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A Systematic Review of Implementing IoT Healthcare Systems: Technological, Organizational, and Ethical Barriers in Rural Settings

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Abstract

The implementation of Internet of Things (IoT) technologies holds transformative potential for healthcare delivery in rural and underserved regions. This systematic review focuses on technological, organizational, and ethical barriers. A comprehensive literature search across six major academic databases yielded eleven empirical studies published between 2015 and 2025. The review adhered to PRISMA protocols, with data synthesized using the Synthesis Without Meta-Analysis (SWiM) guidelines. Findings revealed that technological challenges—such as unreliable internet connectivity, lack of device interoperability, and power supply issues—are widespread across rural implementations. Organizational limitations included inadequate training, resistance to workflow changes, and financial constraints. Ethical concerns primarily involved informed consent, data security, and privacy, often exacerbated by weak regulatory structures and digital illiteracy. Despite these obstacles, successful implementation efforts were marked by community engagement, phased integration strategies, and culturally adapted frameworks. The review underscores the necessity of comprehensive approaches that combine infrastructure development, workforce preparedness, and locally contextualized ethical safeguards. These findings provide a critical foundation for policymakers, system designers, and healthcare practitioners aiming to scale digital health solutions in low-resource settings.

Keywords: digital health equity, ethical challenges, implementation barriers, IoT healthcare, rural health systems

Abstrak

Tinjauan Sistematis Implementasi Sistem Kesehatan Berbasis* Internet of Things (IoT): *Hambatan Teknologis, Organisasional, dan Etis di Wilayah Pedesaan. *Penerapan teknologi* Internet of Things (IoT) *memiliki potensi transformatif dalam penyampaian layanan kesehatan di wilayah pedesaan dan daerah yang kurang terlayani. Tinjauan sistematis ini fokus pada hambatan teknologi, organisasi, dan etika. Pencarian literatur yang komprehensif di enam basis data akademik utama menghasilkan sebelas studi empiris yang diterbitkan antara tahun 2015 hingga 2025. Tinjauan ini mengikuti protokol* PRISMA, *dengan sintesis data menggunakan pedoman* Synthesis Without Meta-Analysis (SWiM). *Hasil menunjukkan bahwa tantangan teknologi—seperti konektivitas internet yang tidak stabil, kurangnya interoperabilitas perangkat, dan masalah pasokan listrik—merupakan masalah umum dalam implementasi di daerah pedesaan. Keterbatasan organisasi mencakup pelatihan yang tidak memadai, resistensi terhadap perubahan alur kerja, dan kendala keuangan. Masalah etika terutama melibatkan* informed consent, *keamanan data, dan privasi, yang seringkali diperburuk oleh lemahnya struktur regulasi dan rendahnya literasi digital. Meskipun terdapat berbagai hambatan, keberhasilan implementasi ditandai dengan keterlibatan komunitas, strategi integrasi bertahap, dan kerangka kerja yang disesuaikan secara budaya. Tinjauan ini menekankan perlunya pendekatan komprehensif yang menggabungkan pengembangan infrastruktur, kesiapan tenaga kerja, dan perlindungan etika yang kontekstual secara lokal. Temuan ini memberikan landasan penting bagi pembuat kebijakan, perancang sistem, dan praktisi kesehatan yang ingin memperluas solusi kesehatan digital di wilayah dengan sumber daya terbatas.*

Kata Kunci: *hambatan implementasi, kesehatan* IoT, *kesetaraan kesehatan digital, sistem kesehatan pedesaan, tantangan etika*

Introduction

The emergence of the Internet of Things (IoT) is reshaping contemporary healthcare by enabling the remote collection, transmission, and analysis of patient information through connected devices and digital systems (Li et al., 2024). This technological innovation offers significant potential to improve rural healthcare systems, where challenges such as geographic factors, resource scarcity, and limited access to medical professionals persistently hamper the delivery of quality care (Castillo et al., 2023). The use of IoT sensors, mobile health applications, and cloud-based systems within the community promotes timely health monitoring and data-driven clinical decisions by healthcare professionals, enhancing health services and outcomes in marginalized and remote communities (Hayudini & Escorial, 2025; Shafi et al., 2024).

Despite the theoretical advantages of IoT-based healthcare systems, their practical implementation in rural settings remains fraught with challenges. Technological barriers such as unreliable internet connectivity, power interruptions, and device interoperability issues frequently undermine the functionality and sustainability of IoT deployments (López et al., 2023). Furthermore, the systems' success does not depend solely on infrastructure. Organizational preparedness—including staff training, workflow adaptation, and the availability of financial and technical resources—is equally critical in determining system uptake and longevity (Meunier et al., 2023).

Ethical considerations further complicate implementation, particularly in contexts characterized by digital illiteracy and limited regulatory oversight (Roossien et al., 2021). Concerns regarding confidentiality, data ownership, consent, and the equitable distribution of healthcare services arise from the collection, transmission, and storage of sensitive health information. In many cases, rural healthcare providers lack the frameworks and tools necessary to ensure ethical compliance, leaving patients vulnerable to breaches of trust and privacy (Keenan et al., 2022).

Given the overlapping barriers and their complexity, this study aims to systematically review the empirical literature on the implementation and deployment of IoT healthcare systems in underprivileged regions, focusing on identifying and synthesizing the key technological, organizational, and ethical challenges reported across diverse locations and implementation approaches. By examining the pivotal factors that contributed to the success and failure of IoT healthcare implementations, this review seeks to offer valuable insights that can guide the development of future policies, system design, and implementation strategies to enhance accessibility and promote equitable healthcare services in underserved areas.

Methods

This systematic review examined and synthesized the technological, organizational, and ethical barriers to implementing IoT-based healthcare systems in rural and underserved settings. ScienceDirect, ProQuest, PubMed, Sage Journals, Taylor & Francis, and Google Scholar were used to identify relevant studies systematically. The search targeted peer-reviewed articles published between 2015 and 2025. The terms "Internet of Things," "IoT," "telehealth," "remote health monitoring," and "mobile health" were combined with "rural healthcare," "underserved regions," "technological challenges," "organizational barriers," and "ethical issues."

To include only empirical studies on rural IoT implementation, selection criteria were used. Studies that deployed IoT healthcare technologies and discussed infrastructure and device reliability, human resource and workflow challenges, or ethical issues like privacy and consent were eligible. Theoretical, non-English, review, and missing-text articles were excluded. The search found 1,921,662 records. After excluding 1,576,753 records for relevance and duplicates, 344,909 remained for abstract screen-

Table 1. Description of PICO Components

PICO	Description
People/ Participants	Rural healthcare providers and community health systems in underserved regions across Africa, Asia, North America, and Latin America.
Intervention	Implementation of IoT-based healthcare systems, including telehealth, remote monitoring, and mobile health technologies.
Comparison	Traditional, non-IoT-based healthcare delivery systems in similar rural settings.
Outcomes	Identification and evaluation of technological barriers (connectivity, device compatibility, maintenance), organizational challenges (training, workflow integration, resource allocation), and ethical concerns (data privacy, patient confidentiality, informed consent).

Table 2. Risk of Bias Assessment for Quasi-Experimental Design

Author & Year [sample respondents']	JBI assessment tools										Interpretation[b]
	Q1[a]	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	% Yes	
Arnaert et al. (2019). [n=71]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100%	Low risk of bias
Boonchieng et al. (2021). [n=75]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100%	Low risk of bias
Bressan et al. (2022). [n=N/A]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100%	Low risk of bias
Fischer et al. (2024). [n=N/A]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100%	Low risk of bias
Geetha & Sankar (2020). [n=N/A]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100%	Low risk of bias
Harris et al. (2016). [n=N/A]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100%	Low risk of bias

*Notes:

[a] Q1 – Q9 indicates questions 1 to 9 based on the JBI risk assessment

[b] The risk of bias was ranked as high when the study reached up to 49% of "yes" scores, moderate when the study reached from 50 to 69% of "yes" scores, and low when the study reached more than 70% of "yes" scores

[c] Not means "Unclear."

ing. After reading 91 full-text studies, 11 were selected for qualitative analysis based on the inclusion criteria.

Table 1 shows the structured PICO framework that guided study design. Rural healthcare providers and community health systems in Africa, Asia, North America, and Latin America were of interest. Telehealth, mobile health apps, and remote monitoring powered by IoT were the interventions under study. These were compared to non-IoT healthcare delivery systems in similar settings. The outcome measures identified and assessed technological (connectivity and maintenance), organizational (staff training and workflow integration), and ethical (data privacy and informed consent) barriers.

Four reviewers (MAH, HKP, AJJ, and JTA) collaborated on article screening, with AAC and JMJ resolving disagreements. Full-text readings were done after keyword searches and title/abstract screening to ensure each study met eligibility criteria. Data was extracted using a template to ensure reviewer consistency. Study location, publication year, research methodology, intervention model, IoT technology used, and implementation challenges were key data. System integration, stakeholder engagement, and the effects on healthcare delivery were also recorded. This provided insights into individual and comparative studies.

The Joanna Briggs Institute (JBI) checklist for quasi-experimental and observational studies,

Table 3. ROBVIS Risk of Bias Tool for RCT

Author (s) & year	Sample size (n)	Allocation concealment	Blinding	Incomplete outcome data	Selective reporting	Other bias	Overall
Kuntagod et al. (2014)	N/A	+	?	+	?	?	?
Leader et al. (2023)	N/A	+	+	+	+	+	+
Pourhomayoun et al. (2017)	600	+	+	+	+	?	+
Serafini et al. (2022)	N/A	+	?	?	?	?	?
Takenga et al. (2020)	N/A	+	+	+	+	+	+

*Note: (+) indicates a low risk of bias, (-) indicates a high risk of bias, (?) shows unclear risk of bias

and the Critical Appraisal Skills Programme (CASP) checklist for randomized controlled trials, were used to assess quality. ROBVIS visualized bias domains. Table 2 summarizes quasi-experimental JBI assessment results. All six quasi-experimental studies—including Arnaert et al. (2019), Boonchieng et al. (2021), and Bressan et al. (2022)—met all nine criteria, demonstrating methodological rigor and low bias.

ROBVIS showed more RCT quality variation. Table 3 details the bias evaluation for these five studies. Leader et al. (2023) and Takenga et al. (2020) found low bias in all domains. However, Kuntagod et al. (2014) and Serafini et al. (2022) found several unclear risk areas, particularly blinding and selective reporting. Pourhomayoun et al. (2017) had one unclear risk in the “Other Bias” category, but otherwise it was good.

Following data collection and validation, thematic analysis was used to identify patterns across reviewed studies using the Synthesis Without Meta-Analysis (SWiM) framework. Themes included technological barriers (e.g., unstable connectivity, hardware failures), organizational constraints (e.g., lack of training, insufficient funding, integration problems), and ethical concerns (e.g., patient confidentiality, consent management). These challenges were mapped across rural regions using comparative synthesis to assess their frequency and severity in different socio-geographic contexts.

Due to heterogeneity in study design and outcome measures, narrative summaries replaced statistical effect sizes. However, the systematic synthesis identified both barriers and enablers to IoT implementation. This method revealed both the nature of these challenges and the contextual strategies that affected deployment success or failure, informing future digital health implementation for underserved communities.

Results

A total of 1,921,662 academic articles were initially identified through a comprehensive database search focusing on the implementation challenges of IoT-based healthcare systems in rural and underserved communities. After broad exclusion criteria were applied to eliminate duplicates, non-relevant studies, and theoretical literature, 1,576,753 records were removed. This left 344,909 articles for title and abstract screening. Through a multi-phase review process, articles were selected based on relevance to the research question, empirical research design, rural healthcare focus, inclusion of health professionals as participants, and the availability of full-text English versions. This process narrowed the eligible studies to 91, with four more articles retrieved through reference list screening. Ultimately, after rigorous methodological quality assessments, 11 studies were included for final analysis. The article screening process is summarized in Figure 1, using the PRISMA 2020 flow diagram to visualize each stage from identification to inclusion.

The selected studies reflected broad geographic representation, spanning from three remote vil-

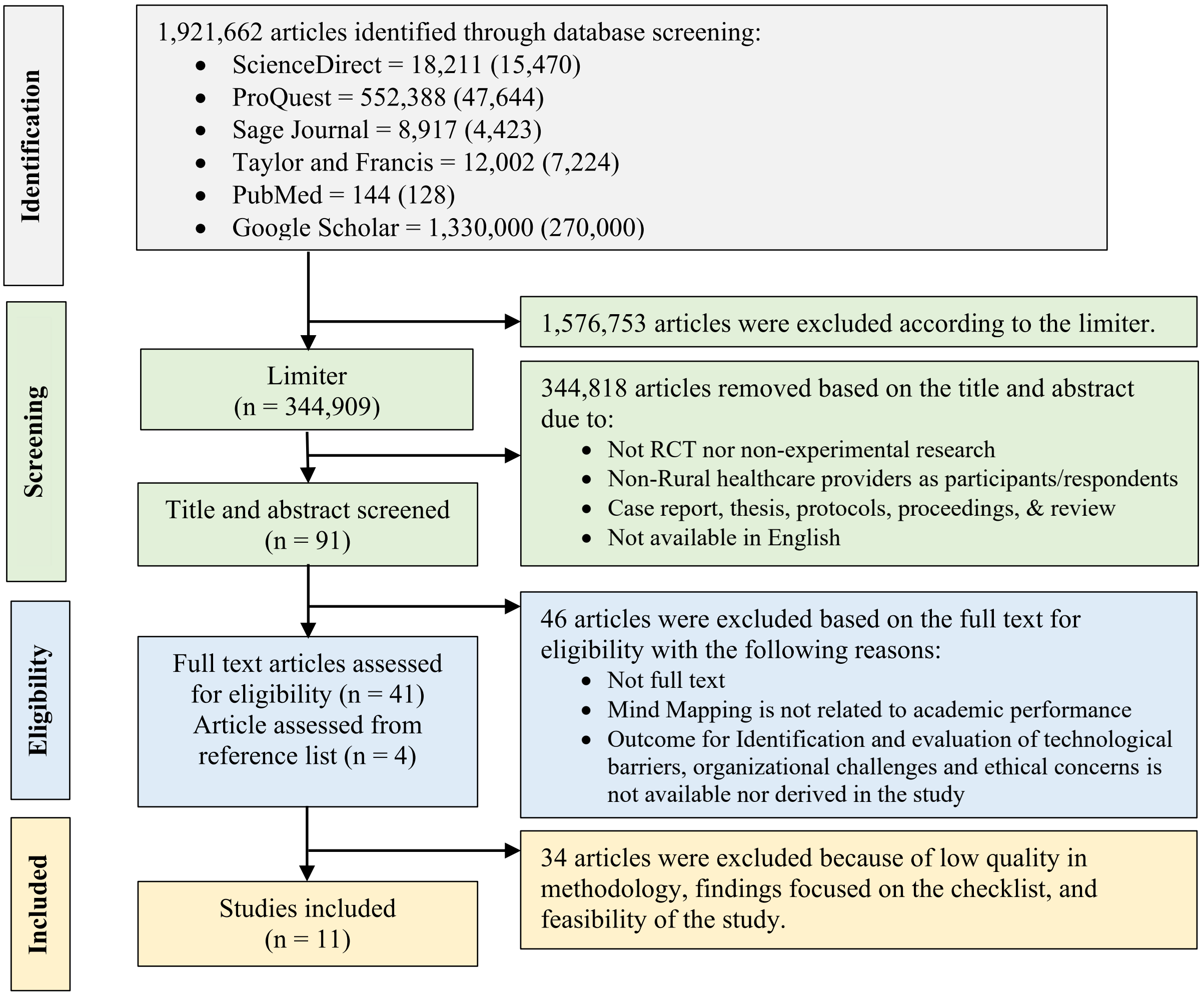

Figure 1. PRISMA flowchart

lages in Burkina Faso to multi-region deployments in the Peruvian Amazon, and from isolated Indigenous communities in northern Saskatchewan to rural hospital networks in Germany and sub-Saharan Africa. Some studies were small-scale pilots in single health centers, others were large-scale studies. In contrast, others involved extended regional implementations, such as in Thailand, where one digital health project began in a single district and expanded to 75 more. Other studies focused on specific populations, including HIV-positive women in rural India, where wearable body sensors were deployed for continuous health monitoring.

As shown in Table 4, the technologies used across studies were diverse, ranging from basic mobile health tools and smartphone apps to more complex systems such as remote health monitoring networks, telerobotic systems for procedures, telehealth stations, and GIS-integrated platforms. For instance, Arnaert et al. (2019) used a cloud-based monitoring system and mobile devices in Burkina Faso. However, they faced significant barriers, including poor internet and electricity infrastructure and cultural and language-related constraints. Similarly, Boonchieng et al. (2021) noted technical and compatibility issues in Thailand during the expansion of mobile health and GIS systems. Studies by Pourhomayoun et al. (2017) and Takenga et al. (2020) reported persistent challenges in transmitting patient data in areas with limited broadband access, particularly in rural India and

Table 4. Characteristics of Included Studies

Study	Study Context	Implementation Scale	Technology Type	Primary Challenges
Arnaert et al. (2019)	Rural Burkina Faso	Three villages covered by Centre de Santé et de Promotion Sociale (CSPS) Diapangou.	Smartphones, laptops, and cloud-based telemonitoring platforms.	Internet connectivity, electricity access, and cultural/language barriers.
Boonchieng et al. (2021)	Semi-rural district in Thailand	Initial implementation in one district, expanded to 75 other districts.	Mobile health, Geographic Information System (GIS).	Technical issues with mobile devices, internet coverage, and the GIS application.
Bressan et al. (2022)	Peruvian Amazon	Multiple regions.	Biomedical technologies (non-specific).	Connectivity, electricity, cultural factors, and corruption.
Fischer et al. (2024)	Rural communities (location not specified)	Multiple rural community centers.	Telehealth stations.	Acceptance, cost concerns, and the need for assistance in scheduling.
Geetha & Sankar (2020)	Rural communities (location not specified)	Rural Communities	IoT-based health monitoring system	Challenges in IoT implementation in remote communities
Harris et al. (2016)	Rural Appalachian Kentucky	Network of Federally Qualified Community Health Centers.	Collaborative healthcare research and analysis network.	Data access, integration, and technical infrastructure.
Kuntagod et al. (2014)	Rural areas in low and middle-income countries	No mention found.	Smartphone-based healthcare system.	Limited health workers' skills, lack of low-cost technology, and poor service utilization.
Leader et al. (2023)	Northern Saskatchewan, Canada	Four rural and remote Indigenous communities.	Telehealth systems.	Broadband access, spatial constraints, and community engagement.
Pourhomayoun et al. (2017)	Rural parts of India	A study involving 600 women with HIV/AIDS.	Body Sensor Networks, Remote Health Monitoring Systems.	Data transmission in areas with poor network connections.
Serafini et al. (2022)	Rural community hospital (location not specified)	Single rural community hospital.	Telerobotic cardiac catheter ablation system.	Team communication, emergency management.
Takenga et al. (2020)	Rural regions of Germany and sub-Saharan Africa	Multiple rural and remote regions.	Telehealth system.	Geographical barriers, data security, and privacy compliance.

parts of sub-Saharan Africa. Even in relatively higher-income countries like Germany and Canada, geographical and spatial limitations, coupled with community hesitancy or the need for specialized training, hindered wide-spread IoT adoption.

The thematic analysis of these studies revealed overlapping patterns of challenges across settings. Technological barriers were the most frequently cited, particularly in low-resource environments where unstable electricity, poor internet infrastructure, and limited availability of technical support disrupted the intended functionality of IoT systems. Organizational hurdles included a lack of training among healthcare workers, insufficient capacity to integrate digital workflows, and limited funding for long-term system maintenance. Moreover, ethical concerns were prominent. Ensuring the confidentiality of patient data, securing informed consent, and safeguarding access to private consultations emerged

Table 5. Implementation Success Factors

Factor Category	Implementation Requirements	Success Indicators	Risk Mitigation
Technical Infrastructure	Reliable internet connectivity; Appropriate device selection; Robust system design	Successful data transmission, System uptime, User satisfaction with technology	Offline functionality; Backup power sources; Regular system maintenance
Organizational Readiness	Healthcare provider training; Workflow integration; Resource allocation	Improved provider efficiency; Seamless integration with existing processes; Sustainable funding model	Comprehensive training programs; Phased implementation; Diverse funding sources
Community Engagement	User education; Cultural sensitivity; Stakeholder involvement	High user acceptance rates, Community ownership of the project, and Increased healthcare service utilization	Community co-design processes; Local language support; Regular community feedback mechanisms
Ethical Compliance	Data security measures; Privacy protection protocols; Equitable access strategies	Compliance with data protection regulations; Maintained patient confidentiality; Reduced healthcare disparities	Robust encryption; Clear consent procedures; Targeted outreach to underserved groups

as significant issues, especially in settings where medical confidentiality is difficult to guarantee, such as communal health settings or areas with low digital literacy.

Despite these obstacles, several studies identified specific factors that contributed to successful IoT healthcare implementation. As summarized in Table 5, these factors were organized under four domains: technical infrastructure, organizational readiness, community engagement, and ethical compliance. Technical success hinged on strong internet connections, reliable, context-appropriate hardware, and system designs capable of operating with minimal downtime. In several studies, offline capabilities and solar-powered solutions were cited as effective responses to unstable power grids.

In terms of organizational preparation, phased rollouts, intensive training sessions, and flexible workflows contributed to improved staff efficiency and smoother transitions. Financial readiness, often through donor-supported or government-backed programs, was also key to sustaining system operations beyond initial pilot phases. The importance of engaging the local population was consistent across nearly all studies. High user acceptance correlated with culturally appropriate content, early stakeholder involvement, and the use of local languages in system interfaces and health materials. Ethically, the most effective implementations were those that addressed digital privacy upfront, employing strong encryption protocols and consent procedures adapted to the literacy levels and cultural expectations of the communities served.

Collectively, the results demonstrated that while IoT-based healthcare systems offer substantial promises for addressing gaps in rural health delivery, their success is tightly bound to a constellation of factors—both technical and human. Understanding these interrelated dimensions provides the necessary groundwork for future efforts aiming to expand innovative health solutions in remote settings.

Discussion

The increasing adoption of IoT technologies is reshaping healthcare systems, especially in efforts to expand access and reduce disparities in rural and underserved areas (Li et al., 2024; Shafi et al., 2024). Based on a synthesis of eleven empirical studies, this review outlines the primary implementation challenges of IoT healthcare systems, categorized into technological, organizational, and ethical domains. Though presented separately, these categories often intersect and influence the overall effectiveness and fairness of digital healthcare systems (Castillo et al., 2023).

Technological limitations were the most reported barriers, particularly in areas like the Peruvian Amazon and rural Burkina Faso, where unstable internet, device incompatibility, and inconsistent power supply disrupted system performance (Arnaert et al., 2019; Bressan et al., 2022). Even in more developed rural regions, such as northern Saskatchewan, challenges included community hesitancy and spatial limitations despite partial internet access (Leader et al., 2023). Some studies suggested offline or hybrid models to address infrastructure gaps (Pourhomayoun et al., 2017), but such systems still rely on trained personnel who are often in short supply. Without improving both infrastructure and technical capacity, digital health tools may fall short of expectations (López et al., 2023).

Organizational readiness also plays a crucial role. In Thailand, India, and Uganda, healthcare workers faced difficulties integrating new tools due to limited digital skills and insufficient training (Boonchieng et al., 2021). These challenges were further complicated by underfunding and staffing shortages typical in rural health systems (Morris et al., 2023). Still, studies that involved frontline workers in early planning stages and introduced systems gradually saw better outcomes. However, some scholars cautioned against prioritizing digital solutions over more urgent needs like essential medicines and sanitation (Roossien et al., 2021), suggesting that technological innovation should complement, not replace, foundational health services.

Ethical challenges—particularly around data privacy, consent, and equitable access—were consistent across studies. In communities with low literacy, digital consent processes were often misunderstood, raising concerns about whether informed consent was truly achieved (Miiro et al., 2022). Weak regulatory environments made sensitive health data more vulnerable, especially in places lacking encryption or private consultation spaces (Mishkin et al., 2023). These concerns are not limited to low-resource settings; even in more advanced systems, ethical frameworks have struggled to keep pace with rapid technological growth (Perez-Pozuelo et al., 2021). Some scholars advocate for locally grounded ethical standards, warning that universal models often fail to reflect cultural expectations or realities. Ownership of health data remains unclear in many contexts, further complicating trust and accountability.

The interaction between these challenges is significant. Weak infrastructure can compromise data security, while poor staff training increases the risk of ethical lapses such as mishandled records or inadequate consent processes (Iyamu et al., 2022). Conversely, participatory approaches—such as involving communities in early design stages and gradually implementing systems—helped improve data handling, ethical safeguards, and overall engagement. However, such approaches may be less effective in emergencies, where faster, centralized responses are needed (Takenga et al., 2020).

The findings underscore the need for integrated strategies that go beyond device deployment. Sustainable implementation requires investments in stable internet, reliable power, and user-friendly devices. Training programs must reflect real-world field conditions, and ethical practices must align with local cultural norms (Mumtaz et al., 2023). Trust-building through culturally sensitive engagement is essential, particularly in communities that have been historically underserved or excluded (Brockman et al., 2023).

Linking IoT tools with familiar public health programs, such as maternal care or community health networks, may improve adoption and acceptance.

Digital tools alone cannot improve rural healthcare outcomes, according to the review. Human, structural, and ethical dimensions must be addressed together. Community involvement was crucial to system sustainability and trust. Data governance policies must be clear and enforceable for long-term accountability.

This review has several limitations. First, the inclusion criteria limited the scope to English-language studies published between 2015 and 2025, potentially excluding relevant local or non-English research. Second, the heterogeneity of study contexts, designs, and methodological approaches limited opportunities for direct comparison and precluded meta-analytic synthesis. Third, the absence of longitudinal follow-up in many studies constrained the assessment of long-term outcomes and sustainability. Finally, the exclusion of theoretical and conceptual works may have overlooked foundational frameworks essential for ethical considerations and early-stage system design.

Conclusion

This review discusses the challenges of implementing IoT-based healthcare in rural areas, including limited infrastructure, unprepared healthcare staff, and ethical issues. The technology has great potential to improve healthcare in remote communities, but unreliable internet connections, gaps in health worker training, and a lack of data management guidelines hinder its use. Future adoption will require policy reform, community participation, and ethical safeguards that promote privacy, equity, and public trust, not just technology.

Long-term research on the impact and practicality of these digital health tools in rural areas is needed to understand their long-term performance. Research should also examine how locally driven ethical practices can be developed, how regional outcomes compare, and how theoretical frameworks can guide implementation. To create effective, resilient, and rural-specific digital health systems, governments, tech developers, and community stakeholders must work together at the policy level.

References

Arnaert, A., Ponzoni, N., Sanou, H., & Nana, N.G. (2019). Using the BELT framework to implement an mHealth pilot project for preventative screening and monitoring of pregnant women in Rural Burkina Faso, Africa. *Telehealth and Medicine Today, 4*, 1–10. doi: 10.30953/tmt.v4.100.

Boonchieng, W., Chaiwan, J., Shrestha, B., Shrestha, M., Dede, A.J.O., & Boonchieng, E. (2021). mHealth technology translation in a limited resources community—Process, challenges, and lessons learned from a limited resources community of Chiang Mai Province, Thailand. *IEEE Journal of Translational Engineering in Health and Medicine, 9,* 1–8. doi: 10.1109/JTEHM.2021.3055069.

Bressan, T., Valdivia-Gago, A., Silvera-Ccallo, R.M., Llanos-Cuentas, A., Condor, D.F., Padilla-Huamantinco, P.G., Vilcarromero, S., Miranda, J.J., & Zavaleta-Cortijo, C. (2022). Challenges of design, implementation, acceptability, and potential for, biomedical technologies in the Peruvian Amazon. *International Journal for Equity in Health, 21* (1), 183. doi: 10.1186/s12939-022-01773-7.

Brockman, T.A., Shaw, O., Wiepert, L., Nguyen, Q.A., Kelpin, S.S., West, I., Albertie, M., Williams, S., Abbenyi, A., Stephenson, N., Almader-Douglas, D., & Patten, C.A. (2023). Community engagement strategies to promote recruitment and participation in clinical research among rural communities: A narrative review. *Journal of Clinical and Translational Science, 7* (1), e84. doi: 10.1017/cts.2023.16.

Castillo, V.S., Cano, C.A.G., & Gonzalez-Argote, J. (2023). Telemedicine and mHealth applications for health monitoring in rural communities in Colombia: A systematic review. *EAI Endorsed Transactions on Pervasive Health and Technology, 9,* e5. doi: 10.4108/eetpht.9.3400.

Fischer, B., Jackson, Y., Roberts, C., Robinson, C., Early, R., & Sprang, R. (2024). Increasing primary and specialty healthcare access for rural older adults: Facilitators, barriers, and opportunities of telehealth in rural community centers. *Alzheimer's and Dementia, 20* (S8), e095045. doi: 10.1002/alz.095045.

Geetha, N., & Sankar, A. (2020). An intelligent IoT-based health monitoring system for tribal people. In *Incorporating the internet of things in healthcare applications and wearable devices* (pp. 137–149). IGI Global. doi: 10.4018/978-1-7998-1090-2.ch008.

Harris, D.R., Harper, T.J., Henderson, D.W., Henry, K.W., & Talbert, J. (2016). Informatics-based challenges of building collaborative healthcare research and analysis networks from rural community health centers. *IEEE-EMBS International Conference on Biomedical and Health Informatics, 2016*, 513–516. doi: 10.1109/BHI.2016.7455947.

Hayudini, M., & Escorial, J.E.A.A. (2025). Community-based healthcare automation: Development of integrated IoT sensor devices with mobile and web monitoring systems. In *2025 IEEE Symposium on Industrial Electronics & Applications (ISIEA)* (pp. 1–10). IEEE. 10.1109/ISIEA65768.2025.11138339.

Iyamu, I., Gómez-Ramírez, O., Xu, A.X., Chang, H.J., Watt, S., Mckee, G., & Gilbert, M. (2022). Challenges in the development of digital public health interventions and mapped solutions: Findings from a scoping review. *Digital Health, 8,* 20552076221102255. doi: 10.1177/20552076221102255.

Keenan, A. J., Tsourtos, G., & Tieman, J. (2022). Promise and peril-defining ethical telehealth practice from the clinician and patient perspective: A qualitative study. *Digital Health, 8,* 20552076211070394. doi: 10.1177/20552076211070394.

Kuntagod, N., Paul, S., Kumaresan, S., & Ganti, S. (2014). Practical challenges for large-scale deployment of mHealth solution insights from a field trial. *IEEE Global Humanitarian Technology Conference,* 235–241, doi: 10.1109/GHTC.2014.6970287.

Leader, J., Bighead, C., Hunter, P., & Sanderson, R. (2023). "Working on a Shoestring": Critical resource challenges and place-based considerations for telehealth in Northern Saskatchewan, Canada. *Journal of Bioethical Inquiry*, *20,* 215–223. doi: 10.1007/s11673-023-10233-y.

Li, C., Wang, J., Wang, S., & Zhang, Y. (2024). A review of IoT applications in healthcare. *Neurocomputing, 565,* 127017. doi: 10.1016/j.neucom.2023.127017.

López, O.L.A., Rosabal, O.M., Ruiz-Guirola, D.E., Raghuwanshi, P., Mikhaylov, K., Lovén, L., & Iyer, S. (2023). Energy-Sustainable IoT connectivity: Vision, Technological enablers, challenges, and future directions. *IEEE Open Journal of the Communications Society, 4,* 2609–2666. doi: 10.1109/OJCOMS.2023.3323832.

Meunier, P.-Y., Raynaud, C., Guimaraes, E., Gueyffier, F., & Letrilliart, L. (2023). Barriers and facilitators to the use of clinical decision support systems in primary care: A mixed-methods systematic review. *The Annals of Family Medicine, 21* (1), 57–69. doi: 10.1370/afm.2908.

Miiro, C., Ndawula, J.C., Musudo, E., Nabuuma, O.P., Mpaata, C.N., Nabukenya, S., Akaka, A., Bebembeire, O., & Sanya, D. (2022). Achieving optimal heath data impact in rural African healthcare settings: measures to barriers in Bukomansimbi District, Central Uganda. *International Journal for Equity in Health, 21* (1), 187. doi: 10.1186/s12939-022-01814-1.

Mishkin, A.D., Zabinski, J.S., Holt, G., & Appelbaum, P.S. (2023). Ensuring privacy in telemedicine: Ethical and clinical challenges. *Journal of Telemedicine and Telecare, 29* (3), 217–221. doi: 10.1177/1357633x221134952.

Morris, M.E., Brusco, N.K., Jones, J., Taylor, N.F., East, C.E., Semciw, A.I., Edvardsson, K., Thwaites, C., Bourke, S.L., Raza Khan, U., Fowler-Davis, S., & Oldenburg, B. (2023). The widening gap between the digital capability of the care workforce and technology-enabled healthcare delivery: A nursing and allied health analysis. *Healthcare, 11* (7), 994. doi: 10.3390/healthcare11070994.

Mumtaz, H., Riaz, M.H., Wajid, H., Saqib, M., Zeeshan, M.H., Khan, S.E., Chauhan, Y.R., Sohail, H., & Vohra, L.I. (2023). Current challenges and potential solutions to the use of digital health technologies in evidence generation: A narrative review. *Frontiers in Digital Health, 5,* 1203945. doi: 10.3389/fdgth.2023.1203945.

Perez-Pozuelo, I., Spathis, D., Gifford-Moore, J., Morley, J., & Cowls, J. (2021). Digital phenotyping and sensitive health data: Implications for data governance. *Journal of the American Medical Informatics Association, 28* (9), 2002–2008. doi: 10.1093/jamia/ocab012.

Pourhomayoun, M., Alshurafa, N., Dabiri, F., Yadav, K., Sideris, C., Tseng, L.Y., Ghasemzadeh, H., Nyamathi, A., & Sarrafzadeh, M. (2017). A robust remote health monitoring and data processing system for rural area with limited internet access. *11th International Conference on Body Area Networks*. doi: 10.4108/eai.15-12-2016.2267661.

Roossien, C.C., de Jong, M., Bonvanie, A.M., & Maeckelberghe, E.L.M. (2021). Ethics in design and implementation of technologies for workplace health promotion: A call for discussion. *Frontiers in Digital Health, 3*, 644539. doi: 10.3389/fdgth.2021.644539.

Serafini, B., Kim, L., Saour, B., James, R., Hannaford, B., Hansen, R., Kohno, T., Monsky, W., & Seslar, S.P. (2022). Exploring telerobotic cardiac catheter ablation in a rural community hospital: A pilot study. *Cardiovascular Digital Health Journal, 3* (6), 313–319. doi: 10.1016/j.cvdhj.2022.10.003.

Shafi, I., Din, S., Farooq, S., Díez, I.T., Breñosa, J., Espinosa, J.C.M., & Ashraf, I. (2024). Design and development of patient health tracking, monitoring and big data storage using Internet of Things and real time cloud computing. *PLoS ONE, 19* (3), e0298582. doi: 10.1371/journal.pone.0298582.

Takenga, C., Preik, P., Berndt, R.D., Arnold, A., Juenger, M., & Vikandy, M. (2020). Design of a telehealth system adapted for health care delivery in rural areas: Tele-consults between general practitioners and specialists. *International Journal of Innovation and Scientific Research, 48* (2), 38-46. Retrieved from https://ijisr.issr-journals.org/abstract.php?article=IJISR-19-322-01