemedicine delivery in Nigeria. Given that local governments are closest to rural residents, lack of cooperation regarding provision of adequate financing, facilities, equipment, and legislation impedes implementation in rural areas. Policy discontinuity following changes in government, particularly within the health sector, further undermines sustained technology-driven healthcare policies.²⁰

Erratic power supply and dysfunctional telecommunication infrastructure also significantly affect telemedicine delivery in rural Nigeria. Telemedicine requires stable electricity and efficient internet connectivity, yet Nigeria's power supply remains inadequate relative to its population. This necessitates substantial investment in the power and telecommunications sectors to improve healthcare accessibility not only for rural dwellers but also for urban populations.²¹

Finally, concerns regarding privacy, data security, and confidentiality of patient information discourage rural residents from utilizing telemedicine. The perception that personal medical

information may be exposed leads to concealment of critical health history, which compromises diagnostic accuracy and treatment effectiveness. Given the importance of comprehensive patient data for efficient telemedicine delivery, perceived risks of information exposure and resultant withholding of critical medical information significantly impede implementation in Nigeria.^{18,19}

Strategic management for solving eHealth challenges in rural areas

Allocation of resources

Strategic management emphasizes efficient allocation of resources across organizational units to enhance operational efficiency and competitive advantage. In healthcare, resources such as information technology, financial capital, and legislative frameworks are vital for a quality health system. This necessitates development of telecommunication infrastructure in rural areas, as exemplified by the United States and the Netherlands where universal internet coverage in rural areas facilitates eHealth access for rural populations. Governments in these countries also implement awareness and sensitization programs to promote eHealth adoption among rural dwellers. Developed countries such as the United States possess not only effective facilities for quality healthcare delivery but also enabling legislation for digital health systems. For instance, data privacy and compliance frameworks including the Health Insurance Portability and Accountability Act of 1996 (HIPAA), the California Consumer Privacy Act (CCPA), and the Health Information Technology for Economic and Clinical Health (HITECH) Act provide regulatory frameworks for digital health practice, thereby encouraging eHealth adoption.²²

Integration of eHealth with the healthcare system

Strategic management emphasizes integration of specific units with other units within the organization to facilitate operational flow, information sharing, and efficiency. There is a need for eHealth to be integrated with other components of the healthcare system, including pharmaceutical units, patient records and data management units, and diagnostic units. Such integration is crucial for enhancing information flow, data sharing, access to patient records, and quality of healthcare delivery. As practiced in developed countries such as the United States, United Kingdom, and several European nations, there is integration between eHealth, pharmacy, and patient record systems. Linkage between eHealth and pharmaceutical units enables recommendations for appropriate medications based on historical data of patients with similar conditions treated with comparable drugs.²

Focus on employee motivation

Strategic management identifies employee motivation as a critical factor for enhancing productivity and competitive advantage. Factors such as effective reward systems and training for health workers are essential for improving performance.^{18,19} Currently, Nigeria faces significant brain drain in the medical sector, attributed to poor working conditions and migration of medical professionals to countries such as the United States, Europe, and Canada in search of better opportunities. This challenge is more pronounced in rural areas where limited facilities and infrastructure reduce motivation to practice. Medical professionals can be motivated through improved remuneration, better working conditions including availability of facilities, manageable workload and working hours, management support, and access to training facilities.⁹

Stakeholder engagement and partnership

Strategic management highlights the importance of stakeholder engagement and partnership. For effective eHealth implementation in rural areas, collaboration is required among the health sector, government, non-governmental organizations, health agencies, administrators, legislators across federal, state, and local governments, media particularly for public awareness on the significance of eHealth and the need for adoption, suppliers, and host communities.⁴

Modern architectural plans

Strategic management emphasizes quality service delivery as a differentiation strategy for competitive advantage, while also highlighting technology's role in cost management. To address eHealth delivery challenges in rural areas, modern architectural plans are needed for the national eHealth directory and national infrastructure required to manage health crises. Essential infrastructure and technologies to enhance quality and efficiency in eHealth delivery include videoconferencing through which physicians communicate directly with patients regardless of distance, high-speed internet, clinical eHealth platforms functioning as interaction centers, remote patient monitoring through which providers obtain vital health information at the point of care including blood pressure, heart rate, blood sugar and blood oxygen levels, and mHealth solutions such as mobile applications and SMS. These architectural approaches, as practiced in some European countries, enable eHealth delivery in both rural and urban areas. These technologies assist in reducing healthcare-related costs, for example, costs associated with transporting providers from urban to rural areas are minimized through videoconferencing, while time to medical attention is reduced, thereby preventing deaths attributed to delayed response.²³

Materials and method

This study majorly focused on secondary data and literature review. Relevant papers were identified by searching the following electronic databases such as: World Health Organization¹ report 2021, Trading Economics report 2022. United Nations report 2024 on Sustainable Development Goals. Likewise review of the past related studies were done. The papers search were restricted to English and those that were publish on and after year 2000. The paper search was done through Google, Google Scholar, and websites of key eHealth framework and strategies for quality healthcare delivery. The reference lists of reviews and included studies were search manually and through the internet. The inclusion and exclusion criteria were used to select relevant studies and exclude the irrelevant ones to enhance unbiased review. Studies were eligible for inclusion if they (i) majorly focused on eHealth (ii) they are between 2000 to 2026 (iii) with major focused on lower-middle-income countries (iv) contained data on eHealth challenges in rural areas, eHealth benefits as well as policies and programs for accessible and affordable quality healthcare delivery in rural areas. The secondary reports and the literature review revealed eHealth framework and strategies for accessible and affordable quality healthcare delivery in lower-middle-income countries.

Recommended Policies and Programs for adoption and delivery eHealth for Quality Healthcare in in Low- and Middle-Income Countries rural areas.

The recommendations are based on literature review.

Offering of financial incentives

The adoption of eHealth in low- and middle-income countries is significantly moderated by economic viability at both health system

and end-user levels. Recent systematic reviews indicate that financial constraints and sustainability concerns are among the most frequently reported barriers to digital health implementation in rural Sub-Saharan Africa, alongside infrastructural deficits.²⁵ The following strategies are therefore recommended for eHealth adoption in LMICs.

Subsidize the cost of eHealth devices: Device cost remains a primary exclusion factor for rural primary healthcare [PHC] facilities. High upfront costs of mobile devices, diagnostic peripherals, and kiosks limit scalability (Chilunjika & Ngulube, 2026). Evidence demonstrates that targeted subsidies accelerate adoption. For instance, South Korea's Ministry of Health allocated approximately USD 310 million in 2024 to subsidize 5G-connected chronic disease kits for rural communities, expanding the addressable market beyond hospital settings. Similarly, India's Ayushman Bharat Digital Mission aims to deploy over 150,000 smart devices in rural facilities by 2029, with government co-financing of diagnostic peripherals. A mixed-methods systematic review found that subsidies for purchasing digital devices significantly increased health workers' propensity to adopt and integrate technologies into routine practice.²⁶ In terms of rural service quality, subsidization reduces out-of-pocket capital expenditure for clinics and enables task-shifting to community health workers using low-cost smartphones and SMS-based platforms.²⁷

Bonuses for using eHealth: Performance-based bonuses serve as extrinsic motivators to overcome attitudinal resistance. However, bonuses alone are insufficient to sustain usage without complementary trust-building measures.²⁸ Combined financial and non-financial incentives were identified as one of the most important improvement strategies for digital health adoption in LMICs. Formal recognition through certification courses for telemedicine platforms significantly increased uptake among health workers in Sub-Saharan Africa. To ensure quality of care, bonuses linked to quality metrics rather than volume prevent perverse incentives and improve referral completion rates.²⁷

Tax incentives: Tax policy influences private sector participation in the eHealth ecosystem. The absence of adequate fiscal legislation is cited as a major barrier affecting eHealth implementation at organizational and professional levels. Tax exemptions on importation of eHealth hardware, value-added tax [VAT] waivers on mHealth software, and corporate tax holidays for telehealth startups reduce total cost of ownership. In LMICs where mHealth innovation is often donor-dependent, domestic tax incentives encourage local manufacturing and reduce donor dependency, which has been shown to cause suspension of digital health initiatives in Burkina Faso following budgetary constraints.²⁹ A narrative review on health financing in Sub-Saharan Africa noted that optimal governance for sustainable digital solutions requires aligning tax incentives with universal health coverage objectives.³⁰

Financial incentives [system-level]: Broad system-level financial incentives encompass implementation grants, meaningful use payments, and insurance reimbursements. In rural China, net medical income increased significantly with incentives alone, making village clinics more financially viable and reducing bypass to county hospitals.²⁸ Financial incentives that offset internet and opportunity costs directly increase willingness to adopt. In Kenya, research on demographic moderators recommended enhancing affordability through subsidies and integrating digital literacy programs to bridge disparities in rural Makueni County.³¹

Affordable Internet Access: Connectivity is the most frequently coded barrier in LMICs.²⁷ Infrastructural limitations including unreliable internet, poor network coverage, and inconsistent electricity

constrain deployment of digital health technologies.²⁹ In Cameroon, where mobile internet is highly affordable and ranked among the top 50 worldwide, mHealth access is more achievable compared to Papua New Guinea, where high data costs restrict access despite comparable network coverage. Data unaffordability was identified as a major barrier to mHealth utilization in Zimbabwe, while airtime costs limited mobile phone-based interventions.²⁹ Universal service funds, zero-rating of health domains, community Wi-Fi hotspots, and negotiations with telecom operators for health-specific bundles are critical enablers. The WHO Global Strategy on Digital Health 2020-2025 emphasizes equitable, affordable, and universal access to eHealth benefits as a core principle.²⁶

Digital literacy

4.2.1 Community-based digital literacy programs: Deployment of simplified, community-level training on the use of mobile health applications, USSD codes, SMS-based health information, and telemedicine booths/kiosks.¹³

Awareness and sensitization campaigns: Utilization of local media, traditional leaders, and town-hall sessions to educate rural residents on benefits, safety, and cost-effectiveness of eHealth for quality healthcare delivery.¹⁸

Multilingual and user-centered training materials: Development of training content in indigenous languages with pictorial guides, voice prompts, and user-friendly interfaces to accommodate low-literacy populations.¹²

On-site technical support and assisted use: Stationing of technical facilitators and community health extension workers at PHCs to assist first-time users, build trust, and address concerns about data privacy and security.⁹

Inclusive training for vulnerable groups: Targeted programs for elderly patients, women, and persons with disabilities to ensure equitable adoption and to reduce digital health disparities across rural communities.³²

Regulatory and governance factors influencing ehealth adoption for quality healthcare in RURAL LMICs

Strengthening and enforcing regulatory relations around eHealth technologies: Lack of appropriate eHealth policy is the second most cited factor affecting successful implementation after cost in LMICs.³³ Mengiste et al.,³⁴ noted that eHealth policies were often vague, lacked consolidated plans, and suffered from poor coordination among government departments and inadequate long-term strategies in unstable political environments. Enforcement is critical, as sound policies minimize data safety concerns, clarify liability, and simplify interoperable Electronic Health Record [EHR] exchange while maintaining integrity.³⁴ Recent evidence from Malaysia illustrates a shift toward structured enforcement: the 2025 guideline on online healthcare services introduced by the Ministry of Health sets clearer expectations regarding safety, quality, accountability, privacy, and traceability for telemedicine, e-pharmacy, and digital platforms, recognizing that many healthcare laws were originally designed for an analogue environment.³⁵ For rural LMICs, emphasis should be placed on establishing a national eHealth regulatory authority with mandate over public and private providers, alongside enforcement of licensing for telehealth providers and periodic audits to ensure quality of care.

Integrating eHealth into the national health insurance scheme [NHIS]: Integration of eHealth data with population data, health insurance records, and patients' medical histories is identified as

crucial for achieving quality healthcare.²⁷ The introduction of digital health insurance could enhance affordability and accessibility of eHealth, thereby facilitating successful implementation nationally. The Digital Health Equity Model identifies key practices to enhance adoption, including health financing mechanisms such as digital health insurance, governance and government support, improved institutional policies and leadership, digital health education and training, investment in digital infrastructure, development of user-friendly eHealth platforms, and implementation of robust data security and privacy measures.¹³

Data security and certification of eHealth products: Certification ensures quality, confidentiality, privacy, security, and integrity of health data.³¹ Although proliferation of eHealth devices has transformed care, it presents significant data protection challenges. Patel et al.,³⁶ emphasized ongoing regulatory amendments required for data security, highlighting requirements for informed consent, data security protocols, and implications of noncompliance under the General Data Protection Regulation [GDPR] and Health Insurance Portability and Accountability Act [HIPAA] as reference frameworks.

Regulatory framework to ensure data privacy and security: Data privacy and security are paramount components of eHealth policy, requiring robust measures to protect health information from unauthorized access and cyber threats. Key considerations include data encryption, access controls, and breach notification protocols.³¹ A privacy-aware framework proposes six coordinated mechanisms: role-based access control, user consent management, stakeholder-specific privacy policies, data sensitivity layering, anonymization and de-identification, multi-level information security, as well as emergency override and audit tracking.³⁰ Regulation should mandate responsible parties to safeguard integrity and confidentiality by identifying foreseeable risks, maintaining safeguards, and continuously updating them in response to emerging threats.³⁶ Recent EU developments provide a reference point: the European Health Data Space [EHDS] Regulation establishes mandatory requirements for primary and secondary use of health data under strict ethical and privacy safeguards, requiring data protection by design under GDPR Article 25 for eHealth products and services.³⁷ For the rural LMIC context, the framework must: (a) mandate explicit patient consent with opt-out provisions for secondary use, (b) require data residency within national borders for sensitive clinical data, (c) establish breach notification within 72 hours, and (d) enforce penalties for non-compliance while providing capacity building for rural facilities lacking dedicated IT security staff.

Infrastructural investment factors influencing ehealth adoption for quality healthcare in rural Nigeria

Private sector investments in eHealth infrastructures such as telemedicine hubs: Private sector participation is increasingly recognized as critical for delivering resilient Primary Health Care [PHC] systems in Africa. Businesses are investing in digital tools, data systems, and supply chain innovations that extend quality services to communities that public facilities alone cannot reach.¹ In Nigeria, the ecosystem is expanding rapidly: as of 2025, Nigeria hosts over 12 active telemedicine startups employing over 5,000 Nigerians in technology roles. Companies such as CloudClinic, Afrihealth, Clafiya (which raised \$610,000 in 2023), MyMedicalBank, CribMD, and Mobihealth are building platforms tailored to Nigeria's specific needs. Clafiya provides training on chronic disease management for rural doctors and employs part-time doctors for rural consultations, while CloudClinic has established extensive partnerships across rural Nigeria, strengthening grassroots reach and addressing urban

congestion (Rome Business School, 2025). Global market analysis notes that AI telehealth rollout in Africa, including PMC360 launching AI-powered telehealth in Nigeria in 2025, is bridging rural care gaps through virtual consultations and diagnostics. The model is shifting from pure video calls to hybrid care incorporating home visits, sample collection, and physical clinic partnerships integrated into omni-channel offerings (HealthTech Report, 2025). For quality assurance, private telemedicine hubs at PHC level function as digital spokes connecting village clinics to specialists via videoconference, a model shown to improve access and quality in Kenya and Nigeria.¹ Nevertheless, eHealth infrastructure such as telemedicine hubs should be further expanded to cover rural communities.^{38–40}

Significant investments in telecommunication: Telecommunication infrastructure forms the backbone of eHealth. In LMIC settings, connectivity and affordability barriers are major constraints.¹⁰ Nigeria's National Digital Health Initiative, supported by the 2024 National Digital Health Strategy, established a federal framework to regulate deployment of EHR across 36 states to minimize technical fragmentation. However, rural communities still lack network coverage, rendering internet-dependent digital tools unusable.³⁹ Telecommunication investment must be differentiated: USSD protocols for rural areas and broadband for urban hubs. Public-private partnerships with telecommunications companies for zero-rating health platforms and community Wi-Fi at PHCs are recommended to enhance equitable adoption.⁴¹

Investment in solar power: Power instability accounts for over 80% of system underperformance of cloud-based EHR in Nigeria, alongside high costs and poor IT infrastructure.⁴¹ Solarization has emerged as a transformative enabler. eHealth Africa, in collaboration with UNICEF under Gavi-CDS3, solarized 371 PHCs: eHealth Systems Africa installed 238 PHCs while Differ Community Power implemented 133 facilities in the North-East.^{42,43} In the first half of 2026 alone, 226 remotely monitored facilities generated 277,800 kWh, saving approximately ₦166 million in fuel costs and preventing 240 metric tonnes of CO₂ emissions (Leadership News, 2026). Patient attendance increased by over 100% across solarized facilities in Kano due to 24/7 maternal and child health services, onsite vaccine storage, and uninterrupted immunization. Following fuel subsidy removal in 2023, petrol prices increased from ₦194 to ₦965 per litre, making generator-dependent services unsustainable. Hence, investment in renewable energy, particularly in rural areas with limited electricity, is essential to improve eHealth systems for accessible and affordable quality healthcare.

Telemedicine and telehealth access expansion: Telemedicine expansion directly addresses physician shortages and travel barriers in rural Nigeria. Evidence from Festac Primary Health Centre in Lagos found EHR significantly reduced paperwork and improved service delivery, freeing health workers for patient care, while telemedicine bridged gaps by bringing doctors to rural families.^{44,45} The federal government has acknowledged dividends at sub-national level with telemedicine bridging gaps.⁴⁵ Digital infrastructure significantly improves clinical outcomes: for instance, vaccine stockout incidences in Kenya dropped from 35% to 4% following transition to automated last-mile Logistics Management Information Systems [LMIS]. Furthermore, digital health tracking initiatives in rural Ghana, such as the Mobile Technology for Community Health [MOTECH] program, saw maternal follow-up completion rates rise from 42% to 81%, directly contributing to a 14% reduction in neonatal mortality.⁴⁶

Digitalization and upgrading healthcare facility: Digitalization encompasses conversion from paper to electronic systems and facility

upgrades. Nigeria is transitioning from error-prone paper-based records to advanced EHR. Continued reliance on hybrid and paper-based processes is unsustainable. Studies show EHR implementation strengthens clinical documentation, improves continuity of care, facilitates timely access to patient records, and streamlines workflows.^{11,47} Implementation of EHR in rural Nigeria will improve clinical decision-making and record accuracy.⁴⁸ Nevertheless, this must be supported by adequate sensitization for users, proper electronic documentation, and improved accessible infrastructure.¹³ Additionally, priority should be given to basic digitization, including electronic registers and mobile tablets for community health workers to track antenatal care and data integration, which helps transform care from isolated treatments into a seamless longitudinal care experience.²

Development and customization of ehr technologies for Nigerian rural areas: Customization is essential because standards from developed countries may not be locally applicable. Nigeria’s National Digital in Health Initiative developed the Nigeria Digital Health Architecture [NDHA], endorsed by the National Council on Health, as a national blueprint for a secure and interoperable ecosystem built around Health Information Exchange with Shared Health Record and national registries for clients, facilities, and workers, anchored on the principle of “one patient, one health record”.⁴⁵ Nevertheless, this should be expanded to cover rural communities. Focus should also be on integrating local languages into the eHealth system to enhance simplicity and wider accessibility.

Unified electronic health record system that ensures continuity of care across facilities and regions: A unified EHR is a health policy system that ensures medical information follows patients securely

across healthcare facilities, enabling authorized health workers to make informed clinical decisions and preventing patients from becoming effectively new patients simply because they have crossed from one facility, program, or level of care to another. Flourence et al.⁴⁹ identified implementation of a standardized EHR system across all healthcare institutions as a key strategy for overcoming fragmentation. This unified system would facilitate seamless transfer of patient information, eliminating repeated medical history taking when visiting facilities in different regions. Such continuity of care is vital for enhancing health outcomes and ensuring digital health technologies foster a more efficient, interconnected healthcare system nationwide. Policies such as Health Information Exchange (HIE), which allows hospitals and providers to share data securely creating unified digital health records that support AI-driven diagnostics while safeguarding patient information, as well as Shared Health Record (SHR), a longitudinal patient-centered record aggregating data from multiple encounters, should be expanded to rural communities. Furthermore, integration of trusted digital identity with patient records is expected to eliminate gaps in patient identification, improve continuity of care, and boost enrollment under National Health Insurance. Additionally, the recently established National Health Technology and Data Analytics Office in Nigeria to coordinate the digital health agenda, harmonize public and private institutions, and supervise operationalization of NDHA should be facilitated with adequate sensitization, digital training, and improved infrastructure, particularly in rural communities.⁴⁵

Framework for the adoption and delivery of eHealth for quality healthcare in in Low- and Middle Income countries rural areas (Figure 3):

Offering of incentives <ul style="list-style-type: none">• Subsidization of eHealth device costs• Performance-based incentives for eHealth utilization• Fiscal incentives through tax relief mechanisms• System-level financial incentives• Provision of affordable and equitable internet connectivity	Improve eHealth Infrastructure <ul style="list-style-type: none">• Private sector investment in eHealth infrastructure, including telemedicine hubs• Substantial investment in telecommunication infrastructure• Investment in renewable solar energy solutions• Expansion of telemedicine and telehealth access• Digitalization and upgrading of healthcare facilities• Development and contextual customization of Electronic Health Record [EHR] technologies for rural Nigeria• Implementation of a unified electronic health record system to ensure continuity of care across facilities and regions• Design and adaptation of EHR technologies to suit infrastructural, linguistic, and operational realities of rural Nigerian settings
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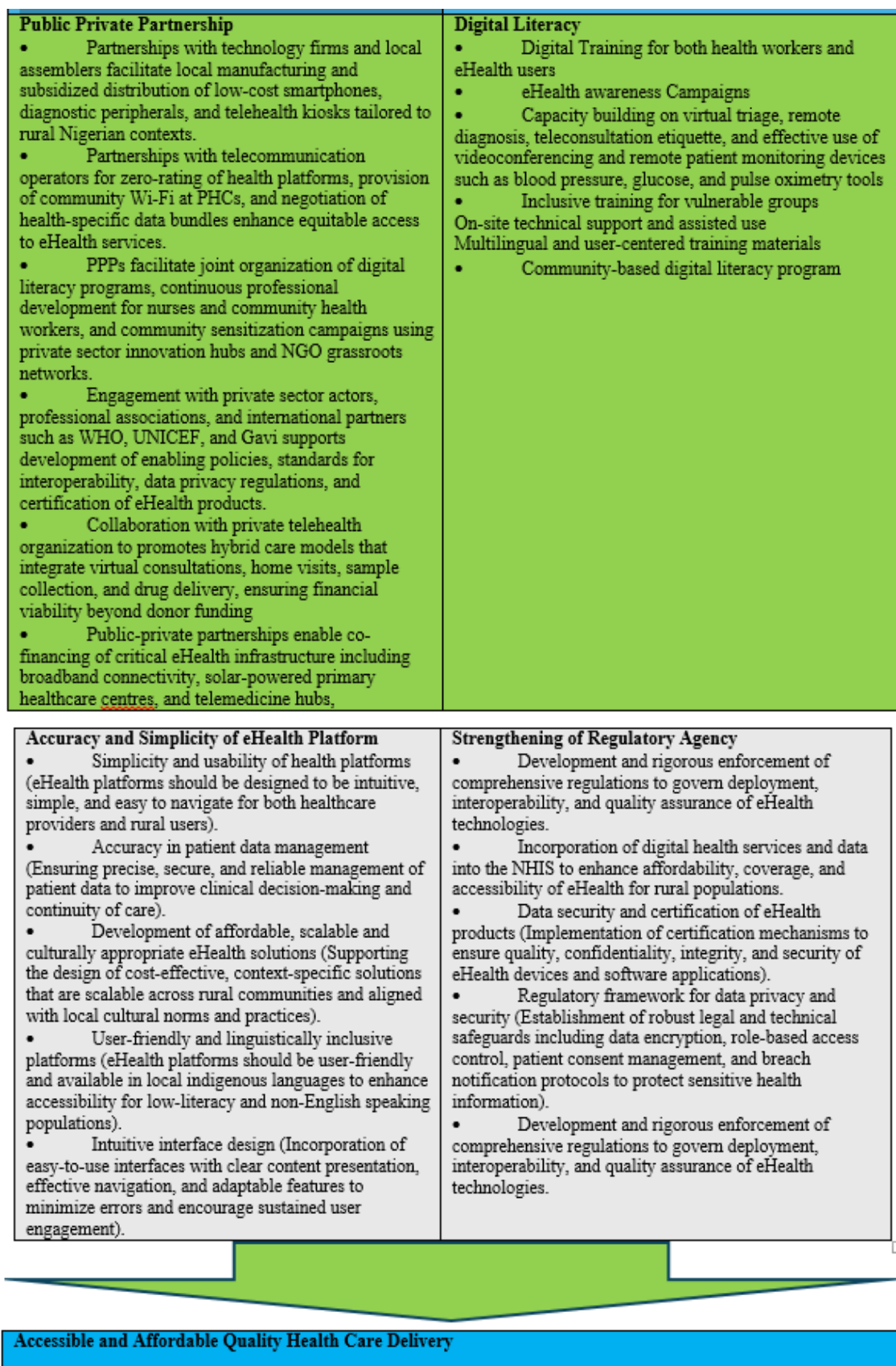


Figure 3 Comprehensive framework for the adoption and delivery of eHealth for affordable and accessible Quality Healthcare in in low- and middle-income countries rural areas.

Conclusion

Although eHealth offers significant benefits including elimination of geographical barriers, provision of quality healthcare to rural patients, and reduction of isolation in accessing quality services, studies have identified multiple challenges facing rural residents in accessing quality healthcare. These challenges include lack of digital facilities, inadequate internet services, shortage of medical professionals, insufficient government support, and limited education and awareness of eHealth among rural populations. These barriers have consequential effects on eHealth delivery in rural Nigeria.⁵ The Sustainable Development Goals aim to improve healthcare quality in Nigeria, an objective that depends significantly on ensuring affordability and accessibility regardless of income or social status.¹² Similarly, SDG 9 emphasizes industry, innovation, and infrastructure, advocating for policies that develop reliable, high-quality, and resilient healthcare systems supported by advanced technologies such as eHealth. These efforts aim to promote sustainable practices and ensure equitable access to quality healthcare for all irrespective of socioeconomic status.¹⁰ To enable eHealth to achieve its intended outcomes of quality and equitable healthcare, particularly in rural areas of low- and middle-income countries, the following recommendations are proposed:

Allocation of resources: This includes provision of financial resources and infrastructure by government in areas such as internet accessibility for rural dwellers, efficient telecommunication systems, and other facilities required for efficient eHealth delivery in rural Nigeria.²²

Integration of eHealth with the healthcare system: There is a need for integration among units such as pharmaceutical, patient records and data management, and diagnostic units to ensure efficiency of eHealth in rural Nigeria.²

Motivation of healthcare providers: As Nigeria currently faces brain drain in the medical sector, good reward systems, conducive working conditions including availability of facilities, manageable workload and working hours, management support, and availability of training facilities are crucial to motivating healthcare providers toward productivity.⁹

Partnership and engagement with stakeholders: Partnership with stakeholders including government, non-governmental organizations, health agencies, administrators, legislators across federal, state, and local governments, international organizations, media particularly for publicity on the significance of eHealth for quality healthcare, suppliers, and host communities is required to enhance eHealth efficiency in Nigeria.⁴

Digital health education and training: These findings underscore the necessity for improved digital health education initiatives to enhance accessibility to eHealth irrespective of geographical location. To address this disparity, community-based training programs are recommended to bolster digital literacy and promote inclusive eHealth adoption across rural communities.³²

Need for public-private partnership and government support: This is particularly important for investment and formulation of policies and laws to ensure efficient eHealth delivery in rural areas. Effective eHealth also requires cooperation among the three tiers of government - federal, state, and local.²³ Government action is essential to invest in infrastructural development such as broadband and electricity, strengthen regulatory frameworks and healthcare policies to support eHealth, and foster public-private partnerships. The

private sector plays a pivotal role in healthcare provision in Nigeria, complementing government efforts to deliver inclusive and affordable medical services through digital health technologies, accounting for over 62% of healthcare services. Public-private partnerships create an enabling environment for successful implementation of digital health technologies such as electronic medical records and other eHealth tools, fostering innovation and improving healthcare delivery. Through collaboration with the private sector, the Nigerian government can improve digital health insurance, internet access, and other facilities aimed at making eHealth more accessible and affordable for quality healthcare.⁵⁰⁻⁵⁶ Additionally, government support through partnership with the private sector to develop or finance diverse eHealth platforms such as telemedicine booths, digital health applications, and websites, particularly in rural areas, would improve access to quality healthcare.

Development of user-friendly eHealth platforms: Simplicity of the eHealth system ensures greater accessibility for patients. Key features such as user-friendly interfaces, multilingual support including indigenous languages, robust data security and privacy measures, effective navigation, clear content presentation, and adaptable design ensuring accessibility for users with disabilities help minimize errors and system disruptions. These elements are critical for driving higher adoption rates in rural communities. Additionally, deploying on-site technical specialists to assist and educate rural users on the use and benefits of eHealth across healthcare centers and local communities is essential.¹² Such support systems further bridge the gap in digital literacy and encourage sustained engagement with eHealth platforms, with emphasis on developing platforms that are user-friendly and available in local languages.

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Conflicts of interest

The authors declare no conflict of interest.

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