Journal of Rural and Regional Innovation Studies

E-ISSN: XXXX-XXXX | P-ISSN: XXXX-XXXXX
JORRIS, Vol. 2 (1), 2026 (1-37)
https://journal.unesa.ac.id/index.php/jorris

Digital Health 5.0 for Health Equity in Rural Developing Regions: A Bibliometric and Systematic Review

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Keywords:
Digital Health 5.0, rural healthcare, health equity, telemedicine, developing countries

***To cite*:**
Alfarizi, M., Ngatindriatun2., (2026). Digital Health 5.0 for Health Equity in Rural Developing Regions: A Bibliometric and Systematic Review. *Journal of Rural and Regional Studies.* 2 (1) 1-37

Abstract

Healthcare access inequality in rural communities of developing countries remains a persistent challenge due to limited infrastructure, shortages of medical personnel, and inadequate supply chains. This study investigates the potential of Digital Health 5.0 as a transformative framework to bridge such disparities by emphasizing human-centered, inclusive, and adaptive healthcare solutions. The research employs an integrative approach that combines bibliometric analysis using Biblioshiny and VOSviewer with a systematic literature review (PRISMA guidelines), focusing on publications from 2019–2025 indexed in Scopus. The analysis reveals significant growth in scholarship, highlighting six major thematic clusters: maternal health literacy, telehealth adoption during COVID-19, health policy and financing frameworks, digital literacy and patient engagement, socioeconomic inclusion strategies, and emerging technologies such as AI, IoT, blockchain, and telemedicine. Results show that Digital Health 5.0 can improve diagnostic accuracy, expand service delivery, and foster patient participation, while challenges persist in digital infrastructure, gender gaps, and socio-cultural acceptance. The findings underscore that sustainable implementation requires multi-sectoral governance, financing integration into national health strategies, and culturally sensitive service design. This study provides a conceptual framework and practical recommendations for policymakers, healthcare providers, and technology developers to leverage Digital Health 5.0 for equitable, resilient, and sustainable healthcare in rural settings of developing countries.

Introduction

The global healthcare industry is currently undergoing a major digital transformation, transforming how healthcare services are delivered, accessed, and managed. Supported by advances in technologies such as artificial intelligence, big data analytics, the Internet of Things, blockchain, telemedicine, and smart health devices, this transformation aims to improve diagnostic accuracy, optimize treatment decisions, and promote patient-centered, evidence-based care (Nguyen & Voznak, 2024; Stoumpos et al., 2023). The COVID-19 pandemic has accelerated the adoption of these technologies, highlighting the importance of online consultations, remote monitoring, and integrated healthcare systems in maintaining service continuity amidst resource constraints (Q. Wang et al., 2021). Globally, the healthcare information technology market is projected to exceed USD 730 billion by 2029, while eHealth solutions are expected to reach nearly 3 billion users by 2027 (WHO Digital Health and Innovation (DHI), 2020). More than 90% of healthcare professionals report improved performance through digital technologies (Tian et al., 2025)This transformation not only offers efficiencies and cost savings but also strengthens system resilience, universal health coverage, and the achievement of the Sustainable Development Goals.

The transformation of Digital Health 5.0 can be seen as the next phase of development from eHealth, mHealth, and Digital Health 4.0, which previously utilized big data, the Internet of Things, and artificial intelligence in healthcare services (Kim et al., 2023). Unlike previous generations, Digital Health 5.0 emphasizes human-centered service delivery, offering a more personalized, crisis-adaptive approach, and focusing on equitable access. This concept aligns with the Society 5.0 vision, which positions technology as a means of improving the quality of life and global inclusivity (Singh et al., 2025). In the context of sustainable development, Digital Health 5.0 significantly contributes to the achievement of SDG 3 by improving diagnostic accuracy, public health education, and emergency preparedness, supported by humanistic healthcare technology (Levin-Zamir, 2023). Furthermore, by emphasizing equal distribution of services, Digital Health 5.0 also supports the realization of SDG 10, namely reducing disparities, so that healthcare technology is not only enjoyed by certain groups but also reaches vulnerable communities in various regions.(Faggini et al., 2021)

Inequality in access to health care remains a fundamental problem in developing countries, particularly in rural areas. Rural communities often face long distances to health facilities and limited medical infrastructure, making basic services inequitable (Mekonnen et al., 2025; Russell et al., 2025). The WHO estimates that a minimum ratio of 2.5 health workers (doctors, nurses, and midwives) per 1,000 people is necessary to ensure adequate primary care coverage, yet most developing countries have not achieved this standard, with a sharp disparity between urban and rural areas (D. Wang et al., 2024). The shortage of medical personnel is even more critical in remote areas, making recruitment and retention policies for health workers

in rural areas a strategic issue (Lin et al., 2023). Furthermore, limited access to essential medicines adds significant barriers. Supply chain issues, affordability, and weak distribution prevent millions of people from receiving the necessary therapy (Koshta et al., 2024). Low primary care coverage also results in high maternal and infant mortality rates, malnutrition, and lower immunization rates compared to urban areas (Apostolopoulos et al., 2021). These empirical facts and statistical data confirm that infrastructure gaps, shortages of medical personnel, and limited access to pharmaceuticals are the main factors causing health inequality in rural areas of developing countries. Digital Health 5.0 offers a strategic opportunity to address healthcare access gaps in rural communities through the integration of cutting-edge technologies. With this approach, Digital Health 5.0 not only expands accessibility and improves service quality, but also encourages active patient participation and strengthens the sustainability of rural healthcare systems in developing countries.

The implementation of Digital Health 5.0 has been studied across diverse country contexts, highlighting nuances in implementation that depend on local infrastructure and policy capacities. In South Asia—particularly India—research on explainable AI and the application of explainable algorithms highlights opportunities to increase clinician trust in AI systems while addressing regulatory and ethical issues (Gudi et al., 2021). In Southeast Asia, studies in Thailand and Singapore emphasize the use of telemedicine and IoT to strengthen primary care in remote areas, but also highlight barriers such as connectivity and digital literacy (Malarvizhi et al., 2025; Periyasamy et al., 2023). In Sub-Saharan Africa, narrative research and reviews indicate that digital interventions—from mobile apps to teleconsultation platforms—can expand health coverage and financing, but their effectiveness is limited by the distribution of health workers and drug supply chains (Awosiku et al., 2025; Wahbi et al., 2025). Several studies in East (e.g., Kenya) and Western African countries highlight community-based models combining SMS, wearables, and local health worker support to improve maternal and immunization monitoring (Olu et al., 2019). In middle-income countries like Brazil and China, research shows that federated learning and blockchain can preserve data privacy while enabling collaboration across healthcare facilities (Chung et al., 2024; Godinho et al., 2022). Meanwhile, conceptual models for equity-focused implementation, such as DH-EquIR in Uganda and an equity impact assessment framework tested in a case study in Kenya, provide contextual guidance for the development of Digital Health 5.0 in regions with significant infrastructure gaps (Bakibinga et al., 2020; Groom et al., 2024).

Although numerous studies have highlighted the role of digital technology in improving healthcare access, most studies remain fragmented and focused on specific aspects or contexts, such as telemedicine, blockchain, or artificial intelligence in urban areas. No study has systematically and bibliometrically explored the potential of Digital Health 5.0 as a transformational framework for equitable rural healthcare access in developing countries. This gap is significant because rural areas

are the primary locus of global health inequalities, where limited infrastructure, medical personnel, and digital literacy pose multiple challenges. Based on this gap, this study aims to map the current research landscape, identify thematic trends, and examine opportunities and barriers to implementing Digital Health 5.0 in rural areas of developing countries. The study's primary contribution is to provide an integrative conceptual framework, based on global scientific evidence, to support more equitable, inclusive, and sustainable digital health policies and innovations for healthcare access in rural areas of developing countries. Unlike previous reviews on Digital Health 4.0 or telehealth, this study provides an original contribution by offering an integrated bibliometric and conceptual analysis of Digital Health 5.0 specifically in the context of rural healthcare in developing countries. It uniquely synthesizes fragmented evidence across technologies and regions to construct a comprehensive, equity-oriented framework that connects digital transformation with the goals of inclusiveness, sustainability, and resilience in rural health systems.

Methods

This study was designed with an integrative qualitative approach that combines bibliometric and systematic literature review (SLR) methods. This design was chosen to provide a comprehensive mapping of research developments, topic trends, author networks, and thematic interpretations related to the role of Digital Health 5.0 in promoting equitable distribution of health services in rural areas of developing countries. This dual approach allows the study to produce a more comprehensive understanding: bibliometrics serves to view the publication landscape quantitatively, while SLR provides a more in-depth qualitative explanation of the substance of the literature. This review process is guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standard so that each stage of the search, selection, and synthesis of articles is carried out openly, systematically, and can be traced back. PRISMA is an international standard guideline used to ensure that the literature review process is carried out systematically, transparently, and replicably (Rethlefsen & Page, 2022). This approach provides a clear framework for the stages of identification, screening, determining eligibility, and inclusion of articles, thereby minimizing the risk of bias. Compared to other review methods that tend to be more narrative, PRISMA is more appropriate for this research because it is able to select literature in a structured and objective manner, especially when the topic being reviewed is interdisciplinary and involves a large number of publications (Page et al., 2022) Such as in the issue of Digital Health 5.0.

The primary source of literature in this study is the Scopus database. This database was chosen because of its broad cross-disciplinary coverage, rigorous indexing quality, and comprehensive metadata that can be exported into analytical formats. (Mongeon & Paul-Hus, 2016) Scopus is considered representative for interdisciplinary research because, in addition to containing health literature, it also

provides sources from the fields of technology, social sciences, and public policy relevant to Digital Health 5.0 issues. Although other databases, such as Web of Science or PubMed, are also useful, this study focused on Scopus for more consistent analysis. The limitation of using a single database is acknowledged as a potential weakness, but it is considered sufficient to address the objectives of this study.

Search keywords were formulated using Boolean operators (AND, OR) to ensure more comprehensive search results. The keywords were grouped into three main domains. First, the digital health technology domain, encompassing the terms "Digital Health 5.0," "Health 5.0," "Smart healthcare," "eHealth," "mHealth," "Telemedicine," "Artificial Intelligence in Health," and "Digital health transformation." Second, there is equitable access to the health domain, encompassing "Health equity," "Health access," "Universal health coverage," "Health disparity," and "Healthcare inequality." Third, the social context domain, encompassing rural communities in developing countries, encompasses keywords such as "Rural community," "Remote area," "Developing countries," "Low and middle-income countries (LMICs)," and "Rural health services." All keywords were combined in the following formula:

("Digital Health 5.0" OR "Health 5.0" OR "Smart healthcare" OR "eHealth" OR "mHealth" OR "Telemedicine" OR "Artificial Intelligence in Health" OR "Digital health transformation") AND ("Health equity" OR "Health access" OR "Universal health coverage" OR "Health disparity" OR "Healthcare inequality") AND ("Rural communities" OR "Remote areas" OR "Developing countries" OR "Low and middle income countries" OR "Rural health services")

The search was limited to the period 2019–2025. This limitation was chosen because the Digital Health 5.0 paradigm only became globally recognized in the late 2010s, and during the COVID-19 pandemic, the cutoff period for the widespread use of digital health products was considered. Therefore, this period was deemed most relevant for capturing the latest trends. The inclusion criteria were: original articles published between 2019 and 2025, written in English, from peer-reviewed journals, and focused on Digital Health 5.0 issues, equal access to health, or the rural context of developing countries. Articles across fields such as health, technology, public policy, and social sciences were also considered. Conversely, exclusion criteria included articles published before 2018, non-article publications (reviews, editorials, proceedings, book chapters), non-English articles, studies in developed countries not relevant to rural areas/LMICs, and research on digital technology unrelated to health aspects. Articles still in press were also excluded.

The PRISMA process in this study began with the development of a research question and scope, followed by a literature search through the Scopus database, resulting in 6,896 records. After an initial screening phase based on the criteria of field of study, document type, language, source type, publication period (2019–2025), and final publication status, the number of articles was reduced to 3,921. Of these, 2,975

records were excluded, leaving 3,191 articles for the eligibility assessment phase. At this stage, Phase 1: Demographic Filtration was conducted, in which 2,207 articles were eliminated. Next, 984 articles entered Phase 2: Content Filtration and were thoroughly reviewed. Finally, the selected articles were analyzed for content to gain an understanding of the Digital Health 5.0 transformation in the context of equitable access to healthcare in rural communities in developing countries. This process ensured a systematic, transparent, and relevant literature selection.

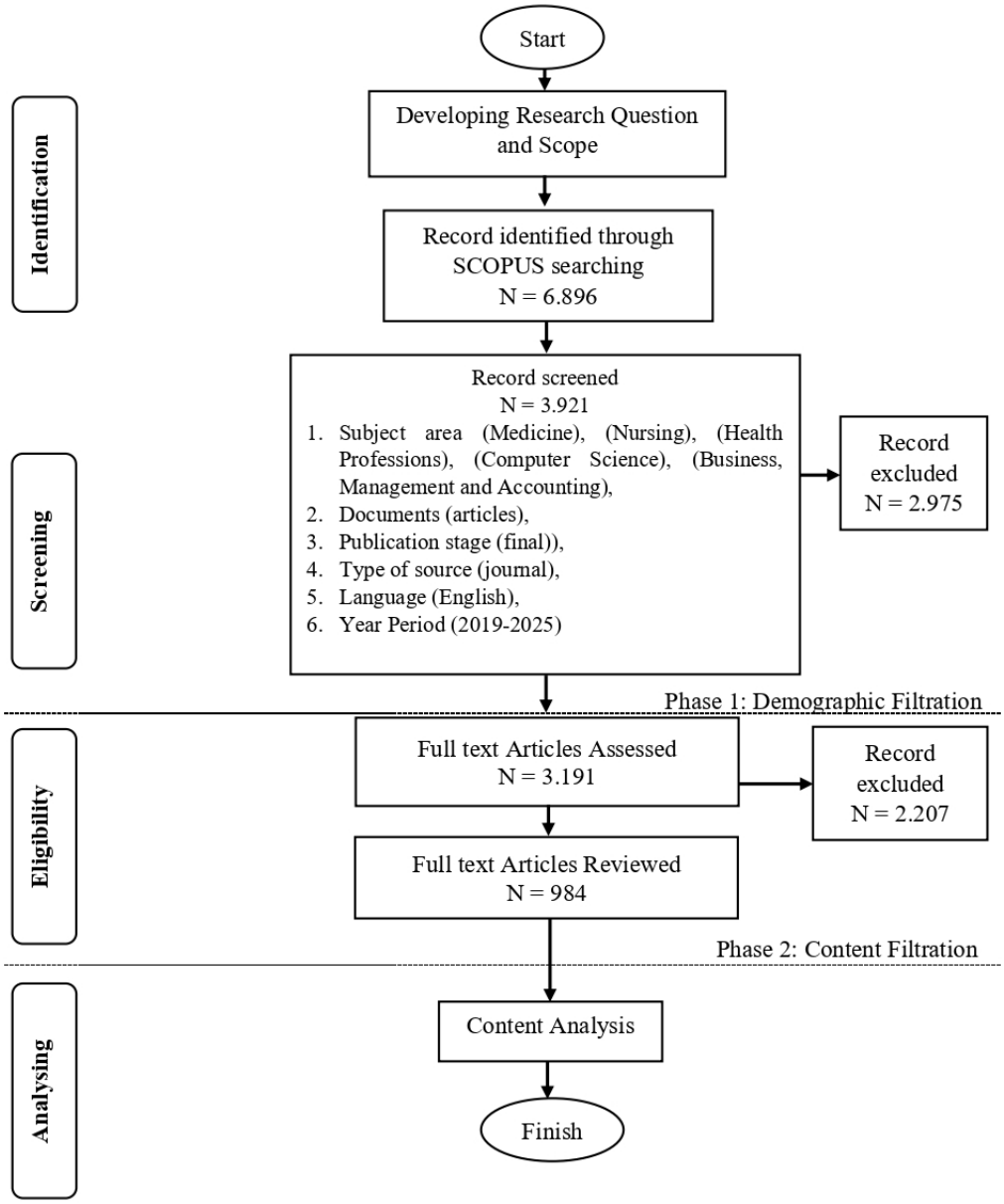

Figure 1. PRISMA Results

After the screening was complete, the analysis was conducted in two stages. First, a bibliometric analysis using Biblioshiny (the Bibliometrix package in R) was conducted to map publication trends, journal distribution, productive authors and institutions, citation counts, and cross-country collaboration networks. (Arruda et al., 2022). The data was then visualized using VOSviewer to construct a map of keyword co-occurrence relationships, citation networks, and thematic clusters that show the direction of research development (Van Eck & Waltman, 2022). Second, a systematic analysis was conducted on articles that passed PRISMA by reading the full text, coding the content, and identifying key themes (Paparini et al., 2021). Some of the thematic focuses reviewed included the types of Digital Health 5.0 technologies implemented, their impact on access disparities, barriers to implementation in rural areas, and recommendations for sustainable policies or strategies in developing countries.

The reliability of the process was maintained by involving two independent researchers in the screening phase, as well as involving a third researcher if there were discrepancies in the assessments. The validity of the results was also strengthened by the use of two different analysis tools (Biblioshiny and VOSviewer), allowing for method triangulation. With this design, the study is expected to provide a more comprehensive picture of how Digital Health 5.0 can be utilized as a transformational tool to narrow the gap in access to healthcare in rural communities in developing countries.

Result

3.1. Descriptive Statistics of Scientific Literature Metadata

Before conducting the mapping analysis, it is important to introduce the main information from the bibliometric metadata as an overview of the literature being analyzed. The results of the Main Information-Bibliometrix R-Studio analysis in Figure 2 show quite rapid research dynamics throughout the 2020–2024 period. There are 696 documents from 389 sources with an annual growth rate of 38.83%. The average document age of 2.45 years indicates this topic is relatively new, while the average citation of 10.72 per document reflects its relevance. The number of references, reaching 6,239, demonstrates the depth of the references. In terms of content, 3,082 Keyword Plus and 4,728 author keywords were identified, indicating the breadth of the issues discussed. A total of 5,991 authors were involved without a single publication, with an average of 14.9 authors per document, and international collaborations accounted for 18.82%.

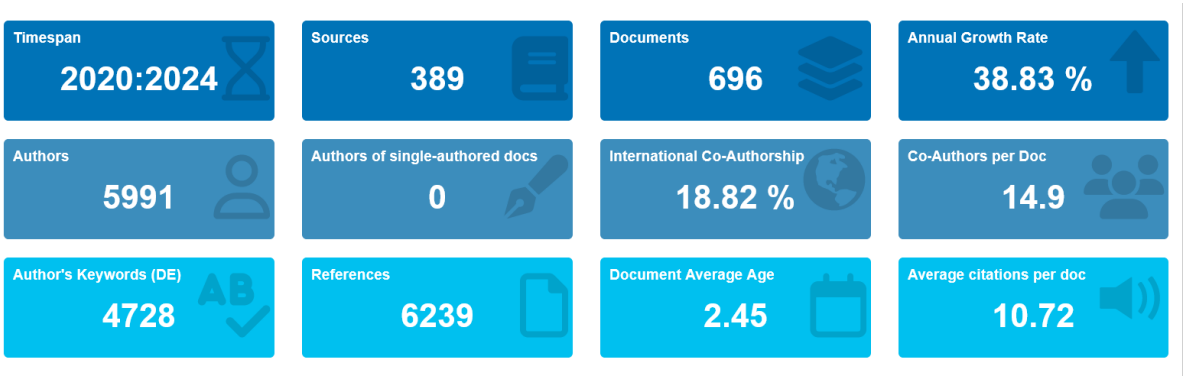

Figure 2. Main Information

The year-over-year development in the number of articles in Figure 3 shows a consistent upward trend. In 2020, 63 articles were recorded, then increased to 113 articles in 2021, and 132 articles in 2022. Growth continued with 154 articles in 2023, peaking at 234 articles in 2024. This upward pattern demonstrates the acceleration of research interest related to Digital Health 5.0 in the context of equitable access to healthcare in rural communities in developing countries. The surge in publications, particularly in 2024, indicates that this topic is gaining increasing global attention, both academically and in the practice of health technology implementation.

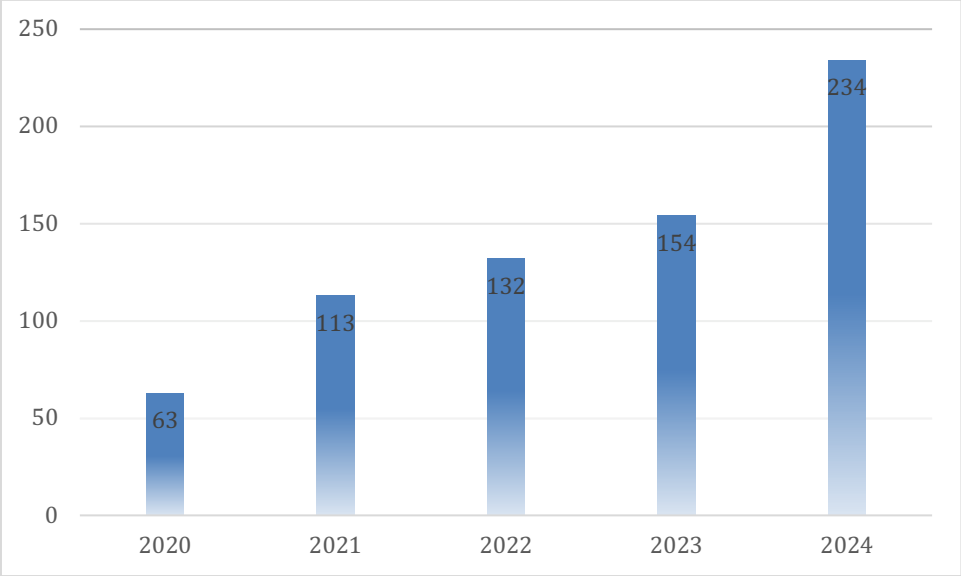

Figure 3. Growth Graph of Related Topic Publications

3.2. Keyword Co-Occurrence Analysis

Keyword co-occurrence analysis using VOSviewer is a bibliometric visualization method for mapping relationships between keywords in scientific literature. This technique helps identify dominant topics, conceptual linkage patterns, and emerging research trends within a field (Arruda et al., 2022). Network maps reveal key clusters reflecting research focuses and open research gaps. This is crucial because it provides a comprehensive overview of the evolving knowledge structure (Van Eck & Waltman, 2022). Therefore, keyword co-occurrence analysis is a suitable basis for a

Systematic Literature Review (SLR) to ensure a focused, relevant, and in-depth systematic review. Figure 4 shows the results of this study's keyword co-occurrence mapping.

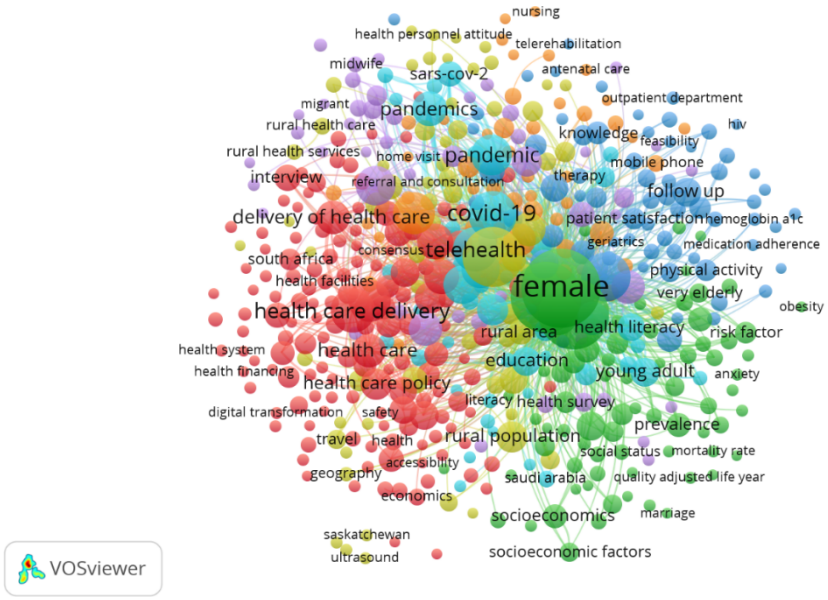

Figure 4. Keyword Co-Occurrence Mapping Results

Keyword co-occurrence analysis using VOSviewer yields an in-depth overview of the research landscape in digital health. The keyword map visualization shows the distribution of clusters, with node sizes reflecting frequency of occurrence, and connection lines depicting the interconnectedness of concepts. The map reveals several dominant keywords central to the network, including female, COVID-19, telehealth, healthcare delivery, rural population, and health literacy. This indicates that literature reviews in the digital health domain focus not only on technology but also on sociodemographic aspects, health policy, and the impact of the global pandemic.

The first major cluster that emerged revolved around women, who appeared to dominate the map. This indicates that much research on digital health in developing countries focuses on women's health issues, both in the context of maternal services, antenatal care, and reproductive health. The association with keywords such as education, health literacy, and rural areas suggests that the literature addresses not only access to services but also the importance of women's empowerment through health literacy and education, particularly in rural communities.

The second significant cluster focuses on COVID-19 and the pandemic. The pandemic has driven a surge in research on telehealth, telemedicine, and remote healthcare access. This aligns with the context of the publication year (2020–2024), where the pandemic has been a major catalyst for digital transformation in healthcare. Keywords such as SARS-CoV-2, telehealth, pandemics, and healthcare

delivery demonstrate how the literature emphasizes the integration of digital technologies to address limited healthcare access during the crisis. The pandemic has also accelerated public acceptance of digital-based healthcare solutions, particularly in areas with limited healthcare infrastructure.

The third cluster addresses healthcare delivery, healthcare policy, and healthcare financing. The association of keywords such as digital transformation, safety, economics, and geography demonstrates that research addresses not only clinical aspects but also systemic dimensions. Key challenges in implementing Digital Health 5.0 in developing countries relate to policy, funding, and geographic disparities. The literature highlights that equitable access requires adaptive policy support and inclusive financing models for digital transformation to reach rural communities truly.

Other prominent clusters include health literacy, education, young adults, and risk factors. This theme illustrates the crucial role of health literacy in the successful implementation of digital technology. Literacy not only influences public acceptance of digital services but also impacts patient compliance, the success of preventive programs, and the effectiveness of health communication. The connection with mobile phones, physical activity, and patient satisfaction demonstrates how research is increasingly focusing on individuals' active participation in maintaining health through digital platforms.

The map also demonstrates the connection between socioeconomic and geographic aspects and digital health transformation. Keywords such as socioeconomics, accessibility, rural population, and travel indicate that inequities in access to services remain a key issue. Digital Health 5.0 is positioned as a solution to bridge this gap by leveraging technology that overcomes geographic and social barriers. However, the literature also emphasizes the importance of contextual strategies tailored to local conditions for effective implementation.

The sixth cluster highlights the latest digital health technology innovations that are beginning to be widely implemented in rural areas. Keywords such as mobile phone, ultrasound, telehealth technologies, and digital transformation describe the integration of smart devices, health apps, and IoT-based services to support access to medical services. These innovations play a crucial role in expanding the reach of diagnosis, patient monitoring, and remote consultation services. The presence of these technologies not only addresses infrastructure limitations but also opens up opportunities for cost efficiency and improved service quality. This confirms that Digital Health 5.0 has the potential to provide practical solutions for rural communities.

Overall, this keyword co-occurrence analysis demonstrates that research on Digital Health 5.0 focuses not only on technological aspects but also places social, demographic, policy, and health literacy dimensions as integral parts of academic discourse. The keyword map depicts a multidisciplinary research ecosystem, where challenges and opportunities are interconnected in the effort to achieve equitable access to health care. These results provide a strong foundation for conducting a

Systematic Literature Review (SLR), according to key thematic clusters, dominant research trends, and gaps that can be the focus of further research.

Discussion

4.1. Cluster 1 Literature Review: The Role of Digital Health 5.0 in Improving Health Literacy and Access to Maternal Care in Rural Communities in Developing Countries

Access to maternal health services in rural communities in developing countries still faces significant challenges. Key barriers include limited skilled health workers, low maternal health literacy, limited infrastructure, and the influence of social and cultural norms that limit women's involvement in health decision-making. (Lecoutere & Chu, 2024; Udenigwe et al., 2023). The presence of Digital Health 5.0 offers transformational opportunities through the integration of digital technologies based on artificial intelligence (AI), the Internet of Things (IoT), wearable sensors, telemedicine, and digital financial services, with an approach that emphasizes human-centeredness, community participation, and sustainability (Holtz et al., 2024; Singh, 2024).

Cross-country studies show that digital interventions for maternal health in rural communities adopt a variety of modalities. SMS-based mHealth, voice messages, smartphone apps, and phone calls are the most commonly used to improve maternal knowledge, remind mothers of antenatal visits, and support midwife-patient interactions (Atukunda et al., 2023; Murthy et al., 2020). Interestingly, in communities with low literacy rates, voice messages have been shown to be more effective than SMS (Murthy et al., 2020), while smartphone apps strengthen the role of cadres and field health workers (Hackett et al., 2019).

Additionally, AI-based wearable devices are beginning to be used for early detection of maternal risks, such as hypertension and gestational diabetes, particularly in isolated communities (Ahmad et al., 2020). Telemedicine is also expanding the reach of services, facilitating remote consultations with specialist doctors, and is being strengthened by a continuous training model for village health workers (Verma et al., 2023; Zhao et al., 2024).

Furthermore, digital financial services such as mobile health wallets help women set aside funds for childbirth and neonatal care. Studies in Madagascar show that digital wallets increase delivery rates in formal health facilities (Lacroze et al., 2023)While in Uganda, mobile money use is correlated with increased antenatal visits (Egami & Matsumoto, 2020). Community-based approaches, including co-design and digital storytelling, ensure that digital interventions align with local norms and values, thereby increasing community acceptance and engagement (T. Coleman et al., 2023; Farao, 2023).

Despite its significant potential, the adoption of Digital Health 5.0 in rural areas of developing countries faces multidimensional challenges. Technological barriers

include limited access to digital devices, poor internet connectivity, and limited electricity (Wasir et al., 2025). Alternative solutions, such as USSD-based applications and renewable energy support, are recommended to mitigate these barriers (Hui et al., 2022).

Socio-cultural barriers are closely linked to gender norms, low female literacy, and patriarchal dominance, which hinder women's access to maternal health services (Udenigwe et al., 2022; Yaya et al., 2019). To address these barriers, communication based on oral traditions, the involvement of religious leaders, and the provision of male-friendly spaces are believed to increase acceptance of interventions (Maluka et al., 2020; Walker et al., 2019).

On the other hand, enabling factors include community involvement from the beginning of intervention design (Obegu et al., 2023), government policies supporting health digitalization (Labrique et al., 2018), and social recognition from community leaders that enhances continued use (Ebenso et al., 2021). Men's participation as partners and household decision-makers has also been shown to strengthen the success of digital maternal interventions (Lusambili et al., 2021).

Evidence from various studies shows that Digital Health 5.0 interventions have a positive impact on three main aspects:

1. **Improving Maternal Health Literacy**
   Mobile health-based interventions consistently improve mothers' knowledge about antenatal care, pregnancy danger signs, and neonatal care practices (Bekyieriya et al., 2023). AI-based advocacy also expands the reach of maternal education through personalized digital content (Boateng et al., 2025).
2. **Improving Access to Maternal Services**
   Studies in various countries in Sub-Saharan Africa and South Asia report significant increases in ANC visits, facility-based deliveries, and postnatal care through digital interventions (Kachimanga et al., 2024). The integration of *health wallets* and digital financial services reduces economic barriers, accelerates access, and improves retention in the continuum of care (Lacroze et al., 2023).
3. **Women's Empowerment and Gender Transformation**
   Gender-transformative approaches to digital interventions have been shown to increase women's decision-making autonomy in maternal health and access to resources (Udenigwe et al., 2023). However, the digital gender gap remains a challenge that must be addressed through inclusive policies.

Popular platforms such as **MomConnect** in South Africa and the use of WhatsApp in rural communities have proven effective for two-way communication and ANC visit compliance, although their effectiveness is highly dependent on internet access and technical support (Muthelo et al., 2023).

For public policy, integrating Digital Health 5.0 into national health strategies is crucial to ensure scale and sustainability (Labrique et al., 2018). From a practical perspective, community engagement, participatory design, and gender-transformative strategies should be the standard for implementation. From a

technological perspective, investments in digital infrastructure, renewable energy, and digital literacy programs will determine the success of interventions (Wagg et al., 2020).

This cluster literature review confirms that Digital Health 5.0 plays a key role in improving maternal health literacy and expanding access to maternal services in rural areas of developing countries. Diverse technological modalities, from SMS to AI-enabled wearables, have demonstrated positive impacts on knowledge, service access, and women's empowerment. However, successful implementation is crucially determined by cultural sensitivity, community engagement, and policy support. Achieving a sustainable digital transformation in maternal health requires longitudinal research, participatory co-design approaches, and inclusive policies that address gender gaps and infrastructure barriers. Thus, Digital Health 5.0 can be a catalyst for achieving a fairer and more equitable balance in maternal health access in developing countries.

4.2. Cluster 2 Literature Review: The COVID-19 Pandemic as a Catalyst for Telehealth Adoption: Accelerating Digital Health Transformation in Remote Areas

The COVID-19 pandemic has become a crucial momentum in accelerating digital transformation in the healthcare sector, particularly through the accelerated adoption of telehealth in rural and remote areas of developing countries. Before the pandemic, telehealth accounted for only about 5% of total healthcare interactions in remote areas, limited by regulatory, infrastructure, and digital literacy barriers (Totten et al., 2024a). However, as mobility restrictions were imposed and the risk of transmission in healthcare facilities increased, telehealth transformed from a supplementary service into an urgent necessity. Its use surged to over 40% in some regions during the peak of the pandemic, before stabilizing at 20–25% post-pandemic, well above pre-pandemic levels (S. Sun & Wang, 2021).

This drastic change marks a paradigm shift in healthcare. The pandemic served as a catalyst, accelerating the integration of telehealth into mainstream care systems, expanding access for rural communities previously hampered by geographic distance, shortages of medical personnel, and transportation costs (Totten et al., 2024b). Early in the pandemic, telephone services dominated due to limited internet infrastructure. As broadband availability increased, video-based consultations became more common, although telephone services remained essential for older patients and those with limited digital literacy (Johannes et al., 2023a).

However, adoption rates are not uniform. Regional variations are influenced by healthcare workforce preparedness, facility capacity, and local population factors (Williamson Yarbrough, 2023). Elderly patients, for example, demonstrated high utilization rates at the peak of the pandemic, but these rates declined after in-person services resumed (Bowman et al., 2024). Conversely, mental health and chronic

disease management services maintained high adoption rates because telehealth proved effective for continuous monitoring (Hamadi et al., 2022). In pediatrics, telehealth expanded access to subspecialty care, but disparities in access based on ethnicity, socioeconomic status, and broadband availability remained (Shannon et al., 2023).

Structural barriers remain a significant issue. Limited broadband infrastructure is a key determinant of variation in telehealth use. Low digital literacy among rural patients limits the use of video-based services, while limited remote diagnostic devices complicate physical examinations (Yuen et al., 2023). Data privacy and security concerns also raise concerns among both patients and healthcare professionals (Iasiello et al., 2023). Immature cross-jurisdictional regulations and uncertain reimbursement models add another layer of barriers that threaten sustainability (Vaidyanathan & Fox, 2020).

However, behind these obstacles lie powerful drivers that emerged during the pandemic. Flexible policies such as licensing relaxation, payment parity, and expanded reimbursement have become key instruments in driving widespread adoption (Brunner et al., 2023). Technological innovations through the use of AI, health sensors, mobile apps, and user-friendly platforms have further facilitated adaptation (Shammout et al., 2025). New training models, such as simulation-based training, have improved the competency of healthcare workers in delivering digital services (Nadaud et al., 2025). Patient acceptance of telehealth has increased rapidly, particularly for chronic disease follow-up and mental health services, demonstrating a strong fit with the need for sustainable access in rural areas (C. Coleman et al., 2024).

The impact of telehealth during the pandemic has been evident in improving access and quality of care. Access to healthcare has improved as barriers of distance, transportation, and cost have decreased. Patients from linguistic minorities and low socioeconomic status have seen significant benefits (Bravo et al., 2023). However, the digital divide persists: areas with limited broadband continue to experience low adoption, and older adults rely more heavily on telephone-based services (Shaw et al., 2024). In terms of quality, telehealth has improved patient satisfaction, particularly in pediatrics and chronic disease management (Pinnock et al., 2024). Video consultations consistently yield higher satisfaction rates than telephone consultations, although in-person care remains superior for new or complex conditions (Shilane & Lu, 2025). Telehealth also reduces no-show rates, improves coordination between providers, and reduces unnecessary hospitalizations (Le & Aggarwal, 2021).

For providers, telehealth requires significant changes in workflow, integration of digital medical records, and adaptation of patient communication. While initially perceived as burdensome, in the medium term, telehealth actually increases efficiency, expands clinician reach, and strengthens care coordination in hard-to-reach areas (Gaziel-Yablowitz et al., 2021).

This transformation has important policy implications. First, telehealth is no longer a supplement, but a permanent part of the rural health system (Predmore et

al., 2021). Second, adaptive policies have proven to be a key catalyst, so the sustainability of telehealth post-pandemic will depend heavily on continued payment parity, licensing flexibility, and broadband investment (Galvin et al., 2024). Third, a hybrid model combining telehealth with in-person services is seen as the most realistic way to ensure both quality and accessibility (Dubose-Morris et al., 2022). Fourth, the digital divide must be urgently closed through digital literacy programs, device subsidies, and equitable distribution of internet infrastructure (Johannes et al., 2023b). Fifth, data protection and digital ethics need to be strengthened to ensure sustainable and trustworthy telehealth (Moecke et al., 2024).

Thus, the COVID-19 pandemic served as a critical catalyst in accelerating digital transformation through telehealth in remote areas. The surge in adoption from 5% to over 40% during the pandemic demonstrates a structural shift in how healthcare is delivered and received. While post-pandemic usage rates declined, retention remains significantly higher than pre-pandemic levels, confirming telehealth as a core component of rural health systems. However, the sustainability of this transformation depends heavily on the health system's ability to address gaps in infrastructure, digital literacy, patient preferences, and maintain ethical standards and data security. Within the Digital Health 5.0 framework, telehealth is expected to become a key pillar in achieving equitable access to healthcare in rural communities in developing countries.

4.3. Literature Review Cluster 3: Dynamics of Health Policies, Financing, and Systems in Supporting Digital Health 5.0 Transformation for Equitable Access

The transformation to Digital Health 5.0 requires more than just advanced technology—it demands policy adaptations, sustainable financing mechanisms, and a reimagining of health systems to truly expand access to digital innovation, particularly in rural areas of developing countries. Recent literature shows that the potential of technologies (telemedicine, remote monitoring, artificial intelligence, and data interoperability) can only be optimally utilized if supported by applicable policy frameworks, sustainable funding allocations, and integration into national healthcare structures (Ho, 2022; Tait et al., 2025).

Various studies emphasize the need for national strategies that are not merely vision documents, but also operational policies that regulate data interoperability, privacy protection, cybersecurity, and accreditation of digital solutions (Iyamu et al., 2021). Global policy documents such as the WHO Global Strategy on Digital Health serve as important references,. However, empirical evidence indicates that many developing countries still experience a gap between formulated policies and regulatory capacity to implement them (Näher et al., 2023). This regulatory unpreparedness often leads to fragmentation of digital solutions on the ground, hampering service connectivity and continuity of care, especially in remote areas.

Financing emerges as a central issue: the literature identifies various sources of financing—from public budgets (APBD/APBN), universal health insurance schemes and reimbursement, to a combination of grants and private investment (blended finance) (Brown et al., 2023). Digitizing financing processes (e.g., electronic claims, data-driven budget management) can improve accountability and efficiency, but these benefits depend on the country's fiscal and administrative capacity (LeFevre et al., 2021). In many low- and middle-income contexts, reliance on donor funding and pilot projects makes digital services vulnerable when initial support ends. Therefore, integrating digital services into public service packages and formal financing mechanisms is crucial to ensure access for rural communities.

Digital Health 5.0 transformation must be placed within a systemic approach — digital tools need to be aligned with primary care workflows, referral systems, and follow-up mechanisms. Studies point to three key pillars: (1) strengthening basic infrastructure such as connectivity and electricity supply, (2) enhancing human resource capabilities through digital literacy and ongoing training, and (3) designing culturally and linguistically relevant services (van Kessel et al., 2022). Experience in rural areas shows that without ongoing training and good workload management, local health workers tend to view technology as an administrative burden rather than a clinical tool — ultimately lowering adoption rates and benefits to health outcomes (Leporatti & Montefiori, 2024).

While technology promises to expand the reach of services to marginalized groups, several studies warn of the risk of widening inequalities. Factors such as device availability, internet access, digital literacy skills, language, and trust in digital services determine who actually benefits (Bhattacharyya et al., 2021). The scoping review confirmed that without proactive policies—such as access subsidies, content localization, and digital literacy programs—digital initiatives tend to benefit urban and more economically empowered populations more (Iqbal & Biller-Andorno, 2022). Therefore, truly inclusive policies must address both physical and non-physical barriers.

Recent literature also highlights the importance of multi-sectoral governance: health, telecommunications, finance, education, and local governments need to work together. Good practices demonstrate the need for national coordination that unifies technical standards (interoperability), clinical and economic value assessment processes (e.g., HTA for Digital Health Technologies), and clear financing rules regarding public and private roles (Blanchard, 2023). Successful interventions are typically supported by public-private partnerships with transparent risk-sharing, and a monitoring and evaluation framework that prioritizes equitable access as a key indicator (Maduekwe, 2024).

In summary, this literature cluster concludes that Digital Health 5.0 does not automatically guarantee equitable access. A combination of implementable policies, financing mechanisms that integrate digital technologies into public service packages, and health system adaptations are needed to integrate technology into primary care practices. Research recommendations include economic studies of DHT

implementation in rural settings, evaluations of sustainable financing models (including blended finance), and implementation research that assesses the impact of regulatory policies on access and quality of care. For policymakers, priorities include incorporating digital equity indicators into national strategies, tying DHT into UHC and reimbursement schemes, and allocating investments to strengthen human resources and basic infrastructure in rural areas.

The dynamics between health policy, financing, and system structure are interconnected; all must be aligned if the promise of Digital Health 5.0 is to truly translate into improved access to services for rural communities in developing countries, rather than simply innovations that widen inequalities.

4.4. Cluster 4 Literature Review: Health Literacy, Digital Education, and Patient Engagement: Key Pillars of Digital Healthcare Implementation

The transformation of Digital Health 5.0 is not only about adopting advanced technologies—AI, IoT, telemedicine, or the metaverse—but also requires a strong human foundation: health literacy (including digital literacy), education of healthcare professionals and the public, and meaningful patient engagement. Health literacy is an individual's ability to access, understand, assess, and use health information in decision-making; digital health literacy adds the dimension of being able to use digital devices and services for health purposes (Kemp et al., 2021). The literature shows that without adequate literacy levels, the full potential of technology—from chronic disease management apps to laboratory results portals—will not be fully realized, as users are unable to utilize available information (Wamala Andersson & Gonzalez, 2025). Vulnerable groups—older people, those with low education, and those with limited access to infrastructure—are hardest hit by this gap (Kemp et al., 2021).

Efforts to improve literacy must be multifaceted: (a) user-centered design for user-friendly interfaces and content, (b) contextual and culturally sensitive community education programs, and (c) strengthening local support services such as health navigators or digital facilitators. Case studies in oncology emphasize the need for structured strategies that integrate behavioral approaches to increase the adoption and use of digital health technologies (Kemp et al., 2021). Furthermore, recent literature emphasizes the need for digital literacy measurement as part of digital intervention evaluations to ensure shifts in access indicators (Wamala Andersson & Gonzalez, 2025).

Integrating digital competencies into medical and nursing education is an urgent need to prepare graduates for employment in the Digital Health 5.0 ecosystem. The scoping review recommended community-based learning that combines field practice, digital simulation, and cross-disciplinary collaboration to enable healthcare professionals to translate technology into context-sensitive care practices (Punzalan & Punzalan, 2025). Furthermore, continuing education (CPD) for

faculty and clinicians is necessary to maintain the relevance of materials as technology rapidly evolves (Punzalan & Punzalan, 2025).

Technology facilitates patient engagement through personalized data access (EHR, wearables), two-way communication, and digital communities that support self-management (Trujillo, 2023). However, true engagement requires privacy governance, transparency of data use, and mechanisms for patient participation in service design—prerequisites for building trust (Shafik et al., 2025). The literature highlights that technology that fails to address trust-by-design can actually lead to patient resistance and withdrawal from digital services (Shafik et al., 2025).

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For rural areas, a "technology + people" approach is necessary: providing basic infrastructure (connectivity, electricity), literacy programs based on local facilitators, integrating digital education into public health programs, and building localized digital communities. Train-of-trainers (TOTs) and partnerships with civil society organizations enable scale and sustainability (Punzalan & Punzalan, 2025; Kemp et al., 2021). Health and digital literacy, health worker education integrated into the community context, and patient engagement based on trust are integral pillars of implementing digital-based healthcare. Without investment in these pillars, advanced technology risks becoming "beautiful but unused tools"—or worse, deepening inequities in access. Therefore, an effective Digital Health 5.0 transformation strategy must combine inclusive technology design, ongoing education programs, and mechanisms for patient participation and protection .

4.5. Cluster 5 Literature Review: Bridging Socioeconomic and Geographic Gaps through Digital Health 5.0: An Inclusive Strategy for Rural Communities

The transformation of Digital Health 5.0 opens up significant opportunities to address disparities in healthcare access in rural communities in developing countries. Socioeconomic and geographic challenges that currently limit the quality and availability of healthcare services can be mitigated through the use of inclusive digital technologies, based on local needs, and supported by sustainable policies.

Geographic limitations in rural areas—such as long distances to health facilities—are often a major barrier to access. Telemedicine has emerged as an effective solution, enabling remote consultations without the need for long travel. Saini et al. (2025)Emphasizes that digital medicine interventions, including telemedicine, mobile apps, and self-monitoring devices, have shown significant potential in improving health outcomes and accelerating the achievement of health equity in remote areas. Furthermore, mobile health (mHealth) apps play a role in chronic disease monitoring, providing health education, and fostering ongoing patient engagement. The use of telehealth and digital tools not only expands access to healthcare but also strengthens efficiency and empowers rural patients (Myneni et al., 2024).

The key to the success of Digital Health 5.0 in rural areas lies in the quality of technological infrastructure. Limited internet access, unstable electricity supply, and lack of interoperability are recurring barriers in the literature (Wasir et al., 2025). For example, in Indonesia, limited digital infrastructure in rural and remote areas reduces the effectiveness of telemedicine and remote patient monitoring (Amato et al., 2024). To address this, Chen & Ye (2024) propose middleware platforms specifically designed for rural needs, thereby increasing the accessibility and usability of digital services. Furthermore, the development of B5G/6G networks is expected to encourage broader connectivity, not only in the health sector but also in strengthening digital economic opportunities and smart agriculture in rural communities (Wei et al., 2023).

Socioeconomic disparities exacerbate geographic issues in rural areas. Low digital literacy, device costs, and a lack of technical skills make it difficult for vulnerable groups—such as older people and women—to access digital services (Jongebloed et al., 2024). Moreover, gender factors often exacerbate participation rates in the digital economy and healthcare (Hayat et al., 2024). These barriers also include limited skilled labor, inadequate regulations, and weak guarantees of infrastructure sustainability (Hui et al., 2022). Therefore, Digital Health 5.0 requires multidimensional interventions, ranging from subsidized internet access and digital literacy training to women's empowerment programs to expand digital inclusion in the healthcare sector.

Digital health literacy is a prerequisite for rural communities to utilize health technology truly. Mwogosi & Mambile (2025)demonstrated that a community-based digital education program improved health literacy and disease prevention in rural Tanzania. A similar approach could be replicated in other developing countries, emphasizing free access to digital health materials. Furthermore, participatory design in the development of digital solutions has been shown to increase the relevance and acceptance of technology. The study Teutemacher et al. (2024)highlighted the successful co-design of a digital education portal in the Eastern Cape, which could serve as a model for implementing digital health services.

The government plays a vital role in expanding the reach of Digital Health 5.0. Schmitter et al. (2024) cite India's experience with Project CardioGram, which built a nationwide network of telehealth-based healthcare facilities (Schmitter et al., 2024). This program demonstrates that policy support, infrastructure, and public-private partnerships can accelerate the adoption of digital health. In China, the government's digital transformation has successfully increased the utilization of basic healthcare services by migrant populations, demonstrating that integrating technology and public policy can reduce healthcare disparities (T. Q. Sun, 2022). Similar strategies can be adapted for rural communities in developing countries.

4.6. Literature Review Cluster 6: Latest Health Technologies in the Digital Health 5.0 Era: Mobile Innovation, Telemedicine, and Smart Devices to Improve Services in Rural Areas

The Digital Health 5.0 transformation ushers in a new paradigm in the global healthcare system by emphasizing the integration of advanced technologies—especially artificial intelligence (AI), the Internet of Things (IoT), 5G connectivity, and cloud computing—to realize smart, connected, and patient-centered healthcare services. The primary focus of this era is not only on technological efficiency but also on creating a humanistic and inclusive ecosystem. This development holds significant significance for rural communities in developing countries, where geographic barriers, limited infrastructure, and shortages of medical personnel still predominate.

Mobile applications and smartphone-based smart devices are spearheading the transformation of rural healthcare. mHealth applications not only enable remote patient-doctor communication but also improve disease diagnosis and chronic health management (Rafiei et al., 2021). Various studies have shown that AI-based applications can detect disease symptoms earlier, provide medication reminders, and even provide real-time health monitoring (Galy et al., 2019; Yang et al., 2024). Furthermore, mobile telemedicine centers are an innovative strategy for bringing specialist healthcare services to remote areas without the need to build new physical infrastructure. This innovation reduces referral costs and increases service affordability, although long-term operational costs remain a significant challenge (Fiordelli et al., 2020). Furthermore, the use of social media and cloud-based platforms also expands public access to health education, strengthens communication between healthcare professionals, and accelerates the dissemination of relevant medical information (Bober et al., 2024). Thus, mHealth serves not only as a diagnostic technology but also as a medium for empowering rural patients to become more actively involved in their health management.

Telemedicine has become one of the most significant components in the Digital Health 5.0 literature for rural areas. Modular, low-bandwidth platforms—such as Intelehealth—are specifically designed for resource-constrained contexts. These systems support task shifting, enabling non-specialist healthcare professionals to

perform services with remote supervision from specialist physicians (A. Sharma & Jain, 2025). The integration of telemedicine with cloud computing and 5G connectivity enables real-time consultations, image-based diagnostics, and simple teleoperations (Depuccio et al., 2021; Kichloo et al., 2020). Furthermore, network planning models based on demographic and epidemiological data can help determine strategic locations for telemedicine centers, reducing patient travel distances while optimizing the workload of healthcare professionals (Haleem et al., 2021). The advent of 5G technology has become a significant catalyst in expanding the spectrum of telemedicine services. Low-latency connections enable remote medical procedures that were previously impossible, such as telerobotic surgery or intensive real-time patient monitoring (X. Wang et al., 2024).

IoT-based smart device technology expands the reach of healthcare services by providing continuous health monitoring. IoT systems enable the constant collection of patient vital data, which is then sent to data centers or medical personnel for further analysis (Dahiya et al., 2023; Vamshikrishna et al., 2024). In areas with limited connectivity, the implementation of vehicular ad hoc networks (VANETs) is an innovative solution to ensure medical data can still be transmitted through opportunistic networks (Trivedi & Patel, 2023). Furthermore, the use of wearable devices and biosensors helps in the management of chronic diseases such as diabetes and hypertension, allowing patients in rural areas to be monitored without having to travel frequently to healthcare facilities (Kathavate & Amudhavel, 2019).

However, the effectiveness of these smart devices depends heavily on adequate network infrastructure and user literacy. Without appropriate training, advanced technology risks becoming obsolete or widening the digital divide.

Artificial intelligence is playing an increasingly important role in supporting rural healthcare. One prominent innovation is telerobotic ultrasonography (TUS), which allows general practitioners to perform ultrasounds under real-time guidance from specialists over a remote connection. This not only expands diagnostic access but also reduces the cost of patient travel to referral centers (Swan et al., 2024). Mobile-based AI applications have also proven effective in the early detection of non-communicable diseases such as skin cancer or diabetes, with high levels of risk assessment accuracy (Pan et al., 2022; Saif-Ur-Rahman et al., 2023). Furthermore, AI-based clinical decision support (CDSS) systems integrated with electronic medical records (EHRs) help rural healthcare workers make more informed decisions while reducing the risk of overprescribing (Gomez-Cabello et al., 2024). Deep learning models have even demonstrated effectiveness in accelerating the diagnosis of chronic diseases, strengthening the capacity of non-specialist healthcare workers, and improving the quality of care in rural areas (Fan et al., 2023). The latest healthcare technologies in the Digital Health 5.0 era—including mHealth, telemedicine, smart devices, and AI-based diagnostics—have paved new paths for equitable access to healthcare in rural areas of developing countries. These innovations have been shown to improve diagnostic accuracy, strengthen chronic disease management, and

expand the reach of healthcare services. However, the success of this transformation depends heavily on overcoming infrastructure barriers, digital literacy, data privacy, cultural factors, and long-term financing. With a contextual, inclusive, and sustainable approach, Digital Health 5.0 has great potential to be a driving force for achieving global health equity, particularly for rural communities that traditional health systems have marginalized.

Conclusion

This study confirms that the Digital Health 5.0 transformation has significant potential to catalyze equitable access to healthcare in rural areas of developing countries. Through the integration of cutting-edge technologies such as artificial intelligence, the Internet of Things, telemedicine, smart devices, and blockchain-based systems, this paradigm can overcome geographical barriers, limited medical personnel, and inadequate infrastructure. A bibliometric review shows a surge in global publications on this issue, reflecting growing academic and practical attention. A systematic analysis identified six key clusters: maternal health literacy, post-COVID-19 telehealth, policy and financing, digital literacy and patient engagement, socioeconomic inclusion strategies, and emerging technological innovations. The findings indicate that Digital Health 5.0, supported by AI, IoT, telemedicine, blockchain, and smart devices, not only improves data-driven diagnosis and services but also emphasizes a human-centered, inclusive, and adaptive approach to local contexts. However, implementation in rural areas faces structural challenges, including limited digital infrastructure, internet connectivity, electricity availability, low digital literacy, and socioeconomic and gender inequalities. Policy factors, sustainable financing, and culturally appropriate service design are key to success. The study also highlighted the role of the COVID-19 pandemic as a catalyst for telehealth adoption, although the digital divide continues to hamper equity.

Digital Health 5.0 has the potential to be a key driver for achieving global health equity, particularly in rural communities in developing countries. Achieving this requires policy integration, infrastructure investment, digital literacy, and cross-sector collaboration. Strategic practical recommendations for strengthening the implementation of Digital Health 5.0 to ensure equitable access to healthcare in rural and underdeveloped areas of developing countries like Indonesia require the involvement of three key actors: the government (the Indonesian Ministry of Health), health technology development companies, and primary healthcare facilities such as community health centers (Puskesmas) and clinics.

National health authorities, such as the Indonesian Ministry of Health, need to develop a national policy framework that ensures interoperability of digital systems across healthcare facilities, data security standards, and sustainable financing models. The Digital Health 5.0 roadmap should include investments in basic infrastructure (internet, electricity, digital medical devices), community-based digital health literacy programs, and incentives for rural healthcare workers. Integrating

digital services into the National Universal Health Coverage (JKN) will ensure sustainable financing. In contrast, digital equity indicators should be included in the National Medium-Term Development Plan (RPJMN) as well as regional performance indicators.

The technology industry must adopt human-centered design principles, taking into account the limited infrastructure and literacy of rural communities. Low-bandwidth solutions such as SMS/USSD-based applications, solar-powered portable devices, and modular telemedicine platforms should be prioritized. Collaboration with community health centers (Puskesmas) and the Ministry of Health through public-private partnerships will ensure technology meets local needs. Companies should also ensure patient data security and affordability, and provide easily accessible technical support services to rural communities.

Community health centers (Puskesmas) and clinics must become centers for implementing Digital Health 5.0 by strengthening the capacity of healthcare workers through digital literacy training, the use of AI for clinical decision support, and the integration of electronic medical records. A hybrid service model (face-to-face + telehealth) can expand reach while maintaining service quality. Community health centers also play a role as facilitators of digital health literacy in the community, for example, through community classes, health cadres, and digital navigation support for vulnerable groups (pregnant women, the elderly, and people with disabilities).

This study has several limitations that should be noted. First, the bibliometric analysis used only the Scopus database, so it is possible that relevant literature in other indexes, such as Web of Science or PubMed, was not captured. Second, the limited timeframe of 2019–2025 potentially overlooked earlier publications related to the digital health concepts underlying Digital Health 5.0. Third, although the systematic review adhered to PRISMA standards, the heterogeneity of social, economic, and infrastructure contexts across developing countries limits the generalizability of the findings. Furthermore, the majority of studies were descriptive or case studies, thus lacking quantitative evidence regarding long-term effectiveness. Future research directions include empirical evaluations based on controlled trials in rural communities, health economic studies to assess financing sustainability, and exploration of culturally sensitive digital service design. Longitudinal research is also needed to understand the impact of Digital Health 5.0 on intergenerational health equity.

Declarations

No ethical issues have arisen during the study, and all procedures followed comply with the ethical standards.

Funding statement

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data availability statement

Data availability statements provide a statement about where data supporting the results reported in a published article can be found, including, where applicable, hyperlinks to publicly archived datasets analyzed or generated during the study.

Declaration of interests statement

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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