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IoT in Healthcare: Infrastructure Challenges and Technical Feasibility for Adoption in Resource-Constrained Settings

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Abstract. The integration of Internet of Things (IoT) technologies into healthcare is increasingly recognized as vital for improving patient outcomes, enhancing system efficiency, and addressing global health challenges. However, in resource-constrained settings, adoption faces significant barriers that are often overlooked in existing literature. While prior studies emphasize IoT's broad benefits, they provide limited empirical evidence on how devices perform under unstable connectivity, how they integrate with legacy hospital systems, and how they remain dependable amidst frequent power outages. This study therefore aimed to critically examine the infrastructure challenges and technical feasibility of IoT adoption in healthcare within such environments. Using the PRISMA methodology, a systematic review of peer-reviewed articles published between 2021 and 2025 was conducted across IEEE Xplore, PubMed, Scopus, and Web of Science, focusing on connectivity, interoperability, and reliability. The findings revealed that unstable internet connectivity, poor system integration, and limited fault tolerance and power resilience are the most pressing challenges. The results underscore the need for context-specific frameworks that strengthen connectivity resilience, enable seamless interoperability with fragmented systems, and ensure robust reliability safeguards. In conclusion, while IoT holds transformative potential for healthcare delivery, its sustainable adoption in resource-constrained settings depends on innovative, resilient, and context-driven solutions tailored to infrastructural realities.

Keywords: Connectivity; Interoperability; Reliability; Internet of Things; Healthcare; Resource-constrained settings

1. INTRODUCTION

The integration of Internet of Things (IoT) technologies into healthcare has become a significant area of academic and practical inquiry, driven by the growing demand for innovative solutions to improve patient outcomes and operational efficiency [1]. Existing literature highlights the potential of IoT to transform healthcare delivery through remote patient monitoring, smart hospital infrastructure, and predictive analytics [2, 3]. Scholars emphasize its role in addressing global health challenges, including chronic disease management, aging populations, and the need for cost-effective care models [4].

Despite these recognized benefits, the adoption of IoT in resource-constrained settings presents distinct infrastructural challenges. Limited and unstable connectivity, difficulties in achieving interoperability with legacy hospital information systems, and reliability concerns under frequent power outages directly affect the technical feasibility and long-term sustainability of IoT deployments [5]. These constraints are particularly pronounced in rural and low-resource regions, where digital health innovations must operate under conditions far removed from those assumed in high-income settings.

This area of inquiry is therefore critical to the broader academic discourse. By examining IoT adoption through the lens of infrastructural and technical constraints, researchers can contribute both to theoretical advancement and to the development of practical frameworks that inform policy, system design, and equitable access to digital health technologies [6].

Although IoT applications in healthcare have been extensively studied, much of the existing literature emphasizes broad adoption benefits while giving insufficient attention to the infrastructural realities of resource-constrained environments. Specifically, three interrelated gaps persist:

1) Limited empirical evidence on how IoT devices perform under unstable or low-bandwidth connectivity, a common condition in rural and developing regions.
2) Insufficient frameworks for integrating IoT solutions with outdated or heterogeneous hospital information systems, where interoperability across diverse devices and data formats remains unresolved.

3) Inadequate attention to reliability concerns, including device failure and power outages, with few studies proposing resilient architectures or backup mechanisms capable of safeguarding continuous patient care.

These gaps underscore the need for context-specific investigations into connectivity resilience, legacy system integration, and reliability safeguards to support feasible and sustainable IoT adoption in healthcare.

The primary objective of this study is to critically examine the infrastructure challenges and technical feasibility of adopting IoT technologies in healthcare within resource-constrained settings. Specifically, the study seeks to:

1) Evaluate how IoT devices can maintain functionality under limited or unstable internet connectivity.
2) Explore strategies for integrating new IoT solutions with legacy hospital information systems.
3) Assess reliability safeguards against device failures and power outages that threaten continuous care delivery.

2. METHODS

This study employed a systematic literature review guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [PRISMA reference if available]. The review was designed to ensure methodological rigor, transparency, and reproducibility in identifying and synthesizing evidence on infrastructure challenges affecting IoT adoption in healthcare within resource-constrained settings.

2.1. Search Strategy

A comprehensive literature search was conducted across four major academic databases: IEEE Xplore, PubMed, Scopus, and Web of Science. These databases were selected for their coverage of engineering, medical, and interdisciplinary research relevant to IoT and digital health. The search was limited to peer-reviewed articles published in English between 1 January 2021 and 31 December 2025.

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The search strategy combined controlled vocabulary and free-text terms using Boolean operators. Core search strings included variations of the following:

("Internet of Things" OR IoT OR "Internet of Medical Things" OR IoMT) AND (healthcare OR "health care" OR hospital OR "digital health") AND (connectivity OR interoperability OR reliability OR "infrastructure challenges" OR "resource-constrained" OR "low-resource" OR "developing countries" OR rural)

Reference lists of included articles and relevant review papers were also screened (snowballing) to identify additional eligible studies.

2.2. Eligibility Criteria

Inclusion criteria were as follows:

1) Peer-reviewed original research articles, systematic reviews, or technical reports published between 2021 and 2025.
2) Studies that explicitly addressed at least one of the following themes in the context of IoT in healthcare: connectivity (e.g., bandwidth, latency, network stability), interoperability (e.g., integration with legacy systems, data standards), or reliability (e.g., fault tolerance, power resilience, device uptime).
3) Studies conducted in or focused on resource-constrained, low-resource, rural, or developing-country healthcare settings, or that discussed technical solutions applicable to such environments.

Exclusion criteria were as follows:

1) Articles focused exclusively on high-income or well-resourced settings without transferable insights for constrained environments.
2) Studies that addressed only clinical or economic outcomes without discussing technical infrastructure challenges.
3) Non-peer-reviewed materials, editorials, opinion pieces, conference abstracts without full text, and duplicate publications.
4) Articles not available in English.

2.3. Study Selection Process

All retrieved records were imported into a reference management tool and duplicates were removed. Two independent reviewers screened titles and abstracts against the eligibility criteria. Full texts of potentially relevant articles were then assessed. Disagreements were resolved through discussion or consultation with a third reviewer. The selection process followed the PRISMA flow diagram structure (identification, screening, eligibility, and inclusion).

2.4. Quality Appraisal

Included studies underwent critical appraisal using standardized checklists appropriate to study design (e.g., CASP for qualitative and review studies, or domain-specific technical quality criteria for engineering papers). Appraisal focused on methodological clarity, relevance to resource-constrained contexts, risk of bias, and transparency of reporting. Studies judged to have critical methodological flaws that compromised the validity of findings related to connectivity, interoperability, or reliability were excluded or flagged during synthesis.

2.5. Data Extraction and Synthesis

A standardized data extraction form was used to capture study characteristics (authors, year, setting, study type), technical focus (connectivity, interoperability, reliability), key findings, proposed solutions or frameworks, and reported limitations. Data were synthesized thematically. Frequency counts of recurring terms and concepts within each theme were compiled to illustrate the relative prominence of specific challenges. Narrative synthesis was then used to integrate findings across studies, identify patterns, and map results against the research objectives.

3. RESULTS AND DISCUSSION

The systematic search and screening process yielded a body of literature that, while extensive on general IoT applications in healthcare, revealed comparatively limited focused attention on infrastructure challenges specific to resource-constrained settings. The included studies were synthesized under three interrelated themes aligned with the research objectives: connectivity resilience, interoperability with legacy systems, and reliability and continuity of care.

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3.1. Connectivity Resilience

Analysis of the literature identified network stability as the most frequently reported connectivity challenge, followed by bandwidth limitations and network latency (Figure 1). These findings indicate that IoT devices deployed in resource-constrained environments frequently encounter unreliable or insufficient internet access, which compromises real-time data transmission and remote monitoring capabilities.

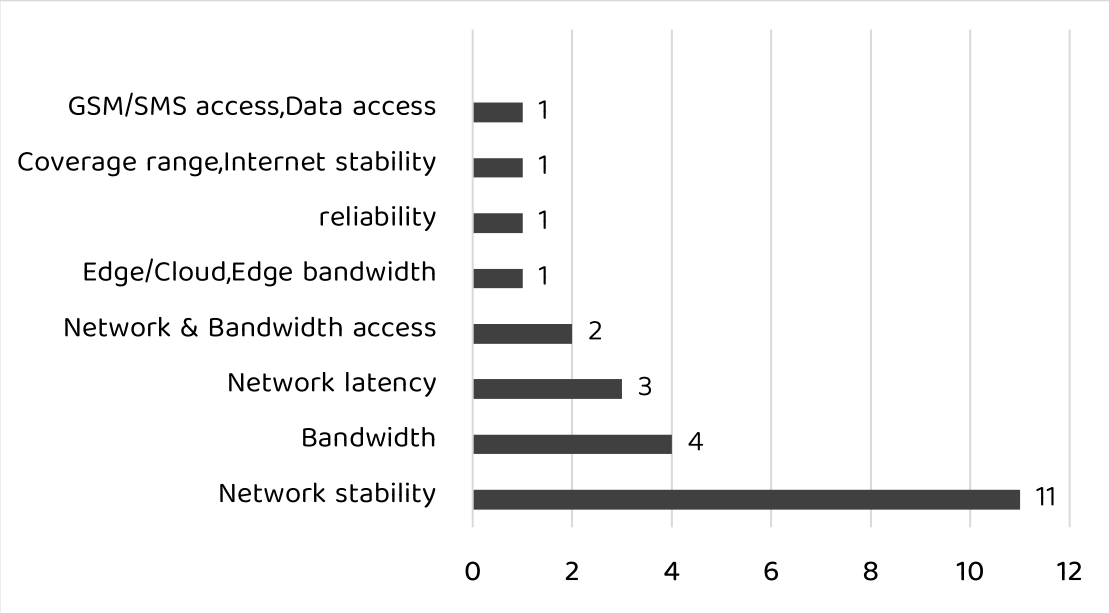

Figure 1. Frequency of reported connectivity-related challenges

The predominance of network stability concerns confirms that unstable internet connectivity remains the most pressing infrastructure barrier. Consequently, successful IoT deployments in rural or low-resource areas require designs that accommodate intermittent connectivity. Strategies repeatedly recommended in the literature include offline data storage, edge computing for local processing, and fallback communication channels such as GSM or SMS [7–9].

3.2. Interoperability with Legacy Systems

Interoperability challenges were dominated by issues of system integration (Figure 2). The high frequency of references to system integration, compatibility, and legacy systems underscores the difficulty of embedding new IoT solutions within existing, often fragmented, hospital information architectures.

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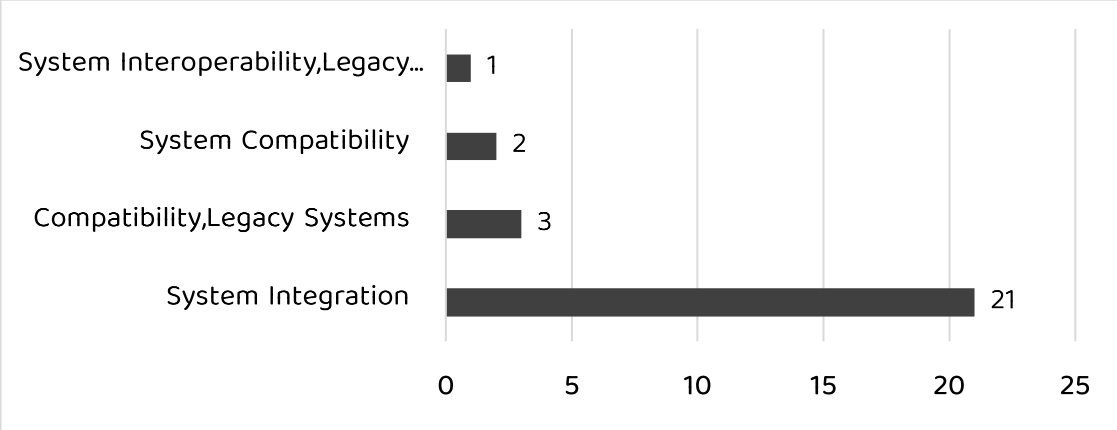

Figure 2. Frequency of reported interoperability-related challenges

These findings indicate that technical and semantic mismatches between modern IoT platforms and older hospital systems constitute a major barrier. Effective adoption therefore depends on the development and use of standardized integration frameworks, application programming interfaces (APIs), and data exchange standards that can bridge heterogeneous architectures [9–12].

3.3. Reliability and Continuity of Care

Reliability concerns centered on fault tolerance and power resilience (Figure 3). Systems operating in resource-constrained environments must continue functioning despite component failures or unstable electricity supply—conditions that are common in many rural healthcare facilities.

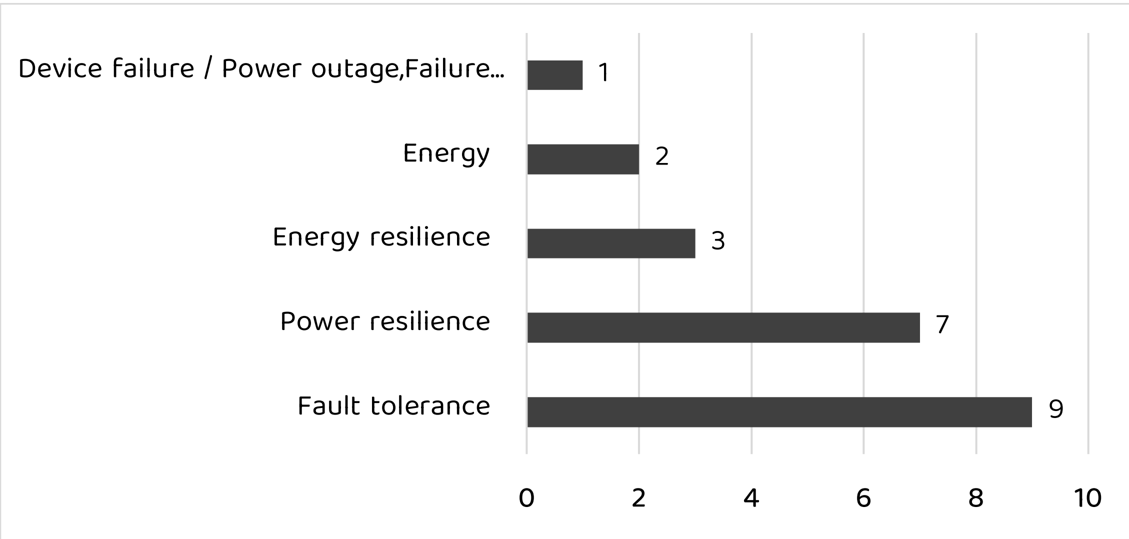

Figure 3. Frequency of reported reliability-related challenges

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Figure 3 show that "fault tolerance" and power resilience are the most frequently emphasized reliability concerns, meaning systems in resource-constrained environments must be able to keep working even when faults occur or when electricity supply is unstable. The repeated mentions of energy resilience and energy efficiency highlight the importance of sustainable power use, while terms like failure recovery, uptime, and infrastructure resilience point to the need for dependable systems that can quickly recover and maintain continuous service. The data indicates that ensuring robustness against faults, outages, and energy limitations is critical for reliable healthcare and IoT solutions in low-resource settings [13, 14].

3.4. Mapping Research Objectives to Findings

Table 1 summarizes the alignment between the study's research objectives and the synthesized findings, together with the corresponding implications for IoT adoption.

Table 1. Mapping Research Objectives to Results in IoT Healthcare Adoption

Research Objective	Key Findings / Results	Implications for IoT Adoption
Evaluate IoT functionality under limited or unstable internet connectivity	Unstable internet connectivity was the most common and pressing issue. Devices struggled with weak bandwidth, high latency, and intermittent access. Strategies like offline storage, edge computing, and fallback channels (GSM/SMS) were highlighted as necessary.	IoT systems must be designed to operate effectively in low-bandwidth environments, ensuring continuity of care even when internet access is unreliable. [16]
Explore strategies for integrating IoT solutions with legacy hospital systems	Interoperability challenges dominated, with "System Integration" mentioned 21 times. Compatibility issues with fragmented and outdated hospital systems were frequent. Semantic and architectural mismatches hindered seamless integration.	Standardized frameworks and APIs are needed to enable IoT devices to work across diverse, legacy infrastructures in resource-constrained healthcare environments.[17]

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Research Objective	Key Findings / Results	Implications for IoT Adoption
Assess reliability safeguards against device failures or power outages	Reliability concerns centered on fault tolerance and power resilience. Frequent mentions of energy resilience, efficiency, and failure recovery emphasized the need for robust systems that withstand outages.	IoT adoption requires fault-tolerant architectures, backup power solutions, and energy-efficient designs to ensure continuous patient care despite infrastructural instability.[18]

3.5. Synthesis and Comparison with Recent Literature

The study confirms that connectivity resilience, interoperability frameworks, and reliability safeguards are the three pillars for feasible IoT adoption in healthcare within resource-constrained settings. Without addressing these, IoT solutions risk being unsustainable and ineffective in real-world low-resource environments.

The results confirm that IoT adoption in healthcare within resource-constrained settings faces three critical infrastructure challenges: unstable connectivity, poor interoperability, and limited reliability. Frequent mentions of network stability, bandwidth, and latency highlight that devices must be designed to function under weak or intermittent internet. The dominance of system integration issues underscores the difficulty of aligning IoT solutions with fragmented and legacy hospital systems[16, 17, 18]. The emphasis on fault tolerance and power resilience shows that reliability safeguards are essential to ensure continuous service despite outages or failures. Together, these findings directly address the objective by showing that feasible IoT adoption requires context-specific frameworks that strengthen connectivity resilience, enable seamless interoperability, and ensure robust reliability in low-resource healthcare environments [22].

Recent literature aligns closely with the results, showing that IoT adoption in healthcare within resource-constrained settings is limited by unstable connectivity, poor interoperability, and reliability concerns[20, 21]. Studies published between 2021 and 2025 emphasize that weak bandwidth and high latency remain major barriers, while fragmented legacy systems hinder seamless integration of IoT devices. Similarly, reliability challenges such as frequent power outages and lack of fault-tolerant designs are highlighted as critical risks. Together, both findings and recent research confirm that sustainable IoT adoption requires resilient connectivity solutions, standardized integration frameworks, and robust reliability safeguards tailored to low-resource environments [22, 23, 24, 25].

A key limitation of this study is that it relies heavily on secondary data and thematic frequency analysis, which may not fully capture the dynamic realities of IoT adoption in healthcare within resource-constrained settings. The focus on published literature between 2021 and 2026 could exclude relevant earlier work or ongoing pilot projects, while the qualitative emphasis may limit generalizability across diverse contexts. Additionally, infrastructure challenges such as connectivity, interoperability, and reliability were analyzed conceptually rather than through direct field experiments, meaning practical performance outcomes of IoT devices in real healthcare environments remain underexplored.

The study recommends that IoT adoption in healthcare within resource-constrained settings should prioritize connectivity resilience, interoperability frameworks, and reliability safeguards. First, systems must be designed to function under unstable or low-bandwidth conditions by incorporating offline storage, edge computing, and fallback channels such as GSM/SMS. Second, standardized integration frameworks and APIs should be developed to ensure seamless interoperability with fragmented and legacy hospital systems[29]. Reliability must be strengthened through fault-tolerant architectures, backup power solutions, and energy-efficient designs to safeguard continuous patient care. Capacity building through training healthcare staff, investing in sustainable infrastructure, and fostering multi-stakeholder collaboration will be essential to ensure that IoT solutions are both feasible and sustainable in low-resource healthcare environments

4. CONCLUSION

This systematic review addressed the critical problem of IoT adoption in healthcare within resource-constrained settings, where unstable connectivity, poor interoperability with legacy systems, and limited reliability hinder effective and sustainable deployment. The key findings demonstrate that network instability and bandwidth constraints are the

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most frequently reported connectivity barriers; system integration with outdated platforms constitutes the dominant interoperability challenge; and fault tolerance together with power resilience are the foremost reliability concerns. These results imply that IoT solutions intended for low-resource environments must be deliberately engineered with context-specific resilience, seamless integration capabilities, and robust operational safeguards. The study is limited by its reliance on secondary literature and thematic analysis; future research should therefore incorporate empirical field testing of IoT devices in rural healthcare facilities, the development and validation of standardized interoperability protocols, and the design of resilient architectures capable of withstanding power and connectivity disruptions.

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