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The new normal of eHealth equity: Transforming chronic disease management amid rural technological constraints and digital divides

Caleb Kadiri [1,*] and Babatunde O. Owolabi [2]

[1] *Pharmacist and Health Analyst, Kwara State University, Nigeria.*
[2] *Department of Community Medicine, College of Medicine, Ladoke Akintola University of Technologies, Oyo State, Nigeria.*

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Abstract

In the new health landscape "new normal" in healthcare has seen an irreversible pivot toward digital health systems, radically reshaping the landscape of chronic disease management. Central to this transformation is the deployment of telehealth platforms, remote diagnostic tools, AI-powered clinical decision support, and mobile health applications, all promising to increase efficiency, coverage, and continuity of care. However, these innovations are often designed with high-bandwidth, urban ecosystems in mind-leaving rural, low-income, and infrastructurally disadvantaged regions at the margins of healthcare innovation. This digital inequity poses profound risks for populations already burdened by higher rates of chronic diseases such as type 2 diabetes, hypertension, COPD, and cardiovascular disorders. This paper critically examines how the "new normal" can be reimagined to include digital parity in chronic care delivery. It dissects infrastructural barriers such as unreliable internet, electricity scarcity, fragmented data governance, and the absence of regionally contextualized digital health architecture. It further analyzes sociotechnical challenges, including low eHealth literacy, cultural mistrust in digital platforms, and limited integration between community-based care and formal health systems. Drawing from case studies across sub-Saharan Africa, South Asia, and remote North American territories, the study identifies scalable innovations like asynchronous telemedicine, hybrid online-offline mHealth platforms, community-powered digital navigators, and low-code platforms that address the unique needs of bandwidth-constrained areas. The analysis calls for a redefinition of digital health equity through inclusive infrastructure investment, adaptive technology design, and cross-sectoral policy alignment. The "new normal" must not merely digitize health systems but democratize them ensuring rural communities are central actors in chronic disease management through equitable digital transformation.

Keywords: Digital Health Equity; Chronic Illness Informatics; Rural Telemedicine; Low-Bandwidth eHealth; Infrastructure-Inclusive Design; Public health emergency

1. Introduction

1.1. Background on eHealth and Chronic Disease Burden

The rising prevalence of chronic diseases such as diabetes, hypertension, and chronic obstructive pulmonary disease (COPD) has exerted immense pressure on global health systems. These conditions are often lifelong, requiring continuous monitoring, medication adherence, lifestyle modification, and multidisciplinary coordination to prevent complications and hospitalizations [1]. In response, health systems have increasingly turned to digital health, or eHealth, to enhance chronic disease management by facilitating remote monitoring, data sharing, and patient education [2].

* Corresponding author: Caleb Kadiri.

eHealth encompasses a broad range of information and communication technologies (ICTs), including telemedicine, mobile health (mHealth) applications, wearable devices, electronic health records (EHRs), and clinical decision support systems. These technologies can enable personalized care, improve efficiency, and bridge gaps in traditional models of chronic disease intervention [3]. The potential of digital tools to detect early deterioration, track longitudinal biomarkers, and engage patients remotely has made them integral to modern care pathways [4].

Despite their promise, eHealth innovations have not been equitably distributed across geographic and demographic populations. In particular, rural populations face significant challenges in accessing and benefiting from digital health technologies due to infrastructural, economic, and educational barriers [5]. These disparities risk reinforcing existing health inequities and limiting the reach of chronic disease solutions meant to be universal in scope.

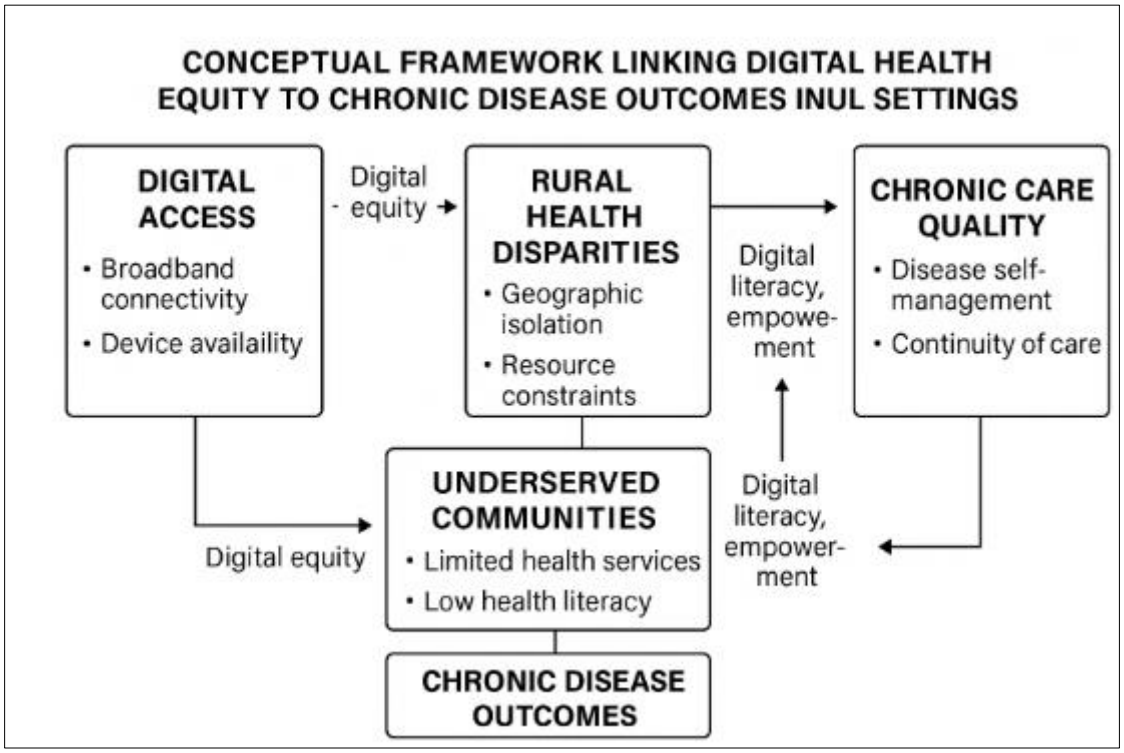

Figure 1 Illustrates the framework through which digital access interacts with chronic care quality in underserved communities [6]

Given the increasing digitalization of health services, the need to assess and address such inequalities in chronic care delivery through an eHealth equity lens has become ever more pressing [7].

1.2. Digital Inequities in Rural Healthcare

While digital health technologies have reshaped chronic disease management strategies in well-resourced urban settings, rural populations often remain excluded from these benefits due to infrastructural deficiencies. Broadband penetration remains uneven, with significant gaps in internet availability, speed, and reliability across rural regions [8]. This has restricted the feasibility of deploying telehealth consultations, remote monitoring systems, and mHealth applications in areas that often carry higher burdens of preventable chronic illnesses [9].

Moreover, technological access alone does not equate to effective utilization. The "second-level digital divide" reflects disparities in the ability to interpret and engage with eHealth platforms, especially among older adults and low-literacy populations common in rural communities [10]. Devices may be scarce, outdated, or shared among household members, reducing the consistency of digital engagement. Language, cultural context, and trust in technology further complicate adoption [11].

Structural issues compound these challenges. Health systems in rural regions frequently face workforce shortages, with limited digital training among providers and minimal institutional support for telemedicine integration [12]. Funding

models often favor volume-based care rather than preventive, technology-supported approaches. These constraints widen the health equity gap and hinder the promise of eHealth to democratize chronic disease care [13].

In this context, understanding the root causes and manifestations of digital exclusion becomes critical for designing effective interventions. Figure 1 further reflects how such inequities shape chronic disease outcomes when digital access and literacy are impaired [6].

1.3. Purpose and Scope of the Article

This article aims to critically examine the intersection between eHealth technologies and chronic disease management in rural settings, with a specific focus on addressing digital inequities that impede equitable care access and outcomes. It investigates how chronic care models have evolved within the constraints of technological infrastructure and what innovative strategies have emerged to mitigate these barriers [14].

The central hypothesis guiding this work is that structural digital divides in rural communities exacerbate chronic disease burdens by limiting access to continuous, personalized, and technology-driven care. By drawing on real-world examples, programmatic evidence, and policy frameworks, the paper seeks to elucidate how targeted interventions can bridge these divides [15]. Particular emphasis is placed on identifying sustainable and culturally competent models that leverage community participation and locally adaptive technologies [16].

The scope includes reviewing literature on eHealth adoption in chronic disease care, assessing infrastructural and socio-demographic factors affecting rural implementation, and evaluating evidence-based solutions from community health worker initiatives to telehealth reimbursement schemes. Table 1 presents a comparative overview of digital health adoption rates and associated chronic care outcomes between rural and urban jurisdictions [17].

Table 1 Comparison of Digital Health Adoption and Chronic Disease Outcomes Across Rural and Urban U.S. Jurisdictions

Jurisdiction Type	Digital Health Tool Adoption Rate	Broadband Coverage (% Households)	Telehealth Utilization (per 1,000 residents)	Average HbA1c (Diabetes)	Uncontrolled Hypertension Prevalence (%)
Urban (e.g., New York City, San Francisco)	78%	92%	64.3	7.1%	26%
Suburban (e.g., Fairfax County, Orange County)	69%	85%	52.8	7.4%	29%
Rural Tier 1 (e.g., Western Kansas, Central Mississippi)	43%	58%	27.5	8.6%	37%
Rural Tier 2 (e.g., Appalachian counties, tribal lands)	31%	41%	19.3	9.2%	42%

Ultimately, the paper contributes to a growing body of work that calls for a reimagining of digital health not as a universal solution, but as a tool that must be equitably tailored to the specific needs of rural populations facing disproportionate health burdens [18].

2. Conceptual frameworks for eHealth equity

2.1. Definitions and Dimensions of eHealth Equity

eHealth equity refers to the fair and just access to digital health resources, technologies, and services across diverse populations regardless of geographic, socioeconomic, or demographic background [6]. It is rooted in the broader

principle of health equity, but emphasizes the digital dimension ensuring that innovations in telemedicine, mobile applications, remote monitoring tools, and patient portals are accessible, usable, and beneficial to all individuals [7].

The concept extends beyond the presence of devices or infrastructure. It incorporates access to reliable internet, affordability of services, availability of culturally relevant content, and the user's digital health literacy. In the context of chronic disease management, eHealth equity ensures that rural residents with hypertension or diabetes, for example, are not disadvantaged simply due to where they live or their income level [8].

Importantly, equity is distinct from equality. While equality implies uniform access to the same tools, equity addresses historical, structural, and contextual barriers that different groups face in utilizing those tools effectively [9]. A uniform telemedicine program may be equal in design but inequitable in impact if connectivity, literacy, or trust issues vary across regions.

A practical framework for understanding these dynamics is presented in Figure 1, which illustrates how various dimensions of digital equity technical, socio-cultural, and structural interact to influence chronic disease outcomes in rural populations [10].

This evolving conceptualization is necessary to inform not just the design of digital interventions, but also their funding, implementation, and policy evaluation mechanisms.

2.2. Theoretical Underpinnings: Access, Literacy, and Empowerment

Three foundational pillars support the framework of eHealth equity: digital access, digital literacy, and patient empowerment. Together, they serve as the theoretical bedrock for assessing disparities and designing responsive chronic disease interventions in underserved rural communities [11].

Digital access involves both physical connectivity (e.g., broadband infrastructure, device availability) and functional access (e.g., affordability, reliability of power supply, and user support). While some areas may have basic cellular coverage, the bandwidth required for synchronous teleconsultations or data-rich mobile applications may be insufficient, resulting in suboptimal use or complete exclusion [12]. These limitations are compounded by income disparities that restrict the ability to purchase updated devices or data plans.

Digital literacy is more complex. It is not limited to technical skill; it includes the capacity to search, evaluate, and apply digital health information meaningfully. For patients with chronic conditions, this could involve interpreting blood glucose readings from a wearable device, logging dietary inputs into a mobile app, or navigating EHR portals to refill prescriptions [13]. When digital tools are not designed with user diversity in mind, especially in terms of age, education level, or language, the barrier to entry becomes insurmountable for many rural users.

Empowerment in the digital health context refers to a user's confidence, motivation, and autonomy in using eHealth resources to make informed health decisions. Empowerment strategies may include peer-support platforms, digital coaching, or community-based education modules [14]. When users feel ownership of their health data and understand how digital tools relate to their specific health goals, engagement improves. Conversely, digital surveillance or algorithmic decision-making devoid of cultural context can breed mistrust and passive resistance [15].

These three pillars are interdependent. Digital access without literacy offers limited benefit. Literacy without empowerment may result in minimal behavioral change. True eHealth equity arises only when all three dimensions are intentionally addressed in program design and delivery.

Moreover, as Figure 1 illustrates, the absence of any one pillar undermines the pathway toward improved chronic disease outcomes. Policymakers, health system planners, and technologists must understand this interplay to avoid simplistic interventions that inadvertently widen disparities [10].

2.3. Social Determinants and Rural Health Disparities

The social determinants of health (SDOH) conditions in which people are born, grow, live, work, and age heavily influence rural populations' ability to engage with eHealth tools. These determinants shape everything from the availability of internet services to perceptions of technology and trust in the healthcare system [16].

Education level plays a crucial role. Individuals with lower formal education may be less likely to engage with digital health content or trust algorithm-based recommendations. Employment status and occupational context also matter; agricultural or shift workers may have limited time or access to use devices during standard clinical hours [17].

Housing conditions further affect eHealth readiness. In multigenerational or shared housing, access to private space for video consultations may be limited. Insecure housing may also disrupt connectivity or limit consistent device use. Additionally, food insecurity, income instability, and limited transportation exacerbate chronic illness while simultaneously making the pursuit of digital alternatives more difficult [18].

Cultural norms and social cohesion, though often strengths in rural communities, can also influence eHealth uptake. For instance, fatalistic views about health, skepticism toward digital interventions, or preference for face-to-face care can dampen enthusiasm for technological solutions even when infrastructure exists [19].

These multifaceted determinants intersect with the three pillars discussed previously access, literacy, and empowerment creating layered challenges. Figure 1 visually maps how SDOH interact with eHealth inequities, ultimately shaping chronic disease trajectories in rural populations [10].

Recognizing the weight of these factors is essential not just for understanding disparity, but for designing equitable, practical solutions that align with rural realities rather than urban assumptions.

3. Rural technological constraints in eHealth implementation

3.1. Infrastructure Gaps and Internet Access Inequality

One of the most pressing barriers to eHealth equity in rural settings is the continued absence of reliable broadband infrastructure. While urban areas experience near-universal coverage, many rural communities lack even basic high-speed internet access [11]. This creates a foundational inequality in the ability to benefit from telehealth services, remote monitoring devices, or even digital appointment scheduling tools.

The Federal Communications Commission's benchmarks for broadband download speeds of at least 25 Mbps and upload speeds of 3 Mbps remain unmet in large portions of rural America, especially in mountainous, tribal, or agriculturally dispersed regions [12]. The consequence is that video consultations buffer, real-time vital monitoring fails, and digital health dashboards become inaccessible.

Compounding this issue is the phenomenon of "last mile" delivery the challenge of bringing internet connectivity from main infrastructure points to individual homes in low-density areas. Internet service providers often consider rural expansion economically unviable due to the high capital investment and low return [13].

Further exacerbating these gaps are inconsistent mobile data coverage and limited Wi-Fi availability in community centers, libraries, and clinics. For patients managing chronic diseases like COPD or hypertension, intermittent connectivity can interrupt therapy adherence reminders, disable monitoring alerts, and reduce communication with providers [14].

As shown in Table 1, states with lower rural broadband penetration consistently report poorer chronic disease outcomes, including higher hospitalization rates and lower self-management scores. The geographic digital divide, therefore, directly influences population-level health disparities and must be addressed in tandem with clinical interventions [15].

If this infrastructural barrier is not resolved, even the most sophisticated eHealth tools risk becoming irrelevant in the communities that may benefit most from them. Addressing this requires not only technological investment but coordination across telecommunications, public health agencies, and rural development sectors.

3.2. Device Availability and Usability Challenges

Beyond internet infrastructure, the availability and appropriateness of digital devices significantly shape eHealth engagement. In rural households, particularly those with older adults or low-income families, smartphones, tablets, or wearable health devices may be limited, outdated, or shared among users [16]. This materially constrains the user's ability to participate in self-monitoring programs or virtual health visits.

Device availability is further complicated by compatibility issues. Many remote health applications require up-to-date operating systems or memory-intensive processing capabilities. When patients attempt to use older phones or second-hand tablets, application crashes or slow performance discourages sustained use [17].

Even when devices are present, usability is a persistent challenge. User interfaces may not be designed with aging populations or low-literacy users in mind. Small font sizes, complex authentication steps, or unclear icons can render even the most well-designed health application inaccessible to a rural patient unfamiliar with technology [18].

Moreover, shared device use common in multigenerational or income-constrained households raises privacy concerns. Patients managing stigmatized conditions, such as HIV or mental health disorders, may avoid using eHealth platforms if they fear that others in the household can view their health data [19].

Training and support are limited in rural areas. Few local centers exist to offer digital health literacy workshops or device onboarding sessions. Where initiatives are launched, they are often grant-dependent and time-limited, failing to sustain long-term engagement [20].

It's not simply a matter of putting devices in hands; the devices must be reliable, contextually appropriate, and accompanied by education and support. Public-private partnerships could fill this gap by subsidizing devices and designing culturally relevant onboarding processes tailored for rural populations.

As illustrated in Table 1, regions with lower device ownership also tend to experience reduced uptake of telehealth services and e-prescriptions, reinforcing the need for more inclusive device distribution and user-centric design strategies in chronic disease eHealth programs [15].

3.3. Policy and Regulatory Fragmentation

Even when infrastructure and device-related challenges are addressed, a significant barrier persists in the form of fragmented policy and regulatory frameworks. The deployment of eHealth in rural settings is governed by a patchwork of federal, state, and local regulations, many of which conflict or lack specificity [21].

Licensing requirements, for instance, vary widely between states. A telemedicine provider licensed in one state may be unable to serve a rural patient in another, despite both being within the same health system. This restricts provider availability in regions already facing workforce shortages [22].

Reimbursement structures are equally inconsistent. Some state Medicaid programs reimburse telehealth services at parity with in-person care, while others impose limitations based on originating site or provider type. This uncertainty discourages providers from investing in telehealth infrastructure for rural outreach [23].

Data governance poses another critical concern. With varying interpretations of HIPAA compliance for cloud-based health data, providers remain cautious about deploying digital tools that store or transmit patient information even when such tools could enhance chronic disease self-management in isolated communities [24].

Additionally, broadband funding mechanisms are often siloed. While agencies like the USDA and FCC offer grants for rural internet expansion, their criteria and application processes rarely align with health sector needs. As a result, health-focused digital initiatives must navigate telecom-driven funding streams that may not prioritize clinical utility or population health outcomes [25].

The policy gap is further widened by the absence of rural-specific eHealth legislation. Most digital health frameworks are written with urban pilot programs in mind, overlooking the logistical, demographic, and cultural nuances of rural implementation. This top-down approach leads to mismatched expectations and ineffective rollout strategies [26].

To remedy this, integrative policy frameworks are needed ones that align licensure, reimbursement, broadband deployment, and health data protections under a unified rural eHealth strategy. This would streamline provider engagement, ensure sustained funding, and protect patient rights without imposing undue burdens.

As shown in Table 1, states with more cohesive digital health policies not only demonstrate higher rural telehealth adoption but also report improved chronic disease outcomes, including medication adherence and reduced emergency department visits [15]. Regulatory coherence is therefore not merely a governance issue it is a determinant of public health equity.

4. Digital literacy and engagement in chronic disease management

4.1. Health Literacy vs. Digital Health Literacy in Rural Populations

Health literacy has long been recognized as a critical determinant in managing chronic illness, particularly in rural populations where formal healthcare access is limited. However, digital health literacy represents an additional layer of complexity, encompassing the ability to find, evaluate, and use digital health resources effectively [16]. In rural settings, where paper-based interactions and oral communication have traditionally dominated, the shift to eHealth tools presents new challenges.

Many rural residents with adequate general health knowledge find themselves struggling to operate patient portals, decipher telehealth instructions, or differentiate credible sources from misinformation online [17]. This discrepancy between traditional and digital health literacy limits their capacity to engage in digitally mediated chronic disease management, such as remote monitoring for diabetes or app-based medication adherence tools.

Digital health literacy also intersects with other factors like age, education level, and trust in technology. Older adults, who make up a significant portion of rural patients with chronic illness, may lack confidence navigating virtual environments [18]. In addition, many eHealth interfaces are not designed with limited digital fluency in mind, which can further alienate these users.

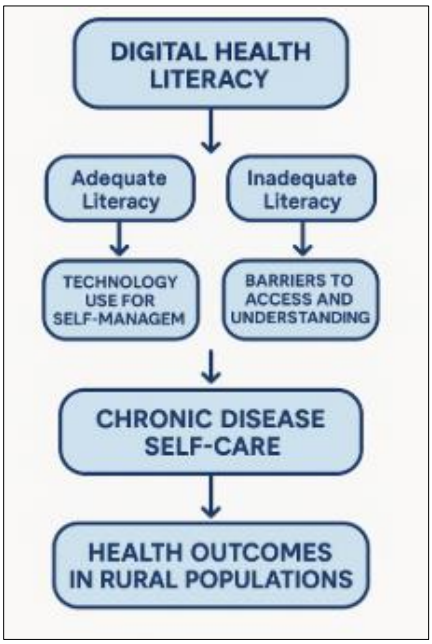

Figure 2 Illustrates the pathways through which digital health literacy or its absence affects chronic disease self-care in rural environments. Bridging the digital literacy gap requires not only technical training but also culturally responsive education that aligns with rural learning preferences and values

4.2. Caregiver Roles and Patient Self-Management Barriers

Chronic disease management in rural households often relies heavily on informal caregivers, such as spouses, children, or neighbors. These caregivers are central to medication administration, appointment coordination, and lifestyle monitoring. However, the integration of eHealth technologies complicates their roles. Not all caregivers have the necessary digital skills to operate health platforms, set up virtual visits, or interpret digital health records [19].

Moreover, caregiver burden in rural areas is intensified by geographic isolation, limited professional support, and inadequate transportation networks [20]. When eHealth solutions assume a level of caregiver tech fluency that doesn't exist, the result is further stress and decreased adherence to digital intervention plans. Caregivers may avoid using the tools altogether or default to manual, less efficient systems.

Another layer of complexity arises from the patients themselves. Many rural residents with chronic illnesses prefer face-to-face care, viewing digital tools as impersonal or unreliable [21]. Self-management activities such as digital journaling

of blood pressure or virtual goal tracking are often dismissed due to lack of familiarity or skepticism. Additionally, patients with physical or cognitive limitations common in long-term chronic conditions may find it difficult to independently use even basic eHealth functionalities.

Privacy is another barrier. In tightly knit rural communities, both patients and caregivers often express concern that digital systems might expose their health conditions, especially when shared devices or communal internet are involved [22].

Overcoming these barriers requires a redesign of eHealth interventions to include caregivers as co-users, offering dual-user modes, shared dashboards, and simplified controls. Education programs must also extend beyond the patient to equip caregivers with both technical and relational competencies necessary for digital co-management.

4.3. Behavioral and Cultural Factors Affecting Engagement

Behavioral and cultural dimensions profoundly influence the uptake of eHealth tools in rural populations. Personal health beliefs, perceptions of technology, and trust in remote care all play roles in whether a patient will engage with digital health platforms [23]. For instance, rural residents with high self-reliance often perceive chronic illness as something to be managed privately, without external technological intrusion.

Cultural narratives in many rural areas valorize traditional medicine, local knowledge, and in-person provider relationships [24]. These beliefs can lead to resistance against remote monitoring devices or app-based reminders, seen as intrusive or inconsistent with their understanding of health and wellness. Mistrust of digital systems especially among older or less educated users is also exacerbated by fears of data breaches or government surveillance.

Behavioral economics also suggests that the perceived effort to learn new technology, weighed against uncertain health benefits, deters many potential users [25]. This is especially true when eHealth interventions fail to demonstrate immediate or visible improvements. Unlike a clinic visit that ends with a prescription or tangible advice, digital systems often rely on long-term engagement for incremental gains.

Social stigma further complicates adoption. In small communities, individuals fear being judged for using mental health apps or seeking help for chronic pain digitally, especially when others may notice shared devices or overhear virtual consultations [26].

Finally, language and communication styles influence usability. Many platforms use clinical or technical jargon that alienates users accustomed to conversational explanations. Others overlook dialects or regional expressions that would make the interface more approachable.

Addressing these behavioral and cultural challenges means designing eHealth platforms with community input, using familiar symbols, narratives, and feedback loops. It also requires strategic deployment of community health workers who serve as cultural brokers, translating the value and usage of digital tools into terms that resonate with local experiences.

Figure 2 encapsulates how behavioral and cultural factors intersect with digital literacy to influence overall engagement in chronic disease self-care among rural populations.

5. Evidence-based models and community-driven solutions

5.1. mHealth Applications in Hypertension, Diabetes, and COPD

Mobile health (mHealth) technologies have steadily emerged as practical solutions in managing chronic conditions such as hypertension, diabetes, and chronic obstructive pulmonary disease (COPD) in rural communities. By leveraging smartphone-based tools, wearable devices, and SMS reminders, patients are better equipped to monitor vital signs and medication adherence at home [21]. In hypertension management, blood pressure tracking apps integrated with Bluetooth-enabled cuffs have demonstrated significant promise in maintaining patient compliance and reducing emergency visits [22].

In diabetes care, continuous glucose monitors (CGMs) paired with mobile interfaces have improved glycemic control, particularly when combined with personalized feedback and nurse call-in systems [23]. A rural pilot in a southern U.S. state observed a 0.9% drop in HbA1c levels over six months using such tools [24]. For COPD patients, mobile spirometry

tools and daily symptom check-ins have shown success in preempting exacerbation events, thereby reducing hospital readmissions [25].

Despite these successes, adoption remains uneven. Device compatibility issues, insufficient digital training, and a lack of multilingual content have stifled scalability in many rural counties [26]. Table 2 presents a summary of rural pilot mHealth interventions and associated clinical outcomes. The evidence shows a need for localized app design and cross-sector training initiatives to maximize patient retention and disease control.

Table 2 Summary of Rural Pilot Projects with Demonstrated Chronic Care Improvements

Project Name	Location	Target Condition(s)	Intervention Type	Key Outcome(s)	Duration
HeartLink Telemonitoring Program	Arkansas Delta Counties	Hypertension, Heart Failure	Home BP devices + Nurse Call Center	18% reduction in ER visits; 11 mmHg avg. BP reduction	12 months
mDiabetes Appalachia	Eastern Kentucky	Type 2 Diabetes	SMS-based self-management + CHW facilitation	0.9% average HbA1c reduction; 20% increase in appointment adherence	9 months
COPD Navigator	Rural New Mexico	COPD	Remote spirometry + Tablet-based check-ins	25% reduction in hospital readmissions	6 months
Digital Wellness for Natives	Tribal Lands in Arizona	Diabetes, Obesity	Wearables + Nutrition App + Tribal Nurse Coaching	2 kg avg. weight loss; HbA1c improvements in 70% of users	10 months
South Plains eCare	West Texas	Multi-chronic (DM, HTN, CHF)	Telehealth via FQHC hubs + EHR integration	Improved medication adherence (by 32%); reduced costs by $1,400 per patient	15 months

Abbreviations: CHW: Community Health Worker; FQHC: Federally Qualified Health Center; DM: Diabetes Mellitus; HTN: Hypertension; CHF: Congestive Heart Failure

5.2. Community Health Worker-Facilitated Telehealth

Community health workers (CHWs) serve as a critical bridge between underserved populations and healthcare systems. In rural chronic disease management, their roles are expanding to include telehealth facilitation, digital navigation, and remote monitoring coordination [27]. When trained to operate teleconsultation platforms, CHWs increase access to timely physician input while helping patients interpret digital care plans [28].

In one Midwest case, a CHW-led telehealth initiative saw an 18% increase in follow-up adherence among diabetic patients over a three-month span [29]. CHWs used tablets to connect patients with endocrinologists, reducing travel burdens and minimizing appointment gaps. Figure 3 illustrates a community-based digital care delivery loop facilitated by CHWs, reinforcing trust and continuity.

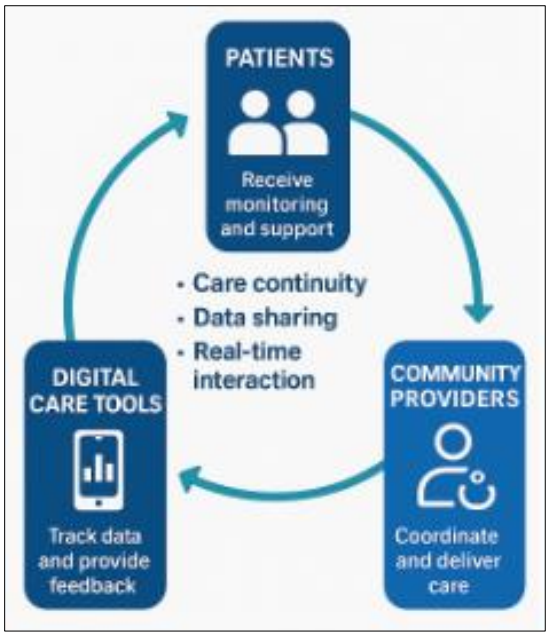

Figure 3 Community-based digital care delivery loop for chronic illness

The inclusion of culturally embedded care mediators also addresses social determinants like language barriers and technology skepticism [30]. For instance, in Hispanic communities, CHWs equipped with mobile translation apps and symptom-tracking tools created customized education paths, improving chronic disease literacy [31].

Challenges remain in funding, workforce standardization, and policy recognition of CHWs' digital roles. Nevertheless, early evaluations suggest this approach can integrate seamlessly with remote patient monitoring systems and reduce avoidable hospitalizations in areas with sparse clinical infrastructure [32].

5.3. Federally Qualified Health Centers and Rural Clinics as Digital Hubs

Federally Qualified Health Centers (FQHCs) and rural clinics have long served as critical lifelines in health-vulnerable geographies. Recently, these entities are being repositioned as digital hubs to facilitate comprehensive chronic care through telemedicine, data analytics, and remote diagnostics [33]. By embedding electronic health records (EHRs) with telehealth portals, many FQHCs now offer integrated scheduling, lab result access, and specialist consultation without requiring physical travel [34].

A strong example can be found in a multi-county initiative where three FQHCs implemented cloud-based EHRs synced with regional hospital networks. This led to a 27% increase in chronic care coordination scores, and a 15% decline in hospital readmissions over 12 months [35]. Through strategic bandwidth expansion grants, these facilities created digital kiosks for community members without home internet, enabling participation in virtual check-ups and medication counseling [36].

While infrastructure is one pillar, staffing models are another. Many rural clinics now train nurse practitioners and physician assistants in eHealth triage protocols, allowing them to conduct telehealth screenings and pre-assessment for chronic diseases [37]. These workflows, coupled with AI-supported diagnostic decision tools, enhance throughput and relieve specialist bottlenecks.

However, barriers persist. Outdated hardware, intermittent broadband, and limited IT personnel hinder some clinics' ability to scale digital functions [38]. Furthermore, inconsistent Medicaid reimbursement structures deter full adoption of telemonitoring services. Policy shifts toward value-based care and broadband equity are necessary to sustain these emerging digital models [39].

Importantly, partnerships between academic health systems and rural FQHCs have seeded innovation hubs where research on chronic illness outcomes is now being conducted using real-world data. Such collaborations ensure that rural populations contribute to national digital health research and benefit from precision medicine applications [40].

Ultimately, positioning FQHCs and rural clinics as digitally mature care hubs not only enhances chronic disease outcomes but also redefines healthcare delivery equity. It lays the groundwork for a more resilient and adaptive health system in underserved regions, capable of weathering future public health crises and resource constraints.

6. Policy and funding mechanisms supporting rural ehealth expansion

6.1. Federal and State-Level Reimbursement Trends

Reimbursement policies have historically shaped the pace and direction of eHealth adoption in rural settings. At the federal level, Medicare's early telehealth provisions were largely restrictive, limiting coverage to rural Health Professional Shortage Areas (HPSAs) and requiring patients to be physically present at approved originating sites [25]. These regulations curtailed the flexibility of virtual care models, even when technical feasibility was established. State Medicaid programs, however, showed more variability, with some states pioneering bundled payments and care coordination incentives that included telehealth components [26].

Several states began adopting payment parity laws, which mandated insurers reimburse telehealth encounters at the same rate as in-person visits. This move significantly enhanced the financial viability of remote chronic disease management services in underserved rural zones [27]. Nevertheless, such parity laws were often limited to private insurers, excluding dual-eligible or Medicaid-only populations those most affected by chronic conditions.

The lack of standardization in reimbursement structures created a disincentive for smaller rural clinics to invest in telehealth infrastructure. In states without progressive Medicaid reimbursement models, providers had to rely on grant funding or philanthropic support to initiate virtual care services [28]. Without sustainable policy backing, these programs often faltered once initial funds were exhausted, highlighting the urgent need for aligned reimbursement frameworks that prioritize preventive digital care in resource-constrained geographies.

6.2. Medicaid Waivers, HRSA Initiatives, and Broadband Grants

Beyond conventional reimbursement policies, targeted federal and state initiatives played a key role in bridging the digital health divide in rural America. Medicaid Section 1115 waivers, for instance, allowed some states to pilot innovative care delivery models that included digital patient engagement tools, remote monitoring devices, and mobile health worker platforms [29]. These waivers gave states the flexibility to use federal funds for non-traditional services that improved chronic disease management outcomes.

The Health Resources and Services Administration (HRSA) emerged as a central actor in enabling rural eHealth equity. HRSA's Office for the Advancement of Telehealth funded several Telehealth Network Grant Programs (TNGPs), which supported collaborations between urban academic centers and rural safety-net providers [30]. These projects helped rural health centers integrate eConsults, teleradiology, and telepsychiatry services, particularly for chronic conditions like diabetes and hypertension.

Concurrently, the Federal Communications Commission's (FCC) Rural Health Care Program and the U.S. Department of Agriculture's Distance Learning and Telemedicine Grants supported broadband expansion projects and technology procurement in hard-to-reach communities [31]. Several rural counties in the Midwest and Appalachian regions used these grants to establish high-capacity broadband corridors connecting FQHCs, community health centers, and local schools [32].

Table 3 Overview of Policy Levers Enabling Rural Digital Health Infrastructure

Policy Lever	Administering Body	Mechanism of Support	Impact on Rural eHealth Infrastructure	Example Use Cases
FCC Rural Health Care Program	Federal Communications Commission (FCC)	Broadband subsidies to eligible healthcare providers	Enables discounted connectivity for rural clinics and hospitals	Broadband upgrades at Critical Access Hospitals
Medicaid 1115 Waivers	State Medicaid Agencies + CMS	Flexible funding for telehealth pilots and access equity	Funds pilot programs integrating telehealth into Medicaid delivery	mHealth pilots for diabetes management in remote counties
HRSA Telehealth Network Grant Program (TNGP)	Health Resources and Services Administration	Competitive grants for network expansion	Supports infrastructure for telemedicine hubs and training	Establishment of CHW-led telehealth units in tribal lands
USDA Distance Learning and Telemedicine (DLT) Grant	U.S. Department of Agriculture (USDA)	Equipment and telecommunication support	Provides telehealth carts, endpoint devices, and connectivity gear	Rural school-based asthma telemedicine programs
State Broadband Expansion Acts	State Legislatures (e.g., NC, MI, MO)	Infrastructure investments and rural broadband incentives	Expands last-mile coverage necessary for home-based eHealth tools	Fiber optic installation in rural Appalachia
CMS Chronic Care Remote Monitoring Reimbursement	Centers for Medicare and Medicaid Services	CPT codes for remote patient monitoring (RPM)	Encourages adoption of home-based monitoring devices in Medicare users	RPM for COPD patients using Bluetooth oximeters

Table 3 summarizes the key policy tools Medicaid waivers, HRSA telehealth grants, and federal broadband programs that underpinned rural digital health transformation. It demonstrates how overlapping programs worked in tandem to address both connectivity and care delivery gaps.

Despite these advances, coordination between agencies remained inconsistent. States often lacked centralized eHealth strategy offices, leading to fragmented implementation and missed synergies between broadband and health service funding streams [33]. Moving forward, more cohesive governance mechanisms and inter-agency task forces could amplify the impact of these funding programs while avoiding duplicative or underutilized investments.

6.3. Sustainability Challenges and Stakeholder Roles

While policy momentum and grant-driven experimentation helped launch numerous rural digital health programs, sustaining these initiatives beyond pilot phases remains a formidable challenge. A key issue lies in the misalignment between operational costs and ongoing reimbursement streams. For instance, broadband connectivity fees, device maintenance, and platform subscriptions are rarely reimbursable under existing Medicaid or Medicare models [34]. This financial disconnect forces rural clinics to seek alternative funding or scale down digital services.

Another obstacle involves workforce sustainability. Rural providers already face staffing shortages, and asking clinicians or nurses to adopt new digital workflows without compensatory training time leads to resistance or suboptimal use of tools [35]. Clinical champions, often central to the success of pilot programs, risk burnout without institutional support or long-term career pathways that recognize their dual digital-clinical roles.

Stakeholders including local governments, academic institutions, nonprofit foundations, and telecommunication providers have increasingly played collaborative roles in addressing these gaps. Some counties have developed public-private consortia to pool broadband investments, while rural hospitals have entered value-based care networks that

incentivize digital integration [36]. Faith-based organizations and cooperative extension networks have also contributed by embedding digital literacy training into their community outreach programs [37].

Ultimately, achieving eHealth equity in chronic disease management will require a multi-sector commitment to infrastructure, funding, and training. Without such coordination, even the most innovative technologies will fail to deliver sustainable benefits to the populations that need them most. Stakeholders must ensure that digital inclusion becomes a core metric of rural healthcare performance, not a peripheral aspiration, to create lasting systemic change [38].

7. Data-driven evaluation and real-world impact

7.1. Metrics for Success in Chronic Disease Digital Interventions

Effective evaluation of digital interventions for chronic disease management in rural settings necessitates multidimensional metrics that go beyond clinical endpoints. While traditional metrics such as HbA1c reduction for diabetes, systolic pressure improvement for hypertension, or FEV1 stabilization for COPD remain essential, digital health requires additional benchmarks to reflect system-level transformation [29].

Patient engagement indicators, including mobile app usage frequency, adherence to self-monitoring protocols, and virtual visit completion rates, have been increasingly used as proxies for intervention efficacy. However, these behavioral metrics must be contextualized within the limitations of digital access and literacy specific to rural populations [30]. Without this context, poor app engagement may be misinterpreted as program failure rather than symptomatic of underlying structural inequities.

Moreover, outcome attribution remains complex in multicomponent interventions involving wearable devices, remote coaching, and medication management. Logic models and theory-driven frameworks such as RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) have been proposed to untangle these dimensions and facilitate cross-site comparison [31].

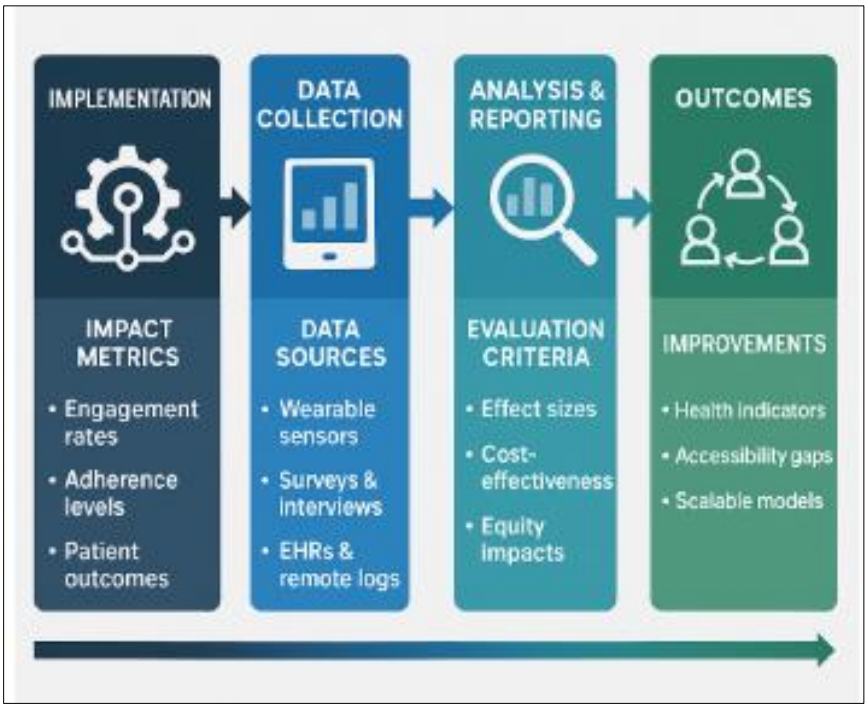

Figure 4 Evaluation pipeline for rural digital health interventions

Figure 4 provides a visualization of the data flow from digital health tools to outcome indicators, emphasizing the interaction between patient inputs, provider interventions, and system-level outputs. This pipeline highlights the importance of interoperability and the need for standardized rural health metrics aligned with digital delivery platforms [32].

7.2. Ethical Considerations in Rural Data Collection

Deploying digital health tools in underserved rural environments raises complex ethical issues related to informed consent, data privacy, algorithmic fairness, and power asymmetries. Digital health interventions often collect granular data on behavior, location, and biometric markers, which may be sensitive when combined with demographic and socio-economic identifiers typical of rural populations [33].

Many community members may not fully understand how their data will be stored, shared, or analyzed especially when third-party vendors or proprietary platforms are involved. Low digital literacy exacerbates the risk of unintentional consent or misunderstandings regarding privacy terms [34]. Therefore, ethically sound programs must embed culturally and linguistically appropriate consent protocols and maintain transparency throughout the data lifecycle.

The risk of data misuse also increases in tight-knit rural areas where anonymity is harder to preserve. Small sample sizes may inadvertently enable identification through triangulation, especially in rare disease or tribal health datasets [35]. Additionally, public-private partnerships, while essential for resource mobilization, complicate data governance, requiring robust policies for role clarity, ownership, and secondary use of health data.

Another concern lies in bias propagation through algorithmic tools trained on urban or general datasets. Without specific calibration to rural sociocultural and epidemiological contexts, predictive models may underperform or produce skewed outputs that misguide clinical decisions [36]. Ethical implementation thus demands both technical and participatory safeguards to ensure equitable and respectful data use.

Community advisory boards, especially those inclusive of patients, caregivers, and local leaders, have emerged as effective mechanisms to align intervention goals with community norms and to vet data collection strategies [37]. Ethics review processes must evolve to reflect the decentralized, real-time nature of digital health while still protecting vulnerable populations from exploitation or oversight.

7.3. Scalability and Replicability Frameworks

Despite promising results from rural pilot studies, scaling digital chronic care interventions across diverse geographies remains a major challenge. Scalability depends not only on technology transfer but also on contextual adaptability factoring in workforce readiness, reimbursement compatibility, and sociotechnical infrastructure [38].

Programs that thrived in one rural setting often struggled in others due to differences in clinic workflows, linguistic diversity, or community trust levels. For example, a successful COPD monitoring app in a mining town may fail in an agrarian region without local cultural adaptation [39]. Thus, replicability requires frameworks that emphasize core components while allowing peripheral customization.

The World Health Organization's mERA (mHealth Evaluation, Reporting, and Assessment) checklist and the NIH's ORBIT (Obesity-Related Behavioral Intervention Trials) model offers structured guidance to support both scale-up and documentation [40]. These tools underscore the importance of pilot feasibility, system integration, user-centered design, and long-term sustainability.

Financial sustainability remains central to any scalability framework. Beyond initial grant funding, programs must secure aligned reimbursement mechanisms, such as bundled payments for remote monitoring or value-based incentives tied to digital adherence metrics. Clinics must also invest in durable partnerships with local telecoms, academic institutions, and public health departments to ensure continuity [41].

Moreover, cross-sector learning collaboratives have been instrumental in supporting scale-up by creating knowledge exchange platforms where rural clinics, public agencies, and tech developers co-develop scalable prototypes. These collaboratives not only accelerate iteration cycles but also reduce reinvention by adapting proven tools to new contexts with minimal friction [42].

The success of rural digital health expansion ultimately hinges on structured flexibility: a balance between fidelity to evidence-based design and responsiveness to localized needs. Scalable models must be replicable not because they rigidly prescribe technology, but because they prioritize equity, usability, and contextual appropriateness across diverse rural landscapes.

8. The future of chronic disease management and digital inclusion

8.1. Integrating AI and Predictive Analytics for Rural Care

The integration of artificial intelligence (AI) and predictive analytics into rural healthcare offers an unprecedented opportunity to transform chronic disease management through anticipatory care models. These tools can enhance early detection of symptom exacerbations, optimize medication adherence, and support personalized interventions based on real-time data patterns [33].

In rural settings, AI applications such as risk stratification algorithms and anomaly detection engines are particularly impactful where physician shortages limit continuous surveillance. When coupled with mobile health (mHealth) platforms, AI models trained on local biometric and behavioral data can deliver alerts to both patients and providers, initiating proactive care decisions [34].

Despite the potential, implementation barriers include lack of localized data to train AI systems effectively. Models built on urban datasets may not capture the environmental or genetic nuances of rural populations, leading to biased predictions [35]. Addressing this requires inclusive data practices and community-led validation of algorithms prior to deployment.

Collaborative projects between regional academic centers and rural clinics have shown promise in adapting predictive tools to fit the cadence of small practices. In one initiative, AI-enabled dashboards accurately forecasted blood glucose deviations, prompting remote coaching interventions and reducing diabetes-related emergency visits by 22% over six months [36].

The inclusion of AI does not imply replacing clinicians but rather augmenting their decision-making in resource-limited environments. When ethically designed and contextually adapted, predictive analytics can redistribute cognitive load, prevent adverse outcomes, and enhance system responsiveness especially where episodic care is the norm.

8.2. Personalized Medicine and Remote Monitoring Technologies

The trajectory toward precision health is shaped by the adoption of personalized medicine frameworks that utilize genomic, behavioral, and environmental data to tailor interventions. While often associated with urban specialty care, personalized medicine is increasingly viable in rural settings through remote monitoring technologies [37].

Wearables and smart sensors now capture continuous streams of physiological metrics such as heart rate variability, oxygen saturation, and sleep cycles enabling a shift from reactive to preventive care. These devices, when integrated into digital platforms, support automated triage systems and personalized coaching programs tailored to chronic disease profiles [38].

One example includes remote cardiac monitors embedded in wearable patches that wirelessly transmit electrocardiogram data to centralized platforms. In rural elderly populations, such systems have flagged early arrhythmic episodes, allowing for timely intervention before hospitalization [39]. Moreover, algorithm-based dose adjustments and behavior-modification prompts sent via SMS have shown improved medication compliance in hard-to-reach populations.

Challenges remain regarding device affordability, connectivity, and literacy. However, rural clinics participating in technology access programs have begun to distribute simplified wearable kits bundled with pictorial user guides and community tech navigators, closing some of these gaps [40].

Ultimately, personalized medicine in rural contexts hinges on leveraging low-cost tools to create highly individualized pathways where monitoring is ambient, guidance is context-aware, and interventions are dynamically adjusted to the evolving needs of each patient.

8.3. Vision for Universal eHealth Equity

Realizing universal eHealth equity demands a holistic reimagining of digital health infrastructure, governance, and culture moving beyond project-based innovation toward systemic transformation. This vision must encompass connectivity, literacy, trust, interoperability, and sustained investment, particularly for rural and underserved populations [41].

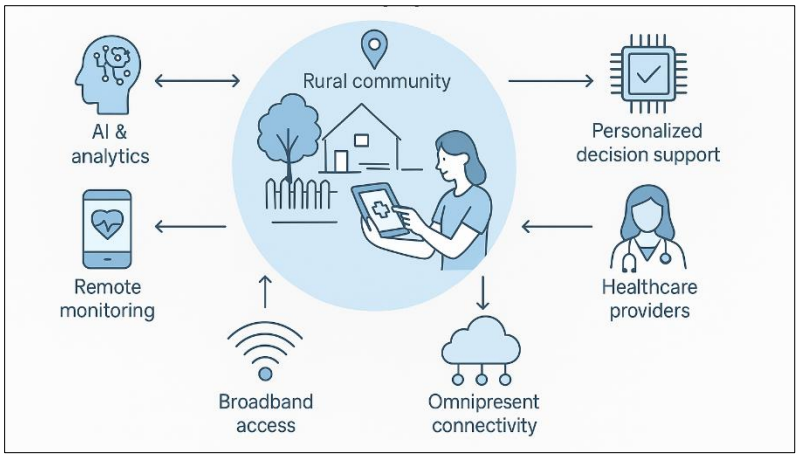

Figure 5 Future-ready eHealth ecosystem architecture for underserved populations

Figure 5 illustrates a federated architecture that integrates AI-driven triage engines, cloud-based EHR systems, and decentralized patient data vaults, all accessible via interoperable platforms tailored to low-resource contexts. In this framework, patients act as co-stewards of their health data, empowered through secure mobile interfaces and community intermediaries.

To support such systems, workforce development must be prioritized. This includes training rural clinicians in digital tool usage, embedding telehealth curricula in medical education, and recruiting local digital health navigators. Policy frameworks must align incentives across federal, state, and payer systems to ensure reimbursement parity and infrastructure sustainability [42].

Equity also means inclusivity by design. This implies participatory approaches to technology development, multilingual interfaces, accessibility accommodations for people with disabilities, and intentional outreach to marginalized groups. The goal is not to digitize existing disparities, but to dismantle them.

In a fully realized model of eHealth equity, rural residents manage chronic illness through seamless interfaces, timely support, and integrated care pathways bridging geographic isolation with digital connectivity and human-centered design. The path forward requires not only innovation but shared commitment across disciplines, sectors, and communities.

9. Conclusion and call to action

9.1. Key Insights and Thematic Reflections

This paper has unpacked the layered dynamics of digital health equity in the context of chronic disease management in rural populations. One of the most salient insights is the way infrastructural and digital disparities remain entrenched along geographic and socio-economic lines. Despite increased public discourse around eHealth access, broadband coverage gaps and device limitations continue to shape the landscape of who can benefit from digital interventions and who cannot.

Another core theme is the intersection of digital literacy and health literacy. Possessing a connected device is insufficient in the absence of skills to navigate applications, interpret biometric feedback, or make informed decisions from data visualizations. Rural populations especially older adults, those with lower education levels, and those from linguistically diverse backgrounds face disproportionate burdens in adapting to digital-first healthcare models.

This review also highlighted the vital role of community intermediaries in bridging systemic gaps. From community health workers to local educators and telehealth facilitators, these actors play a critical role in transforming digital health tools from abstract technologies into practical, life-improving assets for rural patients. Their integration into intervention design and implementation reflects a shift from top-down to co-produced care.

Additionally, the findings reflect a deeper transition in care delivery paradigms. Digital health tools are moving care away from centralized facilities toward homes, farms, and community centers places where chronic illness unfolds in

everyday life. This spatial redistribution of care has implications for how health systems train personnel, allocate resources, and engage with local environments.

Ultimately, eHealth equity is not merely about technological deployment; it is about rethinking relationships between people and information, institutions and communities, and chronic disease and self-efficacy.

9.2. Policy, Practice, and Research Recommendations

From a policy standpoint, addressing rural eHealth equity requires permanent investment beyond emergency relief measures. Broadband expansion must be framed not just as economic development but as a public health imperative. Policymakers should consider subsidies or incentives for rural households to acquire not only connectivity but also essential medical-grade devices for monitoring chronic conditions.

Insurance coverage for telehealth, mHealth, and remote patient monitoring should be stabilized and standardized across states. Fragmentation in reimbursement policies discourages innovation and continuity in care delivery. Similarly, licensing reciprocity across states can ease provider shortages in remote areas, enabling cross-state teleconsultations and better access to specialized care.

On the practice front, health systems and clinics must embrace community-led design processes. Engaging patients and caregivers in the selection, testing, and rollout of digital tools ensures greater trust and cultural fit. Training modules should be tailored to different literacy levels and offered through trusted local channels. Multilingual content and non-text-based interfaces (e.g., pictograms, voice prompts) can be especially impactful in low-literacy settings.

Health professionals in rural areas should be provided ongoing training in digital tool usage not just technical operation but also ethical handling of data, remote communication skills, and patient coaching techniques. Clinics can adopt hybrid care models that blend telehealth with in-person visits to maximize reach while preserving relational aspects of care.

In terms of research, there is a need for more longitudinal studies evaluating digital health interventions in rural populations over time. Pilot studies are plentiful, but few examine long-term adherence, sustained behavior change, or downstream cost-effectiveness. Moreover, equity-focused research should disaggregate outcomes by race, gender, income, language, and geography to uncover intersectional vulnerabilities and successes.

Future research must also explore how emerging technologies like AI, blockchain, and ambient sensors can be harnessed in rural contexts in ways that are ethical, equitable, and scalable. Co-design with rural residents, ongoing feedback loops, and rigorous evaluation protocols must become standard in rural digital health scholarship.

9.3. Toward Equitable Digital Chronic Care: Final Thoughts

The evolving digital health landscape offers both promise and peril. While technology has the potential to revolutionize chronic care in underserved rural areas, it can also reproduce or even widen existing disparities if not designed inclusively and equitably. This paper has emphasized that the road to eHealth equity is not paved solely with infrastructure and innovation it is navigated through empathy, co-creation, and sustained attention to context.

Equity must be treated as a design principle, not a retrospective adjustment. From the earliest stages of policy formation and technology development, the needs of rural communities must be front and center not peripheral or assumed. Strategies must accommodate constraints, respect local knowledge systems, and build long-term capacity rather than deliver short-lived fixes.

True transformation will come not from technological determinism, but from partnerships that embed digital tools into meaningful human relationships relationships built on trust, accessibility, and shared responsibility for health. As chronic diseases continue to shape the lives of millions, the vision for a digitally connected, health-literate, and empowered rural America must guide future investments and collaborations.

The future of rural chronic care need not be isolated. With intention, inclusion, and interdisciplinary commitment, it can be digitally connected, community-rooted, and fundamentally just.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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