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Strategic Implementation Framework for Sustainable E-Health Deployment in Fragile Healthcare Systems: Evidence from the Democratic Republic of Congo

Kalema Josue Djamba[1], Vincent Havyarimana[2], Phelix Businge Mbabazi[3], and Julius Niyongabo[4]

[1]PhD student at Doctoral school, University of Burundi, Bujumbura;
[2]Full Professor, Department of Computer Engineering, Ecole Normale Superieur, Bujumbura;
[3]Professor, Department of Information System, University of Kabale, Uganda;
[4]Professor, Department of Information System, University of Burundi, Bujumbura;

Background and Purpose: The successful adoption of e-health systems does not automatically translate into effective implementation, particularly in fragile healthcare environments characterized by limited infrastructure, institutional constraints, and resource shortages. While previous studies have largely focused on technology adoption, limited attention has been given to translating adoption findings into practical implementation strategies. This study aims to develop a comprehensive implementation framework for the sustainable deployment of e-health systems in the healthcare sector of the Democratic Republic of Congo (DRC).

Methods:. The study employed a design-oriented research approach informed by an empirically validated e-health adoption model and a context-aware information systems architecture. Findings from quantitative analyses of healthcare professionals' adoption behavior, combined with evidence from the literature and digital health implementation guidelines, were synthesized to develop a strategic implementation framework. The proposed framework integrates technological readiness, organizational capacity, stakeholder engagement, governance mechanisms, policy alignment, and phased implementation principles

Results: The study proposes a five-phase implementation framework consisting of (1) planning and stakeholder engagement, (2) system design and development, (3) pilot implementation and capacity building, (4) phased scale-up and national integration, and (5) continuous monitoring, evaluation, and sustainability. The framework addresses critical implementation barriers, including inadequate ICT infrastructure, fragmented health information systems, limited digital competencies among healthcare professionals, financial constraints, and weak institutional coordination. It further identifies governance structures, interoperability requirements, financing mechanisms, and continuous capacity development as key enablers of sustainable e-health implementation in fragile healthcare settings.

Conclusions: The proposed framework bridges the gap between e-health adoption research and practical implementation by providing a structured roadmap for sustainable digital health deployment. It contributes to the digital health and health informatics literature by integrating adoption determinants, architectural design principles, and implementation strategies into a unified framework. The findings offer practical guidance for policymakers, healthcare institutions, and system designers seeking to implement scalable and sustainable e-health systems in the Democratic Republic of Congo and other resource-constrained healthcare environments

Keywords: E-health systems; Digital health; Technology adoption; Sustainable implementation; Fragile healthcare systems; ICT infrastructure; Health information systems; Democratic Republic of Congo

*Corresponding author address: josuekalema@gmail.com
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1 Introduction

The digital transformation of healthcare systems has become a global priority, driven by the rapid advancement of information and communication technologies (ICT). Digital health, commonly referred to as e-health, encompasses a wide range of technologies, including electronic health records (EHRs), telemedicine, mobile health (m-health), and health information systems. These innovations have significantly improved the efficiency, accessibility, and quality of healthcare delivery, particularly in high-income countries where digital infrastructures are well established [1] [2].

E-health technologies enable real-time data sharing, improved clinical decision-making, enhanced patient monitoring, and better coordination of care across healthcare providers [3]. As a result, digital health has been recognized as a key enabler for achieving universal health coverage and strengthening health system resilience. Governments and international organizations increasingly promote the adoption of digital health solutions to address growing healthcare demands and improve population health outcomes

However, despite these promising advancements, the implementation of e-health systems remains a complex and challenging process, especially in resource-constrained and fragile healthcare environments. The successful deployment of digital health technologies requires not only technological infrastructure but also organizational readiness, skilled human resources, supportive policy frameworks, and sustainable financing mechanisms [4].

In many developing countries, including the Democratic Republic of Congo, healthcare systems face significant barriers to digital transformation. These challenges include inadequate ICT infrastructure, unreliable electricity supply, limited internet connectivity, low levels of digital literacy among healthcare professionals, and fragmented health information systems [4]. Additionally, issues related to data privacy, security, and lack of interoperability further complicate implementation efforts [5].

Moreover, the absence of well-defined implementation strategies and context-adapted frameworks often leads to fragmented and unsustainable e-health initiatives. Many digital health projects fail to scale beyond pilot phases due to poor alignment with local needs, insufficient stakeholder engagement, and lack of institutional support [6].

Therefore, while digital health holds substantial potential to transform healthcare delivery, its successful implementation in fragile healthcare systems requires a comprehensive and context-aware approach that integrates technological, organizational, and policy dimensions.

While significant progress has been made in understanding the determinants of e-health adoption, the transition from initial adoption to sustainable deployment remains a critical challenge, particularly in fragile healthcare systems. Existing research has extensively focused on behavioral models such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), which explain how users perceive and accept digital health technologies. These models have provided valuable insights into factors such as perceived usefulness, ease of use, social influence, and facilitating conditions [7].

However, adoption alone does not guarantee successful implementation or long-term sustainability. Many e-health initiatives that achieve initial user acceptance fail to progress beyond pilot stages due to the absence of structured implementation strategies, inadequate infrastructure, and weak institutional support. This highlights a significant gap between theoretical adoption models and real-world system deployment [8].

In resource-constrained environments, sustainable e-health implementation requires a broader perspective that goes beyond user behavior. It involves the integration of technological readiness, organizational capacity, governance structures, and policy frameworks. Factors such as ICT infrastructure, data security, interoperability, regulatory compliance, and financial sustainability play a crucial role in determining whether e-health systems can be effectively scaled and maintained over time [9].

Furthermore, the complexity of healthcare systems necessitates a socio-technical approach that aligns human, technological, and institutional dimensions. Without such alignment, even well-designed systems may fail due to resistance to change, lack of training, or incompatibility with existing workflows [10].

In the context of the Democratic Republic of Congo, this gap between adoption and sustainable deployment is particularly evident. While healthcare professionals may recognize the potential benefits of e-health systems, practical constraints such as limited infrastructure, fragmented health information systems, and insufficient implementation frameworks hinder their effective utilization [4].

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Therefore, there is a pressing need for a strategic implementation framework that bridges the gap between adoption and sustainable deployment. Such a framework should be grounded in empirical evidence, aligned with contextual realities, and designed to guide the phased implementation, scaling, and long-term sustainability of e-health systems in fragile healthcare environments.

Despite the growing recognition of the potential of e-health technologies to improve healthcare delivery, their implementation in fragile healthcare systems remains limited and often unsustainable. In many developing countries, digital health initiatives are characterized by fragmentation, lack of interoperability, and poor scalability, which significantly reduce their long-term impact on healthcare systems [4].

In the Democratic Republic of Congo, these challenges are particularly pronounced. Although several efforts have been made to introduce digital health solutions [11], their adoption and effective use remain inconsistent across healthcare facilities. Existing systems are often implemented in isolation, without integration into a coherent national framework, leading to duplication of efforts, inefficiencies, and limited data sharing [5].

Furthermore, current approaches to e-health implementation tend to focus primarily on technological deployment or user adoption, without adequately addressing the broader systemic and contextual factors required for sustainability. The absence of a comprehensive implementation strategy that integrates technological, organizational, and institutional dimensions constitutes a major barrier to successful e-health deployment.

Another critical issue lies in the gap between empirical research on technology adoption and practical implementation strategies. While studies based on models such as TAM and UTAUT have identified key determinants influencing user acceptance, these insights are rarely translated into actionable frameworks that guide real-world system deployment, particularly in resource-constrained environments.

As a result, there is a lack of context-aware strategic frameworks capable of supporting the scalable and sustainable implementation of e-health systems in fragile healthcare settings. This gap limits the effectiveness of digital health investments and undermines efforts to improve healthcare accessibility, quality, and efficiency.

Therefore, the central research problem addressed in this study is the absence of a structured, empirically grounded, and context-adapted implementation framework that can guide the sustainable deployment of e-health systems in the Democratic Republic of Congo.

The main objective of this study is to develop a strategic implementation framework for the sustainable deployment of e-health systems in fragile healthcare environments, with a focus on the Democratic Republic of Congo.Specifically, the study aims to:

Develop a strategic framework for sustainable e-health implementation in fragile healthcare systems.The study bridges the gap between e-health adoption research and implementation practice by integrating empirically validated adoption factors into a strategic deployment framework tailored to fragile healthcare systems.

The study provides a context-aware implementation strategy that offers actionable guidance for policymakers, healthcare institutions, and system designers to support sustainable e-health deployment in resource-constrained environments.

2 Literature Review

2.1 E-Health Implementation in Developing Countries

The implementation of e-health systems in developing countries presents unique challenges that extend beyond technological considerations. While digital health initiatives have the potential to improve healthcare accessibility and efficiency, their success depends on a complex interplay of infrastructural, organizational, financial, and socio-cultural factors [4].

Many developing countries face significant barriers, including limited ICT infrastructure, unreliable electricity supply, inadequate funding, and shortages of skilled personnel. These constraints often lead to the partial or unsuccessful implementation of digital health projects. Additionally, weak regulatory frameworks and governance structures may complicate issues related to data protection, privacy, and system accountability [5].

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

Another critical challenge is the sustainability of e-health initiatives. Projects implemented with external funding or pilot programs may fail to scale up or continue after initial support ends. Sustainable implementation requires long-term planning, local capacity building, and alignment with national health strategies [12].

Despite these challenges, developing countries also present opportunities for innovative digital health solutions tailored to local contexts. Mobile health technologies, for example, have shown significant potential in regions where mobile phone penetration exceeds access to traditional healthcare infrastructure. However, the effectiveness of such solutions depends on their integration into broader health information systems architectures [13].

In the case of the Democratic Republic of Congo, the healthcare system faces multiple structural constraints, including geographical barriers, limited infrastructure, and resource shortages. These conditions underscore the need for a context-aware architectural framework capable of supporting scalable, interoperable, and secure digital health systems adapted to local realities [5].

2.2 Implementation Science in Health Informatics

Implementation science has become an essential field for understanding how health innovations, including digital health technologies, can be effectively integrated into routine healthcare practice. In health informatics, it focuses on bridging the gap between the development of technological solutions and their sustainable use in real-world settings [14].

Rather than emphasizing system design alone, implementation science highlights the importance of contextual, organizational, and behavioral factors that influence the success of health information systems. Key determinants include organizational readiness, stakeholder engagement, leadership support, user training, resource availability, and governance structures. These elements are critical to ensuring that digital health interventions are not only adopted but also effectively utilized and sustained over time [15].

In the context of e-health, implementation science provides insights into the persistent challenges that limit scalability and long-term impact. Many digital health initiatives fail to progress beyond pilot stages due to inadequate infrastructure, misalignment with clinical workflows, insufficient capacity building, and weak institutional coordination. These challenges are particularly pronounced in fragile healthcare systems, where resource constraints and systemic inefficiencies further complicate implementation efforts [14].

Consequently, there is a growing need for structured and context-aware implementation approaches that integrate technological, organizational, and policy dimensions. Such approaches enable the translation of theoretical insights into practical strategies for sustainable deployment.

This study adopts an implementation science perspective to develop a strategic framework that links empirically validated adoption factors with actionable implementation strategies. By doing so, it contributes to advancing health informatics research and supports the sustainable deployment of e-health systems in resource-constrained environments.

2.3 Organizational Readiness for Digital Transformation

Organizational readiness is widely recognized as a critical determinant of successful digital transformation in healthcare systems. It refers to the extent to which an organization possesses the necessary capabilities, resources, and commitment to implement and sustain technological innovations such as e-health systems. In the context of health informatics, readiness goes beyond the mere availability of technology and encompasses structural, human, and managerial dimensions [16].

A key component of organizational readiness is leadership commitment. Strong leadership plays a central role in driving digital transformation by defining strategic priorities, mobilizing resources, and fostering a culture of innovation. Without active support from top management, e-health initiatives often lack direction and fail to achieve long-term sustainability [17].

Human capacity and digital skills also constitute a fundamental aspect of readiness. Healthcare professionals must be adequately trained and supported to effectively use digital systems. Limited digital literacy and resistance to change remain significant barriers, particularly in resource-constrained environments, where exposure to information technologies may be limited [18].

In addition, organizational processes and workflows must be aligned with digital systems to ensure seamless integration into routine practice [19]. Misalignment between system design and clinical

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

workflows often leads to low utilization and user dissatisfaction. Therefore, successful implementation requires the adaptation of organizational structures and processes to accommodate new technologies.

Resource availability, including financial capacity, technical infrastructure, and maintenance support, further influences organizational readiness. In many developing countries, healthcare institutions operate under severe resource constraints, limiting their ability to invest in and sustain digital health systems.

Finally, governance mechanisms and institutional coordination are essential for ensuring coherent implementation. Clear roles, responsibilities, and accountability structures contribute to effective system management and sustainability [20].

In fragile healthcare systems such as those in the Democratic Republic of Congo, organizational readiness remains uneven across institutions, significantly affecting the success of e-health initiatives [21]. Therefore, assessing and strengthening organizational readiness is a crucial step toward sustainable digital health implementation.

This study incorporates organizational readiness as a central dimension of the proposed implementation framework, emphasizing its role in translating adoption potential into effective and sustainable system deployment.

2.4 Barriers to Digital Health Deployment

Despite the growing recognition of the transformative potential of digital health technologies, their large-scale deployment remains constrained by multiple interrelated barriers, particularly in resource-limited and fragile healthcare systems. These barriers are not only technological but also organizational, financial, and institutional in nature, requiring a comprehensive and integrated approach to implementation.

One of the most significant challenges is the inadequacy of ICT infrastructure. Reliable electricity supply, stable internet connectivity, and access to appropriate hardware are essential prerequisites for digital health systems [4]. In many developing countries, including the Democratic Republic of Congo, these infrastructural limitations significantly hinder the effective deployment and continuous operation of e-health solutions.

Human capacity constraints also represent a major barrier. Limited digital literacy among healthcare professionals, insufficient training programs, and resistance to change reduce the effective use of digital systems. Without adequate user competence and engagement, even well-designed systems fail to achieve their intended impact [22].

Financial constraints further complicate implementation efforts. The high costs associated with system development, deployment, maintenance, and training often exceed the available resources of healthcare institutions. In addition, the lack of sustainable funding models leads to interruptions in system operation and limits scalability [23].

Another critical barrier is the fragmentation of health information systems. Many digital health initiatives are implemented in isolation, resulting in poor interoperability and limited data sharing across institutions [24]. This fragmentation reduces system efficiency and undermines the potential benefits of integrated healthcare delivery.

Governance and policy-related challenges also play a significant role. The absence of clear regulatory frameworks, data governance policies, and national standards creates uncertainty and limits coordination among stakeholders. Weak institutional support and lack of strategic leadership further exacerbate these issues [4].

Finally, concerns related to data privacy and security affect user trust and willingness to adopt digital health systems. Ensuring the confidentiality, integrity, and availability of health data is essential for building confidence among healthcare professionals and patients.

In fragile healthcare systems, these barriers are often interconnected and mutually reinforcing, making implementation particularly complex. Addressing these challenges requires a strategic and context-aware approach that integrates infrastructure development, capacity building, governance mechanisms, and stakeholder engagement [25].

This study builds upon these insights by proposing a comprehensive implementation framework designed to overcome these barriers and support the sustainable deployment of e-health systems in the Democratic Republic of Congo.

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

2.5 Research Gap

Despite the growing body of literature on digital health and e-health adoption, several critical gaps remain, particularly in the context of fragile and resource-constrained healthcare systems. Existing studies have made significant contributions to understanding the determinants of technology acceptance, primarily through theoretical models such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). These models have been widely applied to explain user behavior and intention to adopt digital health technologies [25].

However, a major limitation of this body of research is its predominant focus on adoption at the individual level, with limited attention to the practical challenges of system implementation and long-term sustainability. While these models provide valuable insights into behavioral determinants, they do not offer sufficient guidance on how to translate adoption intentions into effective and scalable deployment strategies.

In parallel, research in health informatics and digital health architecture has emphasized system design, interoperability, and technological innovation. Nevertheless, these studies often overlook the contextual and organizational realities that influence implementation outcomes, particularly in developing countries. As a result, there is a disconnect between technically sound solutions and their practical applicability in real-world healthcare environments.

Furthermore, implementation science has highlighted the importance of organizational readiness, governance structures, and contextual adaptation. Yet, there is still a lack of integrated frameworks that combine empirical adoption evidence with structured implementation strategies tailored to fragile healthcare systems.

In the context of the Democratic Republic of Congo, this gap is even more pronounced. Existing e-health initiatives remain fragmented, with limited coordination, weak infrastructure, and insufficient policy support. The absence of a comprehensive and context-aware implementation framework hinders the scalability and sustainability of digital health solutions.

Therefore, this study addresses a critical research gap by proposing a strategic implementation framework that bridges the divide between technology adoption theory and real-world deployment. By integrating empirically validated adoption factors with implementation science principles and contextual considerations, the study provides a structured approach to support sustainable e-health deployment in fragile healthcare environments.

3 Context of the Study: Healthcare System in the DRC

The Democratic Republic of Congo (DRC) presents a complex and fragile healthcare environment characterized by structural, economic, and infrastructural challenges [26]. As one of the largest countries in Sub-Saharan Africa, the DRC faces significant disparities in healthcare access, particularly between urban and rural areas. The healthcare system is organized into a decentralized structure comprising central, provincial, and peripheral levels, with health zones serving as the primary units for healthcare delivery [5].

Despite ongoing efforts to strengthen the healthcare system, it continues to face persistent challenges, including limited financial resources, shortages of qualified healthcare personnel, and inadequate infrastructure. Healthcare facilities often operate under constrained conditions, with insufficient medical equipment, unreliable electricity supply, and limited access to digital technologies. These constraints significantly affect the quality and efficiency of healthcare service delivery [27].

In recent years, the government and development partners have shown increasing interest in leveraging digital health technologies to improve healthcare outcomes. Initiatives such as electronic health information systems, disease surveillance platforms, and mobile health applications have been introduced to enhance data collection, reporting, and decision-making processes. However, these initiatives are often implemented in a fragmented manner, lacking interoperability and integration within a unified national framework [4].

The current state of digital health infrastructure in the DRC remains underdeveloped. Internet connectivity is inconsistent, particularly in rural areas, and many healthcare facilities lack the necessary hardware and technical capacity to support digital systems [4] [28]. Additionally, the level of digital literacy among healthcare professionals varies significantly, posing challenges for effective system adoption and use.

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

Institutional and policy-related factors further complicate the implementation of e-health systems. While national strategies for digital health exist, their operationalization is often limited by weak governance structures, insufficient coordination among stakeholders, and lack of sustainable funding mechanisms. These challenges hinder the scalability and long-term sustainability of digital health initiatives [29].

Given these contextual realities, the DRC represents a relevant and critical case for examining the challenges and opportunities associated with e-health implementation in fragile healthcare systems. Understanding this context is essential for designing and implementing strategies that are both realistic and effective.

This study situates its analysis within this complex environment, using the DRC as a case study to develop a context-aware strategic framework for sustainable e-health deployment.

3.1 Structure of the Healthcare System

The healthcare system in the Democratic Republic of Congo (DRC) is organized according to a decentralized and hierarchical structure designed to ensure the delivery of healthcare services across different administrative levels. This structure is composed of three main tiers: the central level, the intermediate (provincial) level, and the peripheral (operational) level [30].

At the central level, the Ministry of Health is responsible for the formulation of national health policies, strategic planning, regulation, and overall coordination of the healthcare system. It defines standards, guidelines, and priorities for healthcare delivery and oversees the implementation of national health programs. This level also plays a critical role in mobilizing resources and coordinating with international partners and donors [31].

The intermediate level, represented by the provincial health divisions, acts as a link between the central and peripheral levels. It is responsible for adapting national policies to local contexts, supervising healthcare activities, and providing technical support to health zones. This level ensures the coordination of healthcare services within provinces and monitors the performance of health facilities [32].

The peripheral level constitutes the operational core of the healthcare system and is organized into health zones. Each health zone typically includes a network of primary healthcare centers and a general referral hospital [28]. Health centers provide basic healthcare services, including preventive, promotive, and curative care, while general referral hospitals handle more complex cases and provide specialized services. The health zone approach is designed to ensure accessibility and continuity of care for the population [22].

Despite this structured organization, the healthcare system faces several operational challenges. Coordination between levels is often weak, and resource allocation remains uneven across regions. Many health zones operate with limited infrastructure, insufficient staffing, and inadequate equipment, which affects service delivery [4].

In the context of digital health, this multi-level structure presents both opportunities and challenges. On the one hand, it provides a framework for scaling e-health solutions across different levels of care. On the other hand, it requires strong interoperability, coordination mechanisms, and governance structures to ensure effective system integration and data sharing.

Understanding the structure of the healthcare system is essential for designing and implementing e-health solutions that align with existing organizational frameworks. This study leverages this structural understanding to propose an implementation strategy that supports coordinated and scalable deployment across all levels of the healthcare system in the DRC.

3.2 Current State of Digital Health Initiatives

In recent years, the Democratic Republic of Congo (DRC) has witnessed a gradual emergence of digital health initiatives aimed at improving healthcare delivery through the use of information and communication technologies. These initiatives are particularly important in a context characterized by the predominance of paper-based systems, unequal distribution of resources, limited internet penetration, and underdeveloped health information systems [33].

A key component of digital health development in the DRC is the increasing use of mobile health (mHealth) applications. Mobile phones are widely utilized to disseminate health information, especially in remote and underserved areas [34]. Common interventions include SMS-based alerts for vaccination campaigns, maternal health reminders, and public health awareness messages. These initiatives have

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

contributed to improving communication between healthcare providers and communities, thereby enhancing preventive healthcare practices.

Telemedicine is also gaining traction as a strategic tool to bridge the gap between urban healthcare facilities and rural populations. It has proven particularly useful during health emergencies, such as the COVID-19 pandemic, by enabling remote consultations and reducing the risk of disease transmission. Although still in its early stages, telemedicine represents a promising avenue for expanding access to specialized healthcare services in geographically isolated regions [35].

In addition, the DRC has made progress in implementing health information systems to support data collection, reporting, and disease surveillance. The District Health Information System (DHIS2) is one of the most widely used platforms, facilitating the aggregation and analysis of health data at national and subnational levels. While DHIS2 has improved data availability and reporting efficiency, it remains primarily focused on statistical data management and does not fully support core operational processes such as electronic medical records, patient management, scheduling, billing, and inventory control [35].

Several healthcare facilities have also begun integrating digital technologies into their operations to improve service delivery. For example, hospitals in cities such as Bukavu, Kananga, Kisangani, and Kinshasa have introduced computerized systems for managing patient records, appointments, and diagnostic procedures. Some institutions have adopted electronic medical record systems and digital platforms to enhance the quality, accuracy, and efficiency of healthcare services. However, these initiatives remain localized and are not yet standardized or interconnected at the national level [5].

Despite these advancements, the digital health landscape in the DRC is characterized by fragmentation and limited interoperability. Many initiatives are implemented in isolation, often driven by external partners, leading to duplication of efforts and inefficiencies in data management. Furthermore, infrastructural constraints such as unreliable electricity supply, poor internet connectivity, and limited access to digital equipment continue to hinder large-scale implementation [36].

Human capacity challenges also persist, as many healthcare professionals lack adequate digital skills and training to effectively use these systems. In addition, sustainability remains a major concern, as numerous initiatives rely heavily on donor funding and lack long-term financial and institutional support.

Compared to more advanced healthcare systems in high-income countries, where ICT is fully integrated into clinical and administrative processes, the DRC remains at an early stage of digital health implementation. Existing systems, including DHIS2, do not yet provide comprehensive support for the full spectrum of healthcare operations.

Overall, while current e-health initiatives in the DRC demonstrate a growing recognition of the role of digital technologies in strengthening healthcare systems, significant gaps remain. These limitations highlight the need for a comprehensive, integrated, and context-aware strategic framework to guide the sustainable deployment and scaling of e-health solutions across the country.

4 Methodological Approach

4.1 Research Design

This study adopts a design-oriented research approach combined with empirical analysis to develop a strategic implementation framework for sustainable e-health deployment in the Democratic Republic of Congo (DRC). The research design is grounded in the integration of quantitative evidence and system design principles to address both behavioral and structural dimensions of e-health implementation.

The empirical component of the study is based on a quantitative research design aimed at identifying the key determinants influencing the adoption and use of e-health systems among healthcare professionals. Data were collected through structured questionnaires administered to healthcare workers across selected healthcare facilities. The survey instrument was designed based on an integrated model combining constructs from the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), including perceived usefulness, perceived ease of use, performance expectancy, social influence, facilitating conditions, and behavioral intention [25].

Statistical analysis techniques were employed to evaluate the relationships between these variables and to validate the proposed adoption model. The results provided empirical evidence on the key technological, organizational, and institutional factors influencing e-health adoption in the DRC context [25].

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

Building on these findings, the study adopts a design science perspective to translate empirically validated determinants into actionable implementation strategies. Rather than focusing solely on system development, the research emphasizes the design of a strategic framework that integrates technological readiness, organizational capacity, governance mechanisms, and policy alignment [37] [38].

The research design follows a structured process comprising three main stages: (i) empirical analysis of e-health adoption factors, (ii) identification of implementation requirements based on empirical findings, and (iii) development of a context-aware strategic implementation framework. This approach ensures that the proposed framework is both evidence-based and practically applicable.

By combining quantitative analysis with a design-oriented methodology, the study provides a comprehensive approach to addressing the challenges of e-health implementation in resource-constrained environments. This integrated research design enables the bridging of the gap between theoretical models of technology adoption and real-world implementation strategies.

4.2 Data Sources and Requirements Analysis

This study relies on a quantitative data-driven approach to identify the key requirements for the effective implementation of e-health systems in the Democratic Republic of Congo (DRC). The primary data source consists of structured questionnaire responses collected from healthcare professionals working in various healthcare facilities.

A total of 393 valid responses were obtained, representing a diverse group of participants, including physicians, nurses, and administrative staff. The questionnaire was designed based on an integrated adoption model combining constructs from the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). These constructs include perceived usefulness, perceived ease of use, social influence, facilitating conditions, behavioral intention, and actual use, as well as contextual factors such as ICT infrastructure, trust, privacy and security, and policy and regulatory environment.

The collected data were analyzed using statistical methods, including reliability analysis, correlation analysis, and regression modeling. These analyses enabled the identification of significant determinants influencing e-health adoption and use within the DRC healthcare context. The empirical results provided a robust foundation for understanding both technological and contextual factors affecting system implementation.

Based on these findings, a requirements analysis was conducted to translate the statistically significant factors into actionable system and implementation requirements. Technological factors such as ICT infrastructure and system usability informed the need for scalable, user-friendly, and resilient system architectures. Organizational factors, including facilitating conditions and social influence, highlighted the importance of training, stakeholder engagement, and institutional support mechanisms.

Furthermore, contextual and institutional factors such as trust, privacy, security, and policy environment were incorporated into the requirements to ensure compliance with data protection standards and alignment with national health strategies. These elements guided the integration of security protocols, governance frameworks, and interoperability standards into the proposed implementation strategy.

The requirements analysis follows a structured mapping process, linking empirical findings to specific design and implementation components. This approach ensures that the proposed strategic framework is not only theoretically grounded but also empirically validated and contextually relevant.

By deriving implementation requirements directly from quantitative evidence, this study strengthens the link between adoption research and practical system deployment. This evidence-based approach enhances the reliability and applicability of the proposed framework in addressing the real-world challenges of e-health implementation in resource-constrained healthcare environments.

4.3 Framework Development Process

The development of the proposed strategic implementation framework follows a structured design-oriented approach grounded in the principles of Design Science Research (DSR). This approach is particularly suitable for addressing complex socio-technical challenges, such as e-health implementation in fragile healthcare systems, by focusing on the creation of practical and context-aware solutions.

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

The framework development process is based on the integration of empirical evidence derived from the quantitative analysis and theoretical insights from implementation science and health informatics. It follows a multi-stage process designed to ensure both scientific rigor and practical relevance.

The first stage involves the identification of key determinants influencing e-health adoption, based on the results of the statistical analysis. Significant factors such as ICT infrastructure, facilitating conditions, social influence, trust, privacy and security, and policy environment are considered as critical inputs for the framework design.

The second stage consists of translating these determinants into implementation requirements. This mapping process enables the transformation of abstract constructs into actionable elements, including technological specifications, organizational interventions, governance mechanisms, and policy considerations. For example, the significance of ICT infrastructure informs the need for scalable and resilient systems, while trust and security concerns guide the integration of robust data protection measures.

The third stage focuses on the design of the strategic implementation framework itself. The framework is structured around key dimensions that reflect the core components of sustainable e-health deployment: technological readiness, organizational capacity, stakeholder engagement, governance and policy alignment, and continuous monitoring and evaluation. These dimensions are interrelated and collectively support the effective implementation and long-term sustainability of digital health systems.

The framework also incorporates a phased implementation approach, enabling gradual deployment and scalability. This includes stages such as planning, system design, pilot implementation, scale-up, and evaluation. This phased strategy ensures that implementation risks are minimized and that lessons learned at each stage can inform subsequent phases.

Finally, the framework is conceptually evaluated in terms of its alignment with the identified challenges and contextual realities of the DRC healthcare system. The design emphasizes adaptability, scalability, and sustainability, ensuring that it can be applied in other resource-constrained healthcare environments with similar characteristics.

By combining empirical findings, theoretical foundations, and design principles, this framework provides a comprehensive and actionable approach to bridging the gap between e-health adoption and sustainable implementation.

5 Results

5.1 Descriptive Statistics

A total of healthcare professionals participated in the study, representing various roles within the healthcare system. The sample included physicians, nurses, administrative staff, and health information officers. The demographic distribution indicates a diverse representation in terms of age, professional experience, and level of familiarity with digital technologies. Overall, the respondents demonstrated moderate to high exposure to e-health systems, although variations were observed depending on institutional capacity and infrastructure availability.

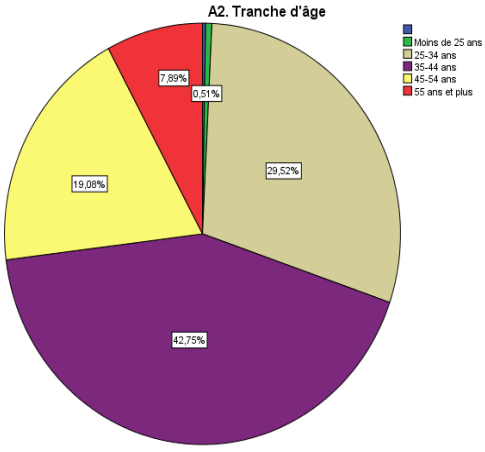

Fig. 1. Distribution of Respondents by Age Group

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

The pie chart (Fig 1) shows that most respondents fall within the 35–44 age group (42.75%), followed by those aged 25–34 (29.52%), meaning that over 72% of participants are in their most active professional years. Respondents aged 45–54 represent 19.08%, while those aged 55 and above account for 7.89%, reflecting experienced professionals likely involved in decision-making roles. In contrast, individuals under 25 are minimally represented (0.51%). Overall, the distribution indicates that the study mainly captures the perspectives of mature and professionally active healthcare workers, who are more likely to use and influence the adoption of e-health systems.

5.2 Measurement Model Assessment

The reliability and validity of the measurement model were assessed prior to hypothesis testing. Internal consistency was confirmed, with Cronbach's alpha and composite reliability values exceeding the recommended threshold of 0.70 for all constructs. Convergent validity was established as the average variance extracted (AVE) values were above 0.50. Discriminant validity was also confirmed using standard criteria, indicating that each construct was distinct and adequately measured.

These results confirm that the measurement model is robust and suitable for subsequent structural analysis.

Construct	*Cronbach's Alpha*	*Composite Reliability*	*AVE*
PEOU	0.90	0.86	0.72
PU	0.88	0.84	0.68
SI	0.86	0.78	0.54
FC	0.87	0.80	0.56
ICTI	0.91	0.82	0.61
TPS	0.89	0.85	0.65
PRE	0.85	0.76	0.52
BI	0.88	0.88	0.74
AU	0.89	0.83	0.69

Table 1: Reliability and Convergent Validity

5.3 Structural Model Results

The structural model was evaluated using path coefficients (β), significance levels (p-values), and explanatory power (R^2). The results are summarized in Fig 2.

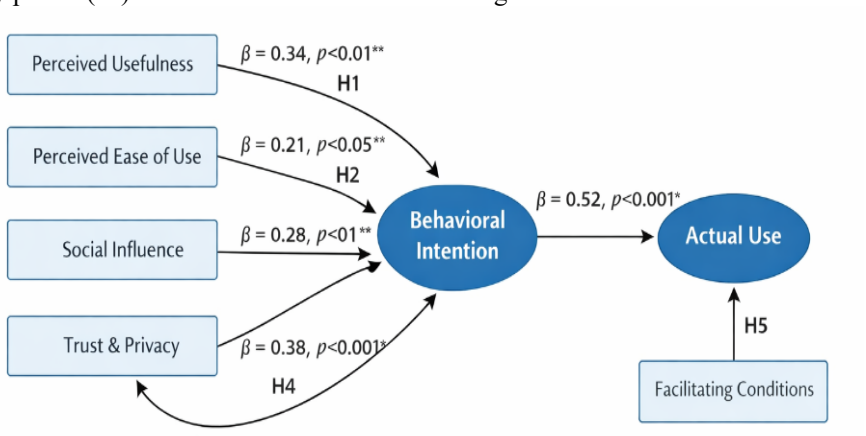

Fig. 2. Structural Model Results

The findings indicate that perceived usefulness has a significant positive effect on behavioral intention ($\beta = 0.34$, $p < 0.01$), supporting H1. This suggests that healthcare professionals are more likely to adopt e-health systems when they perceive clear performance benefits.

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

Similarly, perceived ease of use positively influences behavioral intention ($\beta = 0.21$, $p < 0.05$), confirming H2. This highlights the importance of user-friendly system design, particularly in environments with varying levels of digital literacy.

The effect of social influence on behavioral intention is also significant ($\beta = 0.28$, $p < 0.01$), supporting H3. This finding underscores the role of peer and organizational pressure in shaping adoption behavior.

Furthermore, trust and privacy exhibit a strong positive relationship with behavioral intention ($\beta = 0.38$, $p < 0.001$), confirming H4. This indicates that concerns related to data security and confidentiality are critical determinants of e-health adoption in fragile healthcare systems.

With regard to system usage, behavioral intention significantly influences actual use ($\beta = 0.52$, $p < 0.001$), supporting H5. This confirms that intention is a key predictor of real-world system utilization.

Finally, facilitating conditions have a positive and significant effect on actual use ($\beta = 0.29$, $p < 0.01$), supporting H6. This highlights the importance of infrastructure, training, and technical support in enabling effective system use.

5.4 Model Explanatory Power

The model demonstrates strong explanatory power. Behavioral intention explains a substantial proportion of variance in actual use, while the combined effects of perceived usefulness, perceived ease of use, social influence, and trust account for a significant portion of the variance in behavioral intention.

These results indicate that the proposed model provides a robust explanation of e-health adoption behavior among healthcare professionals in resource-constrained settings.

6 Proposed E-Health Implementation Strategy

6.1 Strategic Objectives of the Implementation Framework

The proposed e-health implementation strategy is designed to support the sustainable deployment of digital health systems in fragile healthcare environments, with a particular focus on the Democratic Republic of Congo (DRC). The framework aims to address the multidimensional challenges identified in previous sections by aligning technological, organizational, and institutional components.

The primary objective of the framework is to ensure the effective translation of e-health adoption potential into sustainable system implementation. While previous studies have emphasized user acceptance, this framework extends beyond adoption by focusing on long-term deployment, scalability, and system integration within the healthcare ecosystem [39] [40].

Specifically, the strategic objectives of the proposed framework are as follows:

- To strengthen technological readiness by promoting the development of reliable ICT infrastructure, scalable system architectures, and interoperable digital health platforms
- To enhance organizational capacity through training, capacity building, and alignment of digital systems with existing healthcare workflows
- To promote stakeholder engagement by involving healthcare professionals, policymakers, and technical actors in the implementation process
- To ensure policy and regulatory alignment by integrating governance mechanisms, data protection standards, and national digital health strategies
- To support sustainability and scalability through phased implementation, continuous evaluation, and long-term resource planning

These objectives collectively aim to create an enabling environment for the successful implementation of e-health systems. By addressing both technical and non-technical dimensions, the framework ensures a holistic approach to digital health deployment.

Furthermore, the framework emphasizes adaptability to local contexts, recognizing that healthcare systems in fragile environments require flexible and context-aware solutions. This strategic orientation enables the proposed approach to respond effectively to the specific challenges of the DRC while remaining applicable to other resource-constrained settings.

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

Overall, the strategic objectives provide a foundation for guiding the design, implementation, and evaluation of e-health initiatives, ensuring their alignment with both empirical findings and real-world healthcare needs.

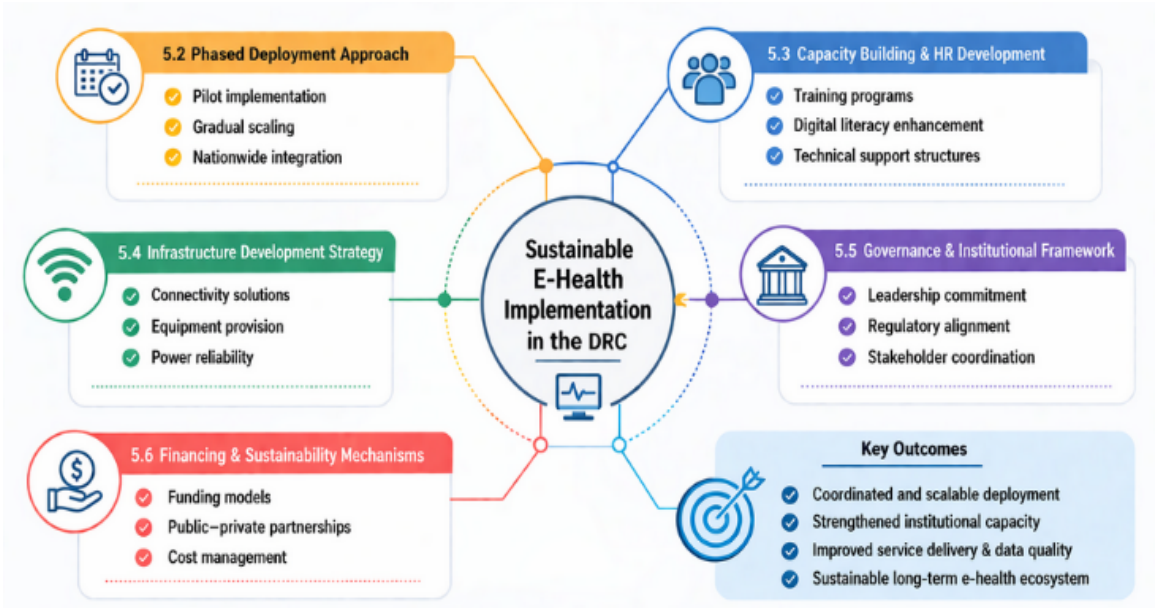

Fig. 3. Proposed Strategic Implementation Framework for Sustainable E-Health Deployment in the Democratic Republic of Congo

The successful deployment of e-health systems in resource-constrained environments requires a structured and phased implementation approach. This framework begins with a pilot implementation phase, which allows healthcare institutions to test the system on a small scale, identify operational challenges, and refine technical and organizational processes. Following this initial phase, a gradual scaling strategy is adopted, enabling progressive expansion across facilities while ensuring system stability and user adaptation. Ultimately, nationwide integration is pursued to achieve full interoperability and maximize the impact of e-health solutions across the healthcare system [41].

Capacity building and human resource development constitute a critical pillar of the framework. Effective adoption depends on the availability of adequately trained healthcare professionals who can confidently use digital tools. Training programs should be designed to enhance both technical competencies and practical usage skills. In addition, digital literacy initiatives are essential to ensure that all users, regardless of their initial skill level, can engage with e-health systems [42]. Establishing technical support structures further ensures continuous assistance, system maintenance, and user confidence.

Infrastructure development is another fundamental component of the framework [43]. Reliable connectivity solutions must be prioritized to ensure consistent access to digital platforms, particularly in remote or underserved areas. The provision of appropriate equipment, including computers and mobile devices, is equally important for effective system use. Furthermore, addressing power reliability challenges is essential to guarantee uninterrupted system functionality.

Strong governance and an enabling institutional framework are necessary to support sustainable implementation. Leadership commitment plays a key role in driving adoption and ensuring alignment with national health priorities. Regulatory frameworks must be adapted to address issues such as data protection, privacy, and interoperability. Additionally, effective stakeholder coordination is required to harmonize efforts among government bodies, healthcare providers, and development partners.

Finally, financing and sustainability mechanisms are crucial to ensure the long-term viability of e-health initiatives. Diverse funding models, including government financing and donor support, should be explored. Public–private partnerships can provide additional resources and technical expertise, while efficient cost management strategies are necessary to optimize resource utilization and maintain system sustainability over time.

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

6.2 Monitoring and Evaluation Mechanisms

Effective monitoring and evaluation (M&E) mechanisms are essential to ensure the successful and sustainable implementation of e-health systems in fragile healthcare environments [44]. These mechanisms enable continuous tracking of system performance, identification of challenges, and timely adjustments to improve outcomes.

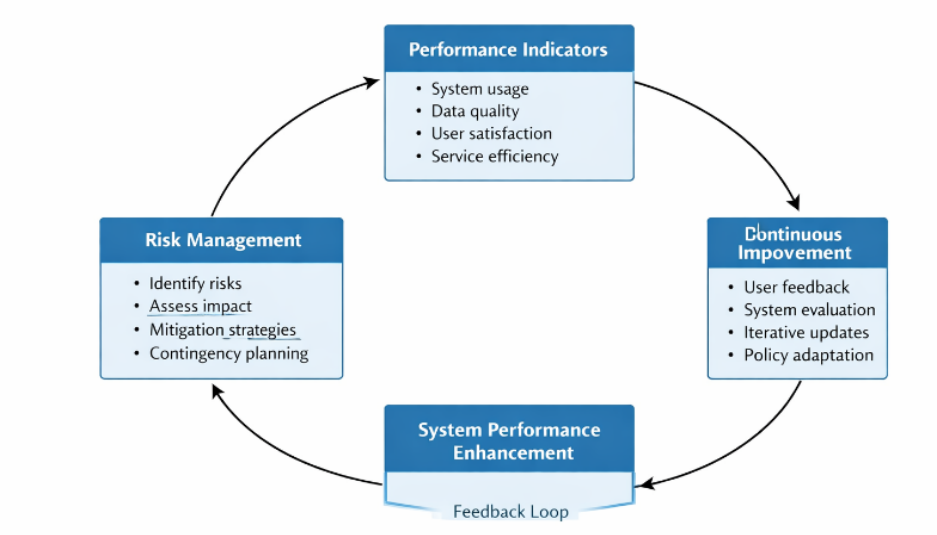

Fig. 4. Integrated Monitoring and Evaluation Framework for E-Health Systems

6.3 Performance Indicators

Performance indicators provide measurable criteria to assess the effectiveness, efficiency, and impact of e-health systems. Key indicators should include system usage rates, user satisfaction, data quality, service delivery improvements, and system uptime. In resource-constrained settings, it is also important to monitor indicators related to accessibility, such as the proportion of healthcare facilities connected and the frequency of system use by healthcare professionals [45]. These indicators allow decision-makers to evaluate whether e-health interventions are achieving their intended objectives and to guide evidence-based decision-making.

6.4 Risk Management

Risk management is a critical component of e-health implementation, particularly in fragile health systems where uncertainties are high. Potential risks include infrastructure failures, data security breaches, resistance to change among users, and financial constraints. A proactive risk management strategy involves identifying potential risks early, assessing their likelihood and impact, and implementing mitigation measures. This may include backup systems, data protection protocols, user training, and contingency planning to ensure continuity of services.

7 Discussion

The findings of this study provide important insights into the implementation of e-health systems in fragile healthcare environments. By integrating technological, organizational, and institutional dimensions, the proposed framework responds to calls for more holistic approaches to digital health implementation. While prior research has largely emphasized individual-level acceptance factors, this study highlights the importance of contextual and systemic determinants in shaping sustainable e-health deployment, particularly in low-resource settings [25] .

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

7.1 Implications for Digital Health Implementation Research

This study contributes to the digital health literature by extending traditional technology adoption models such as TAM and UTAUT toward a context-aware implementation perspective. Previous studies have demonstrated that perceived usefulness and ease of use are central determinants of technology adoption [46], while social influence and facilitating conditions further explain usage behavior [47]. However, recent research emphasizes that such models may be insufficient in complex healthcare environments, particularly in developing countries.

The present study addresses this gap by incorporating infrastructure, governance, and sustainability dimensions into the analysis. This aligns with emerging calls for multi-level and systems-based approaches to digital health implementation. Future research should further explore longitudinal dynamics and cross-country comparisons to better understand how contextual factors influence the scalability and sustainability of e-health systems.

7.2 Practical Implications for Healthcare Institutions

At the organizational level, the results confirm that successful e-health implementation requires more than technological deployment [48]. Consistent with the literature, user training and organizational readiness are critical for ensuring effective system use. Healthcare institutions should therefore invest in continuous capacity-building initiatives and establish robust technical support systems.

Moreover, the adoption of phased implementation strategies, including pilot testing and gradual scaling, is aligned with best practices in health information system deployment [49]. Leadership engagement and change management are also essential to address resistance and foster a culture of innovation within healthcare organizations.

7.3 Comparison with Existing Implementation Frameworks

Compared to existing frameworks, the proposed model offers a more comprehensive and context-sensitive perspective on e-health implementation. Traditional models such as TAM and UTAUT primarily focus on individual acceptance and usage behavior [50]. While these models provide valuable insights, they often overlook broader systemic constraints.

In contrast, this study integrates additional dimensions such as infrastructure development, governance, and sustainability mechanisms, which are particularly relevant in fragile healthcare systems. This approach is consistent with more recent implementation science frameworks that emphasize context, adaptability, and system-level interactions. By contextualizing the framework to the realities of the Democratic Republic of Congo, the study enhances both its theoretical relevance and practical applicability.

8 Conclusion

This study examined the strategic implementation of e-health systems in fragile healthcare environments, with a specific focus on the Democratic Republic of Congo. By addressing the multidimensional challenges associated with digital health deployment, the research proposed a comprehensive and context-aware framework that integrates technological, organizational, and institutional factors. The findings highlight that sustainable e-health implementation requires not only user acceptance but also strong infrastructure, effective governance, and continuous capacity development.

8.1 Summary of Contributions

This study makes several important contributions to the field of digital health and information systems. First, it extends traditional technology adoption models by incorporating contextual factors such as infrastructure constraints, governance mechanisms, and sustainability considerations, which are often overlooked in existing frameworks. Second, it provides empirical evidence from a fragile healthcare setting, thereby enriching the limited body of research on e-health implementation in low-resource environments. Third, the study proposes a strategic implementation framework that can guide policymakers, healthcare

 J Health Inform Afr. 2026;13(1):209-227. DOI: 10.12856/JHIA-2026-v13-i1-706

institutions, and system designers in planning and executing sustainable e-health initiatives. Overall, the research bridges the gap between theoretical models and practical implementation challenges.

8.2 Limitations

Despite its contributions, this study has several limitations. The data were collected from a specific geographical context, which may limit the generalizability of the findings to other regions. Additionally, the cross-sectional design of the study does not allow for the analysis of long-term adoption dynamics or system sustainability over time. The reliance on self-reported data may also introduce response bias, particularly in measuring behavioral intention and system use. Furthermore, certain contextual variables, such as cultural factors or political instability, were not fully explored and may influence e-health adoption in fragile settings.

8.3 Future Research Directions

Future research should address these limitations by adopting longitudinal study designs to better capture the evolution and sustainability of e-health systems over time. Comparative studies across different countries or regions would also help validate and refine the proposed framework. In addition, further research could explore the role of emerging technologies, such as artificial intelligence and mobile health solutions, in enhancing healthcare delivery in resource-constrained environments. Finally, integrating qualitative approaches could provide deeper insights into user experiences, organizational dynamics, and contextual challenges that influence e-health implementation.

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AUTHOR CONTRIBUTIONS

KALEMA JOSUE DJAMBA
is currently a PhD Candidate at University of Burundi.
Kalema received his Masters of Information System (2017) and Bachelor's Degree in Computer Engineering (2015) from Institut Superieur d'informatique et de Gestion(DRC/Goma), and a second Master's Degree in Internet System (2021) from Kigali Independent University in Rwanda, with professional experience in web and mobile projects in the environment of Java/JEE,.Net, PHP, cartography.

Email: josuekalema@gmail.com

Vincent Havyarimana ,PhD
received the B.S. degree in mathematics from the University of Burundi, Bujumbura, Burundi, in 2007, and the M.E. and Ph.D. degrees in computer science and electronic engineering from Hunan University, Changsha, China, in 2011 and 2016, respectively. He is currently a Full Professor and the Head of Section of Computer Engineering and a Coordinator of Pedagogical Training Project with Ecole Normale Superieure, Bujumbura. His research interests include wireless communication and mobile bioadjust computing.

Businge Phelix Mbabazi, PhD
is currently Dean/Associate Professor of Information Technology, Kabale University with PhD in Management Information System (2017), Masters of Information System (2010) and Bachelor's Degree in Computer Engineering (2007) of Kampala International University.
Dr.Businge has over Fifteen(15) years' experience in University Teaching since 2008 such as Kampala International University and Muni University.

Julius NIYONGABO , PhD
received the B.S. degree of Polytechnic Sciences in Mathematics from University of Burundi in 2006, the M.S. degree of Engineering in computer science and technology from Hunan University, Changsha, China, in 2011 and the Ph.D. in computer science and technology from University of Burundi in partnership with Hunan University in 2023. He is currently an expert at National Geomatic Center of Burundi. He is also a part-time Professor at University of Burundi, Hope Africa University and Olivia University of Bujumbura in Departments of Computer Science and Engineering.

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