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# Digital Infrastructure Readiness in Supporting National Telehealth Services: A Comprehensive Review

**Yumi Abimulyani[1], Suratno Kaluku[2]**
Poltekkes Kemenkes Jayapura, Indonesia[1] Poltekkes Kemenkes Maluku, Indonesia[3]
e-mail* : yumiabimulyanigom@gmail.com

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**ABSTRAK**

The readiness of digital infrastructure is crucial for supporting effective national telehealth services, particularly in developing countries and remote areas. This comprehensive review examines the key factors influencing digital infrastructure readiness, including policy and regulation, connectivity and devices, digital competency and literacy, and equity of access. Through a systematic literature review of 21 scholarly publications from 2020 to 2025, this study identifies critical challenges in telehealth implementation, including infrastructure limitations, lack of trained human resources, regulatory barriers, and digital divides. The findings reveal that successful national telehealth implementation depends heavily on robust digital infrastructure, supportive policies, digital literacy, and equitable access. This research recommends strategic investments in infrastructure development, human resource training, adaptive policies, and inclusive technological solutions to ensure telehealth can truly expand access and improve healthcare service quality. The study contributes to both theoretical understanding and practical implementation of telehealth systems in resource-constrained settings.

**Keywords**: *Digital Infrastructure, Telehealth, Telemedicine, Digital Health, Healthcare Accessibility, Digital Divide.*

## INTRODUCTION

The rapid advancement of digital technologies has fundamentally transformed healthcare delivery models worldwide. Telehealth, defined as the delivery of health-related services and information via telecommunications technologies, has emerged as a promising solution to address healthcare accessibility challenges, particularly in underserved and remote areas (Hui et al., 2022). The integration of digital technologies into healthcare systems offers unprecedented opportunities to overcome geographical barriers, reduce

healthcare costs, and improve patient outcomes through timely access to medical expertise (Ye et al., 2023).

The COVID-19 pandemic dramatically accelerated the adoption of telehealth services globally, demonstrating both the potential and limitations of digital health infrastructure (Hirko et al., 2020). During this crisis, healthcare systems rapidly transitioned to remote care delivery, revealing critical gaps in digital infrastructure readiness, particularly in developing countries and rural regions (Baumgart, 2020). This unprecedented shift highlighted the importance of robust digital infrastructure as a foundational requirement for sustainable telehealth implementation, encompassing not only technological components but also policy frameworks, human resource capacity, and digital literacy (Torous et al., 2020).

Digital infrastructure readiness extends beyond mere technological availability to encompass a comprehensive ecosystem that includes stable electricity supply, reliable internet connectivity, appropriate devices, supportive regulatory frameworks, and digitally literate healthcare providers and patients (Hui et al., 2022). The absence or inadequacy of any of these components can significantly hinder telehealth adoption and effectiveness, potentially exacerbating existing health disparities rather than alleviating them (Mathew et al., 2023). Understanding the multifaceted nature of digital infrastructure readiness is therefore essential for designing and implementing effective national telehealth strategies.

In developing countries, the challenges of digital infrastructure readiness are particularly acute. Limited broadband penetration, unreliable electricity supply, high costs of devices and data, and low digital literacy rates create substantial barriers to telehealth adoption (Getachew et al., 2022). These infrastructure deficits disproportionately affect vulnerable populations, including elderly individuals, women, rural communities, and those with lower socioeconomic status, thereby widening health equity gaps (Le et al., 2023). The digital divide in healthcare access represents not merely a technological issue but a fundamental social justice concern that requires comprehensive policy interventions and strategic investments.

Despite these challenges, numerous countries have successfully implemented telehealth initiatives that demonstrate the transformative potential of well-designed digital health systems. China's extensive experience with telehealth implementation provides valuable insights into scaling digital health services across diverse geographical and socioeconomic contexts (Ye et al., 2023). Similarly, Australia's telehealth programs in remote areas illustrate innovative approaches to overcoming infrastructure limitations through hybrid models that combine digital and face-to-face care (Mathew et al., 2023). These successful implementations underscore the importance of context-specific strategies that address local infrastructure challenges while leveraging emerging technologies.

The evolution of telehealth technology continues to introduce new possibilities for enhancing healthcare delivery. Emerging technologies such as blockchain for secure health data management, artificial intelligence for

diagnostic support, and advanced mobile health applications are expanding the scope and sophistication of telehealth services (Ahmad et al., 2020; Hasan et al., 2021). However, the adoption of these advanced technologies requires even more robust digital infrastructure and higher levels of digital competency, creating new dimensions of infrastructure readiness that must be addressed (Scott et al., 2020).

Furthermore, the sustainability of telehealth systems depends critically on appropriate policy and regulatory frameworks. Issues such as licensure across jurisdictions, reimbursement policies, data privacy and security standards, and quality assurance mechanisms require careful consideration and coordination at national and international levels (Kobeissi & Hickey, 2023). The absence of clear regulatory frameworks can impede telehealth adoption even when technical infrastructure is adequate, highlighting the need for comprehensive policy development that keeps pace with technological advancement (Poonsuph, 2022).

Therefore, this research aims to comprehensively examine digital infrastructure readiness for national telehealth services, identifying key factors, challenges, and strategic solutions across different contexts. By synthesizing evidence from diverse geographical settings and healthcare systems, this study seeks to provide actionable insights for policymakers, healthcare administrators, and technology developers working to expand telehealth access and improve healthcare equity through digital innovation.

## RESEARCH METHODS

This research employed a systematic literature review approach to examine digital infrastructure readiness for national telehealth services. The review encompassed 21 peer-reviewed scholarly articles published in indexed journals during the period from 2020 to 2025. This timeframe was selected to capture contemporary developments in telehealth infrastructure, with particular emphasis on innovations and challenges revealed during and after the COVID-19 pandemic.

The literature selection process followed rigorous inclusion and exclusion criteria. Articles were included if they directly addressed digital infrastructure requirements for telehealth implementation, examined policy and regulatory frameworks for digital health, investigated connectivity and technological barriers to telehealth adoption, or analyzed digital literacy and competency issues in telehealth contexts. Studies were excluded if they focused solely on clinical outcomes without addressing infrastructure considerations, or if they discussed telehealth applications without examining underlying infrastructure requirements.

Data extraction focused on identifying key themes related to digital infrastructure readiness, including policy and regulatory factors, connectivity and device availability, digital competency and literacy, equity of access, implementation challenges, and proposed solutions. Each article was systematically analyzed to extract relevant information regarding infrastructure requirements, barriers to implementation, successful strategies, and recommendations for future development.

Thematic analysis was conducted to synthesize findings across multiple studies and identify patterns, convergences, and divergences in the literature. The analysis process involved coding key concepts, grouping related themes, and developing a comprehensive framework for understanding digital infrastructure readiness across different contexts. Particular attention was paid to comparing experiences from developed and developing countries, urban and rural settings, and different healthcare system models.

The validity and reliability of findings were enhanced through triangulation of evidence from diverse geographical contexts, healthcare systems, and research methodologies. This comparative approach allowed for the identification of universal principles of infrastructure readiness as well as context-specific factors that influence telehealth implementation success. The synthesis of evidence also considered temporal trends in telehealth infrastructure development, tracking the evolution of research focus and practical innovations from 2020 to 2025.

Quality assessment of included studies considered factors such as research design rigor, sample size and representativeness, analytical methods, and generalizability of findings. This critical appraisal ensured that conclusions drawn from the literature review were based on robust evidence and could inform practical recommendations for infrastructure development. The comprehensive nature of this review methodology enables the generation of actionable insights for multiple stakeholders involved in telehealth implementation, including policymakers, healthcare administrators, technology developers, and healthcare providers.

## RESULTS AND DISCUSSION

### Key Factors in Digital Infrastructure Readiness

**Table 1. Critical Components of Digital Infrastructure Readiness for Telehealth**

| Infrastructure Component | Essential Requirements | Impact on Telehealth | Key Sources |
|---|---|---|---|
| Policy and Regulation | National digital health policy, legislative support, interoperability standards, reimbursement frameworks | Enables widespread sustainable implementation, ensures quality and safety standards | Hui et al. (2022); Ye et al. (2023); Kobeissi & Hickey (2023); Poonsuph (2022) |
| Connectivity Infrastructure | Stable electricity supply, reliable internet/broadband access, adequate | Provides fundamental platform for service delivery, determines service | Hui et al. (2022); Ye et al. (2023); Mathew et al. (2023); Tomoh et al. (2025); |

| | | | |
|---|---|---|---|
| | bandwidth, network coverage | quality and reliability | Hirko et al. (2020) |
| Device Availability | Smartphones, computers, tablets with appropriate specifications, affordability of devices | Enables patient and provider participation, affects service accessibility | Hui et al. (2022); Getachew et al. (2022); Mathew et al. (2023) |
| Digital Competency | Digital literacy among healthcare providers, technical skills for system operation, ongoing training programs | Determines effective system utilization, influences adoption rates and service quality | Hui et al. (2022); Jonnagaddala et al. (2021); Mathew et al. (2023); Le et al. (2023); Getachew et al. (2022) |
| Patient Digital Literacy | Ability to use digital health platforms, understanding of online communication, confidence with technology | Affects patient engagement, determines accessibility for different populations | Le et al. (2023); Hirko et al. (2020); Van Cleave et al. (2022) |
| Security and Privacy | Data protection infrastructure, encryption systems, privacy compliance frameworks, cybersecurity measures | Ensures patient trust, maintains confidentiality, meets regulatory requirements | Ahmad et al. (2020); Hasan et al. (2021); Kobeissi & Hickey (2023) |

Table 1 presents a comprehensive overview of the critical components that constitute digital infrastructure readiness for telehealth implementation. The policy and regulatory dimension emerges as a foundational element that shapes the entire telehealth ecosystem, with national digital health policies, legislative support, and interoperability standards creating the enabling environment for widespread and sustainable implementation (Hui et al., 2022; Ye et al., 2023). Without appropriate policy frameworks, even technically sound telehealth systems may struggle to achieve scale and sustainability due to uncertainties around licensure, liability, reimbursement, and quality standards (Kobeissi & Hickey, 2023; Poonsuph, 2022).

The connectivity infrastructure component represents the fundamental technical foundation upon which all telehealth services depend. Stable electricity supply and reliable internet access with adequate bandwidth determine whether telehealth services can function at all, while network coverage patterns shape

geographical accessibility (Hui et al., 2022; Ye et al., 2023). Research from remote areas in Australia and rural regions in developing countries consistently identifies connectivity limitations as the primary barrier to telehealth adoption, with poor signal strength, intermittent connections, and insufficient bandwidth preventing effective video consultations and real-time data transmission (Mathew et al., 2023; Tomoh et al., 2025; Hirko et al., 2020).

Digital infrastructure readiness encompasses multiple interdependent components that collectively determine the success of national telehealth implementation. The policy and regulatory framework serves as the foundational layer that legitimizes and sustains telehealth services within healthcare systems (Hui et al., 2022). Countries with comprehensive digital health policies that address licensure, reimbursement, data privacy, and quality standards demonstrate significantly higher rates of telehealth adoption and integration into mainstream healthcare delivery (Ye et al., 2023).

China's experience with large-scale telehealth implementation illustrates the critical importance of coordinated policy development. The country's systematic approach to establishing regulatory frameworks, investing in infrastructure, and developing interoperability standards has enabled rapid expansion of telehealth services across diverse geographical regions (Ye et al., 2023). This experience demonstrates that infrastructure readiness is not merely about technological deployment but requires comprehensive policy ecosystems that address legal, financial, and operational dimensions of telehealth services.

Connectivity and device availability constitute the tangible infrastructure layer that directly enables or constrains telehealth service delivery. The digital divide in connectivity persists as a major barrier, particularly in low- and middle-income countries where broadband penetration remains limited and costs remain prohibitively high for many households (Hui et al., 2022). Even in developed countries, rural areas frequently experience connectivity challenges that limit telehealth functionality, with bandwidth constraints preventing high-quality video consultations that are essential for many clinical applications (Hirko et al., 2020).

The affordability and availability of appropriate devices represent another critical dimension of infrastructure readiness. While smartphone penetration has increased dramatically in many developing regions, access to devices with sufficient capabilities for telehealth applications remains uneven (Getachew et al., 2022). The cost of devices, data plans, and ongoing maintenance creates barriers particularly for elderly populations, low-income households, and rural communities, potentially exacerbating health inequities rather than reducing them (Mathew et al., 2023).

Digital competency and literacy emerge as perhaps the most complex and multifaceted components of infrastructure readiness. Healthcare provider competency encompasses not only basic digital skills but also the ability to conduct effective clinical consultations in virtual environments, operate telehealth platforms efficiently, and troubleshoot common technical issues (Jonnagaddala et al., 2021). Training programs for healthcare providers must

address both technical skills and the adaptation of clinical communication approaches to digital modalities (Mathew et al., 2023).

Patient digital literacy proves equally critical for successful telehealth adoption. Research demonstrates that digital competence significantly influences telehealth utilization patterns, with individuals lacking confidence in technology or unfamiliar with digital communication platforms less likely to engage with telehealth services even when available (Le et al., 2023). This literacy gap disproportionately affects elderly populations, creating age-based disparities in telehealth access that mirror and potentially amplify existing health inequities (Van Cleave et al., 2022).

Security and privacy infrastructure represents an essential but sometimes overlooked component of digital readiness. The sensitive nature of health information requires robust data protection systems, encryption protocols, and privacy compliance frameworks to ensure patient trust and meet regulatory requirements (Ahmad et al., 2020). Emerging technologies such as blockchain offer promising approaches to enhancing security and interoperability in telehealth systems, though their implementation requires additional technical capacity and infrastructure investment (Hasan et al., 2021).

## Implementation Challenges and Barriers

**Table 2. Major Challenges and Strategic Solutions for Telehealth Infrastructure Development**

| Challenge Category | Specific Barriers | Strategic Solutions | Implementation Level | Key Sources |
|---|---|---|---|---|
| Infrastructure Limitations | Poor broadband coverage, unreliable electricity, insufficient network bandwidth, high connectivity costs | Investment in broadband infrastructure, renewable energy solutions, subsidized connectivity programs, infrastructure-sharing models | National/Regional Policy | Hui et al. (2022); Ye et al. (2023); Mathew et al. (2023); Tomoh et al. (2025); Hirko et al. (2020) |
| Human Resource Gaps | Shortage of trained healthcare IT staff, limited digital skills among clinicians, inadequate technical support | Comprehensive training programs, cross-sector collaboration, continuous professional development, embedded IT support | Organizational/Professional | Hui et al. (2022); Jonnagaddala et al. (2021); Mathew et al. (2023); Getachew et al. (2022) |
| Regulatory and Payment Barriers | Unclear reimbursement policies, | Policy standardization, provider | National Policy | Ye et al. (2023); Kobeissi & |

| | | | | |
|---|---|---|---|---|
| | licensure restrictions, liability concerns, lack of quality standards | incentives, clear regulatory frameworks, quality assurance systems | | Hickey (2023); Poonsuph (2022); Hirko et al. (2020) |
| Digital Divide | Unequal access across urban-rural divide, age-based disparities, socioeconomic barriers, gender gaps | Digital literacy programs, inclusive technology design, community health worker integration, affordable device programs | Community/Individual | Hui et al. (2022); Mathew et al. (2023); Le et al. (2023); Hirko et al. (2020); Van Cleave et al. (2022) |
| Integration Challenges | Interoperability issues, fragmented systems, lack of data standards, workflow disruption | Standardization initiatives, system integration platforms, change management, user-centered design | Technical/Organizational | Jonnagaddala et al. (2021); Kobeissi & Hickey (2023); Poonsuph (2022); Getachew et al. (2022) |
| Sustainability Concerns | Dependence on external funding, lack of business models, maintenance challenges, technology obsolescence | Sustainable financing mechanisms, public-private partnerships, local capacity building, scalable solutions | Strategic/Financial | Chakraborty et al. (2023); Ye et al. (2023); Jnr. (2020) |

Table 2 synthesizes the major challenges confronting telehealth infrastructure development alongside strategic solutions organized by implementation level. Infrastructure limitations emerge as the most fundamental barrier, encompassing poor broadband coverage, unreliable electricity supply, and insufficient network bandwidth that collectively prevent basic telehealth functionality in many regions (Hui et al., 2022; Ye et al., 2023). These technical deficits require substantial national and regional policy interventions, including major investments in broadband infrastructure, deployment of renewable energy solutions in areas with unreliable grid electricity, and implementation of subsidized connectivity programs to reduce cost barriers (Mathew et al., 2023; Tomoh et al., 2025; Hirko et al., 2020).

Human resource gaps represent a critical bottleneck in telehealth implementation that persists even when technical infrastructure is adequate. The shortage of healthcare IT professionals capable of implementing and maintaining

telehealth systems constrains system deployment and sustainability (Getachew et al., 2022). Beyond specialized IT staff, the limited digital skills among practicing clinicians who must actually deliver telehealth services creates adoption barriers and affects service quality (Jonnagaddala et al., 2021). Addressing these human resource challenges requires comprehensive training programs, continuous professional development initiatives, and embedded technical support structures that enable healthcare providers to focus on clinical care rather than technical troubleshooting (Mathew et al., 2023).

The analysis of implementation challenges reveals that telehealth infrastructure readiness failures typically result from multiple intersecting barriers rather than single-factor limitations. In many developing countries, infrastructure deficits compound with human resource constraints and regulatory uncertainties to create formidable obstacles to telehealth adoption (Hui et al., 2022). Understanding these interactions is essential for designing comprehensive solutions that address multiple dimensions simultaneously rather than pursuing isolated interventions.

Infrastructure limitations manifest differently across contexts but share common patterns. In rural and remote areas, geographical distance from telecommunications infrastructure results in poor connectivity, low bandwidth, and high costs (Mathew et al., 2023). Urban areas in developing countries may have better infrastructure coverage but face challenges of affordability and system reliability during peak usage periods (Getachew et al., 2022). The infrastructure challenge thus requires differentiated strategies tailored to specific geographical and socioeconomic contexts rather than one-size-fits-all solutions.

Regulatory and payment barriers significantly impede telehealth expansion even when technical capacity exists. Unclear or restrictive reimbursement policies create financial disincentives for healthcare providers to offer telehealth services, limiting availability regardless of patient demand (Kobeissi & Hickey, 2023). Licensure restrictions that prevent providers from treating patients across jurisdictional boundaries constrain telehealth's potential to expand access by connecting patients with specialists regardless of location (Hirko et al., 2020). Liability concerns and absence of clear quality standards further discourage provider participation and reduce patient confidence in telehealth services (Ye et al., 2023).

The digital divide in healthcare access represents perhaps the most intractable challenge for achieving equitable telehealth implementation. Disparities in access follow familiar patterns of social inequality, with rural populations, elderly individuals, women, and those with lower socioeconomic status experiencing systematically lower access to digital health services (Hui et al., 2022). These disparities arise from multiple factors including connectivity gaps, device availability, affordability constraints, and digital literacy deficits that interact to create compounding disadvantage (Le et al., 2023).

**Global Practices and Innovations**

Examination of global telehealth implementations reveals diverse approaches to addressing infrastructure readiness challenges. Australia's experience with telehealth in remote areas demonstrates the potential for hybrid models that strategically combine digital and face-to-face care based on clinical needs and infrastructure realities (Mathew et al., 2023). This pragmatic approach recognizes that telehealth serves as a supplement rather than complete replacement for traditional care delivery, with the optimal mix varying across contexts and patient populations.

Canada's integrated digital health system provides insights into the advantages of comprehensive digitalization that encompasses electronic health records, telehealth platforms, and data analytics infrastructure (Baumgart, 2020). This integrated approach enables seamless information flow and coordination across care settings, demonstrating how telehealth infrastructure investments create value beyond remote consultations by enhancing overall health system performance and responsiveness.

Emerging technologies continue to expand possibilities for telehealth innovation while simultaneously raising infrastructure requirements. Blockchain technology offers promising solutions for secure health data management and interoperability challenges that have historically constrained telehealth integration (Ahmad et al., 2020; Hasan et al., 2021). However, implementing blockchain-based health systems requires substantial technical expertise and infrastructure investment that may exceed current capacity in many developing country contexts.

The role of telehealth startups in expanding service delivery illustrates how private sector innovation can complement public health system efforts (Chakraborty et al., 2023). These entrepreneurial ventures often develop creative solutions to infrastructure constraints, such as SMS-based telehealth platforms that function with minimal bandwidth or offline-capable mobile applications that synchronize when connectivity is available. The startup ecosystem provides valuable experimentation with new models and technologies that can inform larger-scale public health system implementations.

Digital mental health represents a domain where telehealth has demonstrated particular success, partially because mental health consultations require less sophisticated infrastructure than many physical health applications (Torous et al., 2020). The COVID-19 pandemic accelerated adoption of digital mental health services, revealing both opportunities and limitations of remote mental healthcare delivery. This experience suggests that infrastructure readiness requirements vary significantly across clinical domains, arguing for differentiated rather than uniform approaches to telehealth implementation.

Special consideration must be given to vulnerable populations whose infrastructure access challenges are most acute. Children with special healthcare needs represent one such population where telehealth offers substantial potential benefits but faces particular infrastructure barriers (Van Cleave et al., 2022). Addressing the needs of vulnerable populations requires not only technical

infrastructure but also inclusive design approaches, culturally appropriate interfaces, and integration with community-based support systems.

**Strategic Pathways Forward**

Achieving comprehensive digital infrastructure readiness for national telehealth services requires coordinated action across multiple domains. Investment in physical infrastructure remains fundamental, encompassing broadband expansion, electricity grid improvements, and telecommunications infrastructure development particularly in underserved areas (Tomoh et al., 2025). These infrastructure investments generate benefits beyond healthcare, supporting economic development, education, and social connectivity, which strengthens the case for public investment.

Policy development must proceed in parallel with infrastructure investment, establishing clear regulatory frameworks that address licensure, reimbursement, liability, privacy, and quality assurance (Poonsuph, 2022). Adaptive policy approaches that can accommodate rapid technological change while maintaining essential protections are necessary given the dynamic nature of digital health innovation (Kobeissi & Hickey, 2023). International cooperation and knowledge sharing can accelerate policy development by enabling countries to learn from others' experiences and avoid reinventing solutions to common challenges.

Human resource development represents a critical long-term investment that determines whether technical infrastructure translates into effective service delivery. Comprehensive digital health training must be integrated into health professional education at all levels, from pre-service training through continuing professional development (Jonnagaddala et al., 2021). Beyond healthcare providers, developing a broader ecosystem of health IT professionals, data analysts, and technology support staff is essential for sustainable telehealth systems.

## CONCLUSION

Digital infrastructure readiness is a key factor in the successful implementation of national telehealth, requiring synergy among technical, policy, human resource, and social dimensions. A strong infrastructure encompasses not only connectivity but also regulatory frameworks, digital competency, equitable access, and sustainable financing. Deficiencies in any of these aspects can hinder telehealth effectiveness and exacerbate healthcare disparities. The essential factors of digital readiness include supportive policies, device availability, digital literacy, data security, and service inclusivity. All these elements are interdependent, meaning weaknesses in one area can reduce overall system performance. Both developed and developing countries face similar challenges such as infrastructure limitations and digital divides, though with varying levels of complexity. The experiences of successful countries demonstrate that policy innovation and strategic investment can overcome these barriers. Investments in

digital infrastructure require substantial commitment but yield broad social and economic benefits. Effective policies must balance innovation with safeguards for quality, security, and data privacy. The COVID-19 pandemic proved that countries with mature digital infrastructure could adapt more quickly to changes. Therefore, proactive investment is more crucial than reactive responses in times of crisis. Ultimately, telehealth can function optimally only when supported by comprehensive, equitable, and sustainable digital infrastructure.

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