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Barriers and Enablers of Post Pandemic Digital Health Sustainability in Ghanaian Public Hospitals

Abdul Wadudu Braimah

awbraimah@kath.gov.gh

Komfo Anokye Teaching Hospital

Rufai Adjei

University for Development Studies

Rashida Yakubu

Ghana Health Service

Peter Darko

Peadato Limited Company

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Abstract

The period of Covid-19 pandemic witnessed an accelerated use of digital health tools in Ghana's public hospitals. However, the rapid use of these technologies during crisis does not necessarily mean their usage will become routine after the crisis. This study explored barriers and enabling conditions that shape the sustainability of digital health technologies in public hospitals in Ghana, post Covid-19. The study used a qualitative descriptive design to analyse open-ended survey responses from 13 healthcare workers who participated in a larger mixed-methods study. The responses were analysed and interpreted using the Non-adoption, Abandonment, Scale-up, Spread and Sustainability (NASSS) framework. Four themes emerged: infrastructure, technical and clinical barriers; organisational and workforce enablers; conditions for sustainable digital health; and equity, access and perceived value. Participants described unreliable internet and electricity, limited access to devices, technical knowledge gaps and limitations in digitally mediated care as important challenges. Training, technical support, leadership, peer collaboration and organisational adaptability helped support digital health use. For continued use, participants emphasised reliable infrastructure, ongoing training, equipment maintenance, system integration, data security and regular evaluation. They also saw digital health as an opportunity to improve access to healthcare, particularly for rural and underserved populations. The findings suggest that successful digital health use during a crisis does not by itself create the conditions needed for long-term sustainability. Moving from crisis-driven adoption to sustained institutional use requires continued investment in infrastructure, people, organisational support and the capacity to adapt digital health systems over time.

1. Introduction

The COVID-19 pandemic accelerated the adoption of digital health technologies across healthcare systems worldwide. As hospitals faced restrictions on face-to-face consultations, infection-control requirements, workforce pressures, and the need to maintain continuity of care, technologies such as electronic medical records, telemedicine, mobile health applications, and digital communication platforms became increasingly important to healthcare delivery (Senbekov et al., 2020). In low- and middle-income countries (LMICs), this acceleration occurred under substantially more constrained conditions, including limited digital infrastructure, unreliable electricity and internet connectivity, shortages of technical expertise, and restricted financial resources (Chandra et al., 2022; Mishra et al., 2022). Nevertheless, the pandemic created an unusual opportunity for health organisations to introduce or expand digital technologies at a pace that would have been difficult under normal circumstances.

In Ghana, public hospitals similarly expanded their use of digital technologies during the pandemic. Electronic medical records, teleconsultation, mobile health applications, digital communication platforms, and electronic reporting systems became increasingly relevant to healthcare delivery and pandemic response (Demuyakor et al., 2024; Preko & Boateng, 2024). This rapid adoption demonstrated the potential of digital technologies to support healthcare continuity under conditions of severe disruption. However, the rapid deployment of digital technologies during a crisis does not necessarily

mean that those technologies will become embedded in routine healthcare practice after the crisis. Crisis conditions can temporarily mobilise resources, accelerate decision-making, strengthen leadership attention, and create a strong organisational imperative for technology use (Soomro & Khan, 2026). Once those conditions recede, however, organisations may have to confront the underlying financial, infrastructural, human, and governance constraints that existed before the crisis.

The sustainability of crisis-driven digital health innovations has therefore emerged as an important concern, particularly in resource-constrained health systems. Existing research shows that digital health initiatives in LMICs frequently encounter difficulties moving beyond pilot implementation towards sustained and system-wide use (Bernardi, 2023; Chandra et al., 2022; Preko & Boateng, 2024). Initiatives may depend on external funding, donor support, individual champions, temporary technical assistance, or infrastructure that is difficult to maintain. Fragmented systems and limited interoperability can further restrict integration into routine workflows, while inadequate training and technical support can undermine users' ability to maintain digital practices over time (Peek et al., 2023). These challenges raise an important question about what happens after the exceptional circumstances that stimulated rapid adoption have disappeared.

Although existing literature identifies broad barriers to digital health sustainability, including inadequate infrastructure, limited funding, workforce constraints, weak interoperability, and policy challenges (Baudier et al., 2023; Mensah et al., 2023; Okeke et al., 2025), less is known about how these factors are experienced and interpreted by healthcare workers within Ghana's public hospitals. Quantitative measures can identify the prevalence or strength of particular factors, but they provide less insight into how different barriers interact, how they affect every day work practices, and why some conditions may undermine the transition from emergency adoption to routine institutionalised use. Qualitative inquiry is therefore necessary to explain the mechanisms underlying the sustainability paradox.

This study addresses this gap by exploring healthcare workers' experiences and perceptions of the barriers and enablers affecting the post-pandemic continuation of digital health technologies in Ghana's public hospitals. The study draws on 13 purposively selected respondents with relevant experience of digital health implementation and use. Their accounts provide an opportunity to examine how technological, organisational, human, and wider system conditions shaped the prospects for sustaining technologies that were rapidly adopted during the COVID-19 crisis.

The study is guided by the Non-adoption, Abandonment, Scale-up, Spread and Sustainability (NASSS) framework (Greenhalgh et al., 2017), which was developed to explain the factors that influence the adoption, implementation, scale-up, spread, and sustainability of health technologies. The framework provides a useful lens for examining sustainability as a process involving interactions between the technology, users, organisation, wider system, and the changing conditions within which technologies are implemented. Applying the framework to Ghana's public healthcare context allows the study to examine whether and how these dimensions help explain the transition from crisis-driven adoption to longer-term institutionalisation. The study addresses three research questions:

RQ1: What barriers do healthcare workers perceive as constraining the post-pandemic continuation of digital health technologies in Ghana's public hospitals?

RQ2: What organisational, technological, and environmental factors do healthcare workers perceive as enabling the long-term sustainability of digital health technologies?

RQ3: How do these barriers and enablers explain the apparent gap between crisis-driven digital health adoption and post-pandemic sustainability?

The remainder of the paper is organised as follows. Section 2 reviews relevant literature on digital health sustainability, crisis-driven innovation, and the factors influencing the continuation of digital health technologies in LMICs, followed by a discussion of the NASSS framework. Section 3 presents the methodology, including the qualitative research design, participant selection, data collection, analytical procedures, and ethical considerations. Section 4 presents the findings from the thematic analysis. Section 5 discusses the findings in relation to the existing literature and the NASSS framework and considers their implications for policy and practice. Section 6 concludes the paper by summarising the key contributions, limitations, and directions for future research.

2. Literature Review

2.1 Digital Health Sustainability in Low- and Middle-Income Countries

The sustainability of digital health interventions has become an important concern as health systems move from initial technology adoption towards longer-term integration of digital tools into routine service delivery. Sustainability extends beyond the continued availability of a technological system. It involves the ability of health organisations to maintain digital technologies, preserve their intended benefits, integrate them into routine workflows, and adapt them as organisational and technological requirements change (Peek et al., 2023). This distinction is particularly important in low- and middle-income countries (LMICs), where digital health initiatives frequently operate within resource constraints involving infrastructure, financing, workforce capacity, and institutional support.

Evidence from LMICs identifies several interconnected dimensions that influence digital health sustainability (Kaboré et al., 2022). At the organisational level, leadership commitment, institutional readiness, workforce capacity, and the integration of digital tools into routine workflows influence whether technologies become embedded in everyday practice (Chavarnakul et al., 2025; Subrahmanyam 2026). At the technological level, reliable infrastructure, interoperability, system usability, maintenance, and technical support determine whether digital systems can function consistently over time (Irani et al., 2023). Human factors, including digital literacy, user confidence, training, workload, and attitudes towards technology, also influence continued use (Subrahmanyam 2026). At the wider health-system level, funding arrangements, governance structures, national policies, regulation, and external

partnerships shape the conditions under which digital health initiatives can be maintained and scaled (Olayiwola et al., 2026).

The challenges are particularly significant where digital health initiatives depend on short-term external funding or project-specific support. Although external resources can facilitate rapid implementation, dependence on donors or temporary technical assistance may create difficulties when such support ends. Similarly, digital health initiatives that operate as isolated projects may remain poorly integrated with existing systems, creating parallel workflows and limiting their long-term value. These challenges have contributed to concerns about the ability of LMIC health systems to move digital health innovations from initial implementation towards sustained institutional use (Bernardi, 2023; Kaboré et al., 2022).

The COVID-19 pandemic intensified this issue. The urgency of maintaining healthcare services during the crisis created exceptional conditions for digital health adoption, allowing organisations to accelerate implementation and overcome barriers that might otherwise have slowed technology deployment (Desai et al., 2024; Lee et al., 2025). However, the conditions that facilitate emergency adoption may not persist once the immediate crisis has passed. The transition from crisis-driven adoption to routine institutional use therefore represents an important sustainability challenge. Understanding this transition requires attention to the interaction between technology, healthcare workers, organisations, and the wider health system.

2.2 From Crisis-Driven Adoption to Post-Pandemic Sustainability

The COVID-19 pandemic created exceptional conditions for the rapid adoption of digital health technologies. Restrictions on face-to-face healthcare delivery, the need to protect healthcare workers and patients, and the disruption of conventional service-delivery arrangements created strong organisational incentives to deploy digital alternatives. Across different healthcare settings, the pandemic accelerated the use of telemedicine, digital communication, electronic information systems, mobile technologies, and other forms of digitally enabled care (Mahmoud et al., 2022; Mishra et al., 2022). The pace of change was significant because technologies that might ordinarily have required extended periods of evaluation, organisational preparation, and workforce adaptation were introduced or expanded under conditions of immediate necessity.

Crisis conditions can alter the organisational context in which technology adoption occurs. During an emergency, the perceived need for a technology may become more immediate, leadership attention may increase, decision-making may become faster, and resources may be redirected towards maintaining essential services. Organisational actors may also become more willing to adapt established procedures when existing arrangements are disrupted. Research examining digital transformation during the pandemic suggests that COVID-19 created opportunities for organisations to overcome some of the barriers that had previously constrained technology adoption and use (Iyanna et al., 2022). Evidence from health information systems also indicates that resilience during the pandemic was associated with local capacity, collaboration, flexible digital platforms, and enabling organisational conditions

(Amarakoon et al., 2023). These observations suggest that crisis-driven adoption can be facilitated by a combination of urgency, organisational mobilisation, technological flexibility, and user adaptation.

However, rapid adoption under exceptional circumstances does not necessarily establish the conditions required for long-term sustainability. Once the immediate crisis subsides, digital technologies must operate within the ordinary institutional environment of healthcare organisations. This requires continuing investment in infrastructure, maintenance, technical support, workforce development, system integration, governance, and organisational ownership. The challenges associated with continued use may therefore become more visible after the initial implementation period. Peek et al. (2023) noted that although digital health matured rapidly during the pandemic, important sociotechnical, evaluation, and trust challenges remained. Similarly, research on continued technology use has identified factors extending beyond initial adoption, including user-related, organisational, technological, and contextual conditions (Iyanna et al., 2022).

This distinction suggests that crisis-driven adoption and post-pandemic institutionalisation should not be treated as equivalent processes. Adoption concerns the decision or ability to begin using a technology, whereas institutionalisation involves the extent to which that technology becomes embedded within routine organisational structures, workflows, resources, and practices (Janmethakulwat & Thanasopon, 2024). A digital system may therefore achieve extensive use during an emergency without becoming sufficiently integrated into the organisational arrangements needed for its continued operation. The difference is particularly important where adoption has depended on temporary resources, exceptional leadership attention, external technical assistance, or the immediate necessity created by the crisis.

The transition from adoption to institutionalisation is consequently shaped by whether temporary responses can be converted into durable organisational capabilities. Technologies introduced during COVID-19 may require continuing infrastructure investment, technical support, training, system maintenance, interoperability, and governance after the crisis (Sharifi et al., 2021; Simionescu & Strielkowski, 2025; Wang et al., 2021). Where these conditions are weak, the reduction in crisis-related pressure may expose underlying organisational limitations. Conversely, where organisations are able to retain knowledge, develop internal technical capacity, and maintain institutional support, crisis-driven innovations may become established components of healthcare delivery. The distinction therefore shifts attention from whether a technology was successfully adopted during the crisis to whether the organisation developed the capacity to sustain and adapt it afterwards.

The Ghanaian context illustrates this distinction. Ghanaian public healthcare facilities have progressively adopted digital health technologies, while studies have identified continuing challenges relating to readiness, infrastructure, workforce capacity, implementation, and system integration (Abdulai & Adam, 2020; Geng & Demuyakor, 2022; Kaburi et al., 2023; Mensah et al., 2023; Yusif et al., 2020). The pandemic created additional pressure and opportunities for digital adoption, but the persistence of pre-existing infrastructural and organisational constraints raises questions about whether technologies adopted or

expanded during the crisis can become embedded in routine healthcare practice. The sustainability question therefore concerns not only whether healthcare workers can use digital technologies when circumstances demand it, but whether hospitals can provide the continuing organisational, technological, and system conditions necessary for their use after the crisis.

2.3 The NASSS Framework for Understanding Digital Health Sustainability

The NASSS framework is particularly appropriate for examining the sustainability paradox identified in this study because it allows digital health sustainability to be understood as the outcome of interactions across multiple domains rather than as a property of the technology alone. In the Ghanaian public hospital context, infrastructure reliability, system usability and interoperability relate to the technology domain, while healthcare workers' digital competence, confidence, workload and capacity to adapt relate to the adopter domain. Leadership, resources, technical support, organisational readiness and workflow integration correspond to the organisation domain (Wang et al., 2026). Policy, governance, regulation, financing and broader health-system conditions relate to the wider-system domain. The value proposition domain is relevant to how healthcare workers and organisations perceive the benefits and costs of continuing digital technologies after the immediate crisis has passed. Finally, embedding and adaptation over time provides a direct lens for examining whether technologies introduced or expanded during COVID-19 become incorporated into routine practice and continue to evolve after the crisis (Machado et al., 2021; Shonubi, 2024; Vong et al., 2025).

The framework therefore provides a basis for examining why conditions that supported rapid adoption during the pandemic may not be sufficient for sustained institutionalisation. A technology may be usable and valued during a crisis, for example, while continued use may be constrained by inadequate infrastructure, limited technical support, insufficient organisational resources, or weak integration into routine workflows. NASSS consequently enables the study to examine sustainability as a dynamic process in which technological, human, organisational, and wider-system conditions interact over time.

The framework comprises seven domains:

NASSS domain	Focus
1. The condition	The health or clinical condition being addressed and its characteristics
2. The technology	The characteristics, complexity, adaptability and usability of the technology
3. Value proposition	The perceived benefits, costs and value of the technology to relevant stakeholders
4. Adopters	The individuals and groups expected to use or engage with the technology
5. Organisation(s)	Organisational capacity, leadership, resources, workflows and readiness for change
6. Wider system	Political, regulatory, economic, professional and socio-cultural conditions
7. Embedding and adaptation over time	The processes through which technology becomes integrated, adapted and sustained

3 Methodology

3.1 Research Design

This study employed a qualitative descriptive exploratory design based on secondary qualitative analysis of open-ended survey responses. The study sought to understand healthcare workers' perceptions and accounts concerning the post-pandemic continuation of digital health technologies in Ghana's public hospitals. The study constituted a secondary qualitative analysis of open-ended responses collected as part of a larger mixed-methods study on digital health adoption and sustainability in Ghana's public hospitals. Secondary analysis provides an opportunity to examine existing qualitative material from a new analytical perspective or in relation to research questions that were not fully addressed in the original study (Costa, 2024). In the present study, this approach was appropriate because the original survey included open-ended questions that elicited participants' accounts of digital health challenges, enabling conditions, sustainability requirements, and potential benefits for underserved populations.

The analysis was informed by the Non-adoption, Abandonment, Scale-up, Spread, and Sustainability (NASSS) framework. The framework was used as an interpretive lens for examining how technological, adopter, organisational, and wider-system conditions shaped perceptions of embedding and sustaining digital health technologies after the pandemic.

3.3.2 Participants

The original survey included 262 healthcare workers. Of these, 13 participants provided responses to all the open-ended questions. Following assessment of the completeness and substantive content of the

responses, all the 13 participants provided sufficiently substantive material for inclusion in the thematic analysis. The 13 participants whose responses constituted the final qualitative dataset provided perspectives on the use and implementation of digital health technologies within Ghana's public hospital environment. Their accounts included issues relating to clinical work, technical support, organisational arrangements, infrastructure, training, and accessibility of digital health services.

3.3.3 Qualitative Data

The open-ended questions were positioned after the structured survey questions to allow participants to elaborate on their experiences in their own words. The questions, presented in Table 1, were intentionally broad, enabling participants to identify issues that may not have been captured by a predefined quantitative measure. Although the questions were not originally developed specifically for the present qualitative study, their focus on challenges, enabling conditions, sustainability requirements, and perceived benefits provided relevant material for examining factors associated with post-pandemic digital health continuation.

Because the data were originally collected through a questionnaire rather than individual interviews, the study does not treat the responses as interview transcripts. The analysis focuses on the content, patterns, and meanings expressed in the written responses and does not claim the depth or interactional richness associated with interview-based qualitative data.

Table 1
Open-ended Questions for the Study

Code	Open-ended question
F1	What challenges have you experienced when using digital health technologies in your work?
F2	How has the use of digital health technologies affected the way you care and interact with patients?
F3	What factors have helped you and your colleagues to use digital health technologies successfully in your work?
F4	What would be needed for digital health technologies to continue being used effectively in your hospital over the longterm?
F5	What organizational, management, policy or system-level changes would help your hospital sustain these technologies?
F6	How should the technologies and the way they are implemented be changed or improved to meet the needs of healthcare workers and patients over time?
F7	In what ways can these technologies improve healthcare access and health outcomes for rural or underserved populations?

3.4 Data Analysis

3.4.1 Thematic Analysis

The qualitative responses were analysed using thematic analysis, following the approach proposed by (Braun et al., 2022; Braun & Clarke, 2006). Thematic analysis was considered appropriate because it provided a systematic approach for identifying, analysing and reporting patterns within the participants' written accounts while allowing the analysis to remain grounded in the context of their experiences. The analysis proceeded through several stages. First, the researchers familiarised themselves with the qualitative dataset by repeatedly reading the responses to the Seven open-ended questions. This process provided an overall understanding of participants' accounts and helped identify areas relevant to the research questions.

Second, initial codes were generated from segments of text that represented meaningful aspects of participants' responses. Coding was primarily descriptive and included issues such as poor internet connectivity, unstable electricity, limited access to devices, technical knowledge, training, IT support, leadership involvement, peer support, maintenance, system integration, data privacy, security, evaluation, remote access and health education. Coding was conducted across the responses rather than treating each open-ended question as a separate analytical dataset.

Third, related codes were examined for conceptual relationships and grouped into candidate categories and subthemes. For example, codes relating to unstable internet, electricity, limited devices and equipment problems were considered together as aspects of technical and infrastructure constraints. Similarly, training, technical knowledge and knowledge sharing were examined as related aspects of workforce capability.

Fourth, candidate themes and subthemes were reviewed against the original responses to assess their internal coherence and their distinction from other categories. During this stage, closely related or overlapping categories were consolidated. This was particularly important because several issues appeared in different forms across the open-ended questions. Similarly, infrastructure problems identified as barriers were also identified by participants as conditions requiring attention for continued use.

The final analytical structure therefore distinguished between the context in which digital health was used during the pandemic and the conditions participants considered necessary for its sustainability. Following this process, four overarching themes and nine consolidated subthemes were developed: (1) Infrastructure, Technical and Clinical Barriers, (2) Organisational and Workforce Enablers, (3) Conditions for Sustainable Digital Health, and (4) Equity, Access and Perceived Value. The consolidation was intended to avoid excessive fragmentation of closely related findings while retaining conceptually meaningful distinctions within each theme.

Finally, the themes and subthemes were interpreted in relation to the Non-adoption, Abandonment, Scale-up, Spread and Sustainability (NASSS) framework. The framework was used as an interpretive lens rather than as a rigid coding structure. The analysis considered how participants' accounts related to the NASSS domains of technology, adopters, organisation(s), wider system, value proposition, and embedding and adaptation over time. Themes that did not fit neatly within a single NASSS domain were

retained and interpreted across relevant domains to reflect the interconnected nature of digital health sustainability.

3.5 Trustworthiness of the Qualitative Analysis

Several measures were used to enhance the trustworthiness of the qualitative analysis. First, the analysis followed a clearly defined thematic analysis procedure based on the six phases described by (Braun & Clarke, 2023). The researcher repeatedly reviewed the original responses during coding, theme development, and theme refinement to ensure that the interpretations remained grounded in the participants' written accounts. Also, the analysis combined inductive thematic development with interpretation through the NASSS framework. This approach allowed themes to emerge from the participants' accounts before they were considered in relation to the theoretical framework. Themes that did not correspond directly to a NASSS domain were retained where they provided relevant insight into the Ghanaian context. The coding process resulted in four overarching themes and nine consolidated subthemes, with each subtheme mapped to relevant NASSS domains, (Table 2).

4. Findings

Table 2
Themes, subthemes, codes and alignment with the NASSS framework

Themes	Subtheme	Codes	Alignment with NASSS Framework
Infrastructure, Technical and Clinical Barriers	Technical and Infrastructure Constraints	Poor internet, unstable power, limited devices, equipment malfunction, limited technical knowledge	Technology; Organisation(s)
	Clinical and Relational Disruptions	Inability to perform physical examination, reduced patient engagement, loss of human touch	Technology; Adopters; Value Proposition
Organisational and Workforce Enablers	Digital Literacy and Training	Staff training, experienced personnel, technical knowledge, knowledge sharing	Adopters; Organisation(s)
	Institutional and Technical Support	IT support, vendor support, leadership involvement, supervision, communication	Organisation(s); Technology
	Peer Collaboration and Adaptive Capacity	Peer support, collective problem-solving, flexibility, needs assessment, tool evaluation	Adopters; Organisation(s); Embedding and Adaptation Over Time
Conditions for Sustainable Digital Health	Technical Continuity and Evolution	Stable internet, stable power, equipment maintenance, repairs, updates, continuing technical support	Technology; Organisation(s); Embedding and Adaptation Over Time
	Governance, Integration and Data Security	System integration, privacy, security, backup, policies	Organisation(s); Wider System; Technology
Equity, Access and Perceived Value	Geographic and Financial Access	Remote consultation, rural access, reduced travel costs, reduced waiting time, affordability	Value Proposition; Wider System
	Patient Empowerment and Public Health Value	Health education, medication reminders, self-care, health information, disease surveillance	Value Proposition; Wider System

4.2 Theme 1: Infrastructure, Technical and Clinical Barriers

Participants described several technological, infrastructural and clinical challenges that affected their use of digital health technologies during the COVID-19 pandemic. The accounts centred on unreliable connectivity and electricity, limited access to digital devices, equipment problems, differences in technical knowledge, and limitations associated with digitally mediated clinical interactions. These

issues indicate that the challenges experienced by participants extended beyond the availability of digital systems themselves to include the infrastructure, equipment, user capabilities and clinical circumstances within which the technologies were used.

4.2.1 Technical and Infrastructure Constraints

Technical and infrastructure constraints were among the most frequently mentioned barriers in the qualitative responses. Participants referred to poor or unstable internet connectivity, unreliable electricity, limited access to digital devices and malfunctioning equipment.

Poor connectivity was mentioned by several participants. Participant 1 explained: “Poor internet connectivity hindered effective communication between healthcare providers and patients.”

The responses indicate that connectivity problem could interfere with the effective use of digital health technologies. In particular, Participant 1 directly linked poor connectivity to communication between healthcare providers and patients. The accounts therefore suggest that reliable connectivity was important practical condition for digital health use.

Participants also reported limitations in access to suitable digital devices and problems with equipment. Participant 9 stated: “Limited access to tablets and computers by healthcare professionals making it challenging in using digital health tools in efficient patient care.” (P9)

Participant 3 identified limited access to smartphones or tablets alongside other concerns: “Technical knowledge among many users especially the elderly. Privacy concerns and limited access to smart phones (Tablet).”

Taken together, these responses indicate that participants experienced digital health implementation within an environment where access to functioning equipment and dependable infrastructure was not always assured. The availability of digital applications therefore did not necessarily translate into consistent access to the technological resources required for their use.

4.2.2 Clinical and Relational Disruptions

In addition to technological and infrastructural barriers, participants identified limitations associated with the use of digital technologies for clinical care. These concerns related particularly to physical examination, patient engagement and the interpersonal dimension of healthcare.

Participant 1 reported: “The quality of care as far as doctor-patient relationship is concerned was compromised.”

Participant 6 similarly identified several limitations: “Inability to perform physical examination. Reduced patient engagement. Loss of human touch.” (P6)

These accounts indicate that participants perceived some aspects of healthcare delivery as difficult to reproduce through digitally mediated interactions. Physical examination was identified as a specific limitation, while reduced patient engagement and the loss of human interaction raised broader concerns about the quality of the patient-provider relationship.

4.3 Theme 2: Organisational and Workforce Enablers

Despite the infrastructural, technical and clinical challenges described under Theme 1, participants identified several factors that supported their ability to use digital health technologies during the COVID-19 pandemic. These included training and knowledge development, institutional and technical support, leadership and communication, peer collaboration, and the ability of users and teams to adapt to changing circumstances. The findings indicate that digital health use was supported not only by the availability of technologies but also by organisational and human resources that helped healthcare workers overcome implementation difficulties.

4.3.1 Digital Literacy and Training

Training and knowledge development were prominent enabling factors in the participants' accounts. Several participants described training as an important means through which healthcare workers acquired the knowledge and confidence required to use digital health systems.

Participant 1 stated: “Comprehensive training on digital tools and platforms. Identify specific needs of the team and choosing suitable digital tools.”

Participant 5 explained: “The very month I was employed was the same month the pandemic started while I was still catching up with my training on the digital health system. Thus it took me time to get used to it”.

These responses indicate that training supported healthcare workers' ability to engage with digital systems during the pandemic. The responses also suggest that knowledge development occurred through both formal training and internal support from personnel with relevant experience. Participant 5's account, in particular, indicates that experienced staff contributed to training colleagues across different departments.

4.3.2 Institutional and Technical Support

Participants also identified organisational and technical support as important enablers of digital health use. Support came from internal IT personnel, software developers, supervisors and organisational leadership.

Technical assistance was available from software developers. Participant 4 explained: “Owners/builders of the software application were always available to train and assist with challenges that arose.”

Also, Participant 9 stated “There was a training and support for healthcare workers and quick adaptation and flexibility”

These accounts indicate that support was provided through several organisational channels. IT personnel and software developers assisted users with technical difficulties, while supervisors and leaders provided direction and communication. The findings suggest that such support helped create conditions in which healthcare workers could address problems and continue using digital technologies during the pandemic.

4.3.3 Peer Collaboration and Adaptive Capacity

Peer collaboration and the ability to adapt were also evident in the responses. Participant 3 described how colleagues assisted one another: “We supported each other in solving technical issues.”

This account indicates that problem-solving did not depend exclusively on formal IT support. Healthcare workers also drew on colleagues when difficulties arose.

Participant 1 emphasised the importance of identifying user needs and adjusting digital tools: “Identify specific needs of the team and choosing suitable digital tools. Regularly assessing digital tool effectiveness and making adjustments.”

Together, these responses suggest that successful use involved a degree of collective learning and adaptation. Peer collaboration provided an informal mechanism for addressing technical problems, while attention to user needs and regular assessment allowed digital tools to be adjusted in response to changing requirements. The findings therefore indicate that healthcare workers were not simply passive recipients of digital technologies. They participated in problem-solving, knowledge sharing and adaptation as they incorporated digital tools into their work. This provides an important link to the NASSS concept of adopters and, particularly, embedding and adaptation over time.

4.4 Theme 3: Conditions for Sustainable Digital Health

The third theme captures the conditions that participants considered necessary for maintaining digital health use beyond the immediate crisis. Whereas Theme 2 focused on factors that supported technology use during the pandemic, participants' responses to the sustainability question emphasised the need for more continuous and durable forms of support. These included reliable infrastructure, adequate equipment, continuing training, technical maintenance, system integration, data protection and ongoing adaptation of digital tools.

4.4.1 Technical Continuity and Evolution

Participants repeatedly identified reliable infrastructure, functioning equipment, maintenance and continuing technical support as important conditions for sustaining digital health. The responses suggest that participants viewed digital health sustainability as requiring continued investment in the technological environment rather than treating implementation as a one-time activity.

Reliable connectivity and electricity were particularly prominent. Participant 8 called for: “Ensuring constant and stable internet connectivity.”

Participant 5 provided a broader description of the infrastructure required: “There is the need for Robust infrastructure such as reliable internet, computers and servers.”

These responses indicate that participants associated sustainability with the continued availability, maintenance and updating of the technological resources required to support digital health. The emphasis on both infrastructure and continuing technical support suggests that maintaining digital health requires attention to the conditions that allow systems to remain functional after their initial deployment.

Training also featured prominently in participants' responses concerning sustainability. Participant 1 called for: “Periodic training of staff on effective use of digital tools on patient care.”

The recurrence of training alongside infrastructure and maintenance suggests that participants viewed sustainability as involving both technological continuity and continuing workforce capability. Unlike the training described under Theme 2, which related primarily to enabling use during the pandemic, the responses here emphasised training as an ongoing requirement for maintaining digital health over time.

4.4.2 Governance, Integration and Data Security

Participants also identified organisational and governance arrangements as important conditions for sustaining digital health. These included system integration, data privacy, security and backup.

Participant 5 similarly recommended: “Integrated system that connects all department services.” He also identified “Data security and backup.”

These responses indicate that participants viewed sustainability as extending beyond the continued operation of individual digital applications. Digital systems were expected to work together across departments, while information generated through their use needed to be protected and backed up. The findings therefore point to the importance of governance arrangements that support integration, privacy, security and continuity of digital health services.

4.4.3 Continuous Evaluation and User Responsiveness

Participants also identified the need to evaluate digital tools and adjust them in response to users' needs.

Participant 1 recommended: “Regularly assessing digital tool effectiveness and making adjustments.”

Participant 6 similarly stated: “Training and education. Continuous evaluation. Use friendly tools which encourage adoption(Simplicity).”

These responses suggest that participants did not view sustainability as simply keeping existing systems operational. They also considered continued assessment and adjustment important to maintaining the usefulness of digital tools. The emphasis on user-friendly systems indicates that perceived usability was also considered relevant to continued engagement with digital technologies.

The findings therefore suggest that sustainability involves a continuing process of evaluation, adjustment and responsiveness to user needs. Digital systems may need to evolve as organisational requirements and user experiences change.

4.5 Theme 4: Equity, Access and Perceived Value

The fourth theme concerns participants' perceptions of the potential value of digital health technologies for improving access to healthcare, particularly among rural and underserved populations. The responses highlighted two broad areas: geographic and financial access, and patient empowerment and public health value. Participants associated digital technologies with remote access to healthcare, reduced travel and waiting burdens, health information and education, medication support, disease surveillance and self-care.

4.5.1 Geographic and Financial Access

Remote access to healthcare was frequently identified as a potential benefit of digital technologies, particularly for populations living in rural or underserved areas.

Participant 2 proposed: “Centers can be created where those underserved community can call at any time for consultation and medications prescribed on phone and if possible using of the drone system of delivering medications must be enhanced.”

Participant 3 similarly stated: “Providing remote access to doctors especially in rural areas where health facilities are limited.”

These responses indicate that participants perceived digital technologies as having particular value where geographical distance or limited availability of health facilities creates difficulties in accessing care. Remote consultation and mobile health applications were viewed as potential mechanisms for connecting patients with healthcare professionals without requiring every interaction to take place at a physical facility.

Participants also associated digital health with reduced financial and practical burdens on patients. Participant 1 stated that digital technologies could: “reduce costs associated with travelling and infrastructure.”

Participant 3 similarly reported that digital technologies could: “Reduce waiting times, cost and making healthcare more accessible and affordable.”

These accounts suggest that participants perceived digital health as having the potential to reduce some of the costs and inconveniences associated with accessing healthcare. The perceived value therefore extended beyond the hospital's internal operations to include patients' travel requirements, waiting time and affordability.

Taken together, the responses suggest that geographical and financial access formed an important part of how participants perceived the value of digital health. Remote services could potentially reduce the physical distance between patients and healthcare providers while also reducing some of the practical burdens associated with facility-based care.

4.5.2 Patient Empowerment and Public Health Value

Participants also identified the provision of health information and education as important potential benefits of digital health. Participant 1 referred to: “health education, tracking and support systems.”

Participant 4 identified “Early access to health information.”

Participant 7 similarly recommended: “Provide health information and education online.”

These responses indicate that participants viewed digital technologies as mechanisms for extending health information and education beyond the physical boundaries of healthcare facilities. Digital platforms were perceived as having the potential to provide patients and communities with information that could support greater awareness and engagement with health-related issues.

One participant also identified potential benefits extending to self-care and broader public health functions. Participant 6 stated: “Electronic health records. Improved disease surveillance. Telemedicine and virtual care. Mobile health that is patient receives medication reminders fostering better self-care.”

This response extends the perceived value of digital health beyond remote consultation to include disease surveillance, medication reminders and patient self-management. It suggests that digital technologies could support both individual-level care and broader public health activities.

The findings therefore indicate that participants perceived digital health as having value beyond simply improving access to healthcare facilities. They associated digital technologies with access to information, health education, self-care and public health functions. These perceived benefits provide an important dimension to the sustainability question because technologies may be more likely to remain relevant when users and health systems perceive continuing value in their application.

5. Discussion and Implications

5.1 Theoretical and Practical Implications

The findings suggest that this discrepancy can be understood in terms of a difference between the conditions that enable rapid adoption during a crisis and those required for institutionalisation after the

crisis. During the pandemic, participants described training, technical assistance, leadership involvement, peer collaboration and rapid adaptation as important in enabling digital health use. For longer-term continuation, however, they emphasised reliable infrastructure, continuing training, equipment maintenance, technical support, system integration, data security and ongoing evaluation. This distinction is consistent with research showing that digital health sustainability in LMICs is multidimensional and depends on interdependent technological, organisational, human and system-level conditions rather than on adoption alone (Kaboré et al., 2022). It also extends work examining digital transformation beyond initial adoption towards the conditions influencing continued use (Iyanna et al., 2022).

The findings provide further support for the argument that crisis conditions can alter the normal trajectory of technology adoption. During COVID-19, the immediate need to maintain healthcare services created a strong imperative for digital technology use. The literature similarly indicates that the pandemic accelerated digital transformation by creating conditions in which technologies could be adopted more rapidly than would normally occur (Chandra et al., 2022; Mishra et al., 2022; Peek et al., 2023). (Bernardi, 2023), for example, conceptualises telehealth adoption during the pandemic in terms of values and crisis-related pressures that altered the conditions under which organisations and users evaluated digital technologies.

This distinction is important for the application of the NASSS framework. Greenhalgh et al. (2017) conceptualise technology-supported change as a complex process involving the technology, value proposition, adopters, organisation, wider system, and embedding and adaptation over time. The present findings cut across these domains. Technical and infrastructure constraints relate principally to the technology and organisation domains. Digital literacy and training relate to the adopter and organisation domains, while institutional and technical support reflects the interaction between the organisation and technology. Peer collaboration and adaptive capacity extend the analysis towards embedding and adaptation over time. Governance, integration and data security involve the organisation, technology and wider system, while geographic access and patient empowerment relate to the value proposition and wider system.

The findings therefore support the multidimensional interpretation of sustainability proposed by NASSS. The sustainability problem identified in this study does not appear to reside within a single domain. Instead, it emerges from the interaction among several domains. Unreliable connectivity is a technological problem, but its consequences for sustainability depend on organisational workflows and the ability of healthcare workers to continue using the system when connectivity is poor. Similarly, training is an adopter-related factor, but its contribution to sustainability depends on whether the organisation continues to provide opportunities for learning and whether technical systems themselves remain usable. This interpretation is consistent with Kaboré et al. (2022), who found that sustainability of digital health interventions in LMICs depends on interdependent barriers and facilitators involving infrastructure, equipment, staff competence, stakeholder support, governance and monitoring.

The findings also reinforce the importance of local organisational capacity and collaboration in sustaining digital health. Participants described peer support, experienced personnel, IT assistance, vendor support and leadership involvement as factors that helped them overcome difficulties. This finding corresponds with Amarakoon et al. (2023), whose qualitative examination of health information system resilience during COVID-19 identified local capacity, networking, collaboration, flexible digital platforms and enabling antecedent conditions as important elements of resilience. The similarity is noteworthy because both studies point to the importance of organisational and relational capabilities when digital systems are implemented under conditions of disruption. However, the present study extends this perspective by showing that participants viewed these capabilities differently depending on the stage of implementation. Peer support and rapid adaptation helped enable use during the crisis, whereas long-term sustainability required these capabilities to be supported by more durable infrastructure, maintenance and organisational arrangements.

The study also contributes to understanding the role of healthcare workers in digital health sustainability. Participants did not describe themselves merely as recipients of technologies introduced by their organisations. Their responses referred to peer learning, collective problem-solving, adaptation, needs assessment and evaluation. This is consistent with evidence from qualitative research in Ghana showing that healthcare professionals' experiences of digital health are shaped by both the benefits of digital systems and the practical difficulties encountered during their use (Mensah et al., 2023). They found that digital health could support continuity of care and improve access to information, while poor internet connectivity and unstable electricity disrupted work processes and reduced some of these benefits. The present study adds that healthcare workers themselves participate in overcoming such difficulties through learning, collaboration and adaptation. The adopter dimension of NASSS can therefore be understood as dynamic, with users contributing to the process through which technologies are incorporated into everyday practice.

The findings further highlight the importance of perceived value in understanding sustainability. Participants associated digital health with remote access, reduced travel and waiting times, health education, self-care and disease surveillance. These perceived benefits are consistent with the wider literature on digital health's potential to improve access and continuity of care, particularly during periods of disruption (Senbekov et al., 2020). They also correspond with (Kaboré et al., 2022), who identified convenience, improved satisfaction, better service delivery and improved health-system performance as potential facilitators of sustainability. However, the present findings should be interpreted as evidence of perceived or anticipated value, rather than evidence that these benefits were objectively achieved. This distinction is important because perceived value forms part of the NASSS framework, but the existence of potential benefits does not guarantee that a technology will be sustained.

The equity findings also need to be interpreted alongside the infrastructure constraints identified elsewhere in the study. Participants viewed digital technologies as potentially useful for rural and underserved populations through remote consultation, health information and reduced travel burdens. At the same time, digital access depends on connectivity, devices, digital skills and supporting

infrastructure. This creates a potential tension between the promise of digital health for underserved populations and the risk that existing digital inequalities may limit who benefits from it. This concern is consistent with (Nanyonga et al., 2026), who note that weak infrastructure, fragmented implementation and inadequate governance can widen inequalities even where digitalisation is intended to improve access.

5.3 Limitations and Future Research

This study has several limitations that should be considered when interpreting its findings. First, the qualitative analysis was based on substantive responses from 13 healthcare workers drawn from the larger quantitative sample. The small number of qualitative contributors limits the breadth of perspectives represented in the analysis. The findings should therefore be understood as exploratory and context-specific rather than as a comprehensive representation of healthcare workers across Ghanaian public hospitals. Studies in the future can look at doing comparative studies across different types of facilities (urban vs. rural, tertiary vs. district) to identify context-specific barriers and enablers (Pai, 2025).

Second, the qualitative data were obtained through open-ended survey questions rather than individual interviews or focus groups. Although the responses provided useful accounts of participants' experiences and perceptions, they were generally shorter than interview accounts and did not allow the researcher to ask follow-up questions or probe emerging issues. Some potentially important aspects of digital health sustainability may therefore not have been explored in sufficient depth. Therefore, future studies should consider doing an in-depth qualitative interviews with healthcare workers, hospital administrators, and policymakers to provide richer insights into the dynamics of sustainability (Okeke et al., 2025).

Finally, the study examined participants' perceptions of the conditions associated with post-pandemic sustainability rather than longitudinally tracking individual digital health technologies over time. The findings therefore do not establish whether particular technologies were subsequently sustained, abandoned, replaced, or modified after the pandemic. Rather, they provide insight into how healthcare workers understood the conditions that could support or constrain continued use (Joseph, 2026; Peek et al., 2023). Future research should address this through a longitudinal study that tracks specific digital health technologies over time to determine whether sustainability concerns materialise into actual abandonment or continuation (Peek et al., 2023).

Conclusion

This study explored the barriers and enablers affecting the post-pandemic sustainability of digital health technologies in Ghana's public hospitals, with particular attention to the apparent discrepancy between high crisis-period use and lower confidence in continued use after the COVID-19 pandemic. Through a secondary qualitative analysis of open-ended survey responses from 13 healthcare workers, four

overarching themes were identified: infrastructure, technical and clinical barriers; organisational and workforce enablers; conditions for sustainable digital health; and equity, access and perceived value.

The findings show that digital health use during the pandemic was supported by training, technical assistance, leadership involvement, peer collaboration, and the ability of healthcare workers to adapt to changing circumstances. At the same time, participants identified substantial constraints involving connectivity, electricity, equipment, technical knowledge, and the suitability of digitally mediated care for some clinical activities. When considering longer-term sustainability, participants placed greater emphasis on reliable infrastructure, continuous training, maintenance and technical support, system integration, data security, governance, and ongoing evaluation and adaptation.

These findings provide a qualitative explanation of the sustainability paradox identified in the original quantitative study. High levels of digital health use during a crisis do not necessarily indicate that the organisational and system conditions required for sustained institutional use are in place (Greenhalgh et al., 2017; Peek et al., 2023). Crisis conditions can enable rapid mobilisation, adaptation, and temporary support, while post-crisis sustainability requires these capabilities to become embedded within routine organisational structures and resources (Gomes & Romão, 2025).

The findings also demonstrate the usefulness of the NASSS framework for interpreting digital health sustainability in a resource-constrained public healthcare setting (Greenhalgh et al., 2017). The barriers and enablers identified in the study cut across the technology, adopters, organisation, wider system, value proposition, and embedding and adaptation domains. This reinforces the view that digital health sustainability is a multidimensional process shaped by interactions among technologies, users, organisations, and the wider health system (Greenhalgh et al., 2017; Kaboré et al., 2022; Peek et al., 2023).

The study therefore concludes that sustaining the digital health gains associated with COVID-19 requires a transition from crisis-driven adoption to institutionalised capability. Continued use depends not simply on whether healthcare workers are willing to use digital technologies, but on whether hospitals can provide the infrastructure, workforce capacity, technical support, governance arrangements, clinical suitability, and mechanisms for adaptation required to maintain their value over time (Joseph, 2026; Nanyonga et al., 2026; Peek et al., 2023).

Declarations

Ethics approval and consent to participate

Ethical approval for the study was obtained from the Komfo Anokye Teaching Hospital Institutional Review Board (KATH IRB/AP/038/25). The study was conducted in accordance with the Declaration of Helsinki and applicable institutional ethical requirements. Permission was obtained from the participating health facilities, and informed consent was obtained from all participants. The present

study involved secondary analysis of de-identified open-ended survey responses collected as part of the original study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

A.W.B. and R.A. conceptualised the study. R.Y. led data collection. A.W.B., R.A. and R.Y. conducted the qualitative data analysis. A.W.B., R.A. and P.D. contributed to the interpretation of the findings and development of the Discussion, Conclusion and Limitations. A.W.B. led the drafting and revision of the manuscript. All authors reviewed and approved the final manuscript.

Data Availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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