International Journal of Advanced and Applied Sciences, 12(7) 2025, Pages: 173-177

Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

Usability of health information systems in rural and low-resource settings of Sudan

Asim Seedahmed Ali Osman [1,*], Adil Mahmoud Mohamed Mahmoud [2]

[1]College of Computer Science and Engineering, University of Hafr Al Batin, Hafar Al Batin, Saudi Arabia
[2]Deanship of E-Learning and Digital Transformation, University of Hafr Al Batin, Hafar Al Batin, Saudi Arabia

ARTICLE INFO

Article history:
Received 18 January 2025
Received in revised form
31 May 2025
Accepted 25 June 2025

Keywords:
Mobile health
Usability challenges
Rural healthcare
User satisfaction
Health information systems

ABSTRACT

Mobile devices play an important role in Health Information Systems (HIS), especially in rural and low-resource areas of Sudan, where they help improve access to and use of healthcare services. However, these devices still face major usability problems, such as difficult navigation, inconsistent interface designs, hard-to-use input methods, and poor compatibility between devices. These problems reduce the effectiveness of mobile devices in meeting the needs of underserved communities. This study examines the efficiency, effectiveness, and user satisfaction of HIS features in rural settings, using the After-Scenario Questionnaire (ASQ) to measure how well users complete tasks. A total of 113 people took part in the study, revealing specific usability patterns and ongoing difficulties. The results highlight important design and functionality issues in mobile health applications and show the urgent need for adaptable user interfaces based on user-centered design. Such interfaces would support the smooth completion of key health tasks and encourage wider use of HIS in low-resource environments.

1. Introduction

Health information systems (HIS) play a crucial role in modern healthcare. They support the collection, analysis, and sharing of essential data, enabling healthcare providers to make informed decisions and deliver high-quality services. Despite their potential to improve health outcomes, ensuring the usability and effectiveness of HIS in rural and low-resource settings remains challenging. In these contexts, particularly in low- and middle-income countries (LMICs), barriers such as unreliable internet connectivity, unstable power supplies, insufficient hardware, and a shortage of trained personnel often hinder the adoption and sustainability of HIS (Sanders et al., 2023). These challenges highlight the need to prioritize usability in the design of HIS to ensure they are practical and effective in such environments. Usability refers to how easily healthcare workers—often with limited experience using digital technologies—can understand, learn, and operate these systems. A focus on usability ensures that HIS are not only functional but also accessible, user-friendly, and adaptable to the constraints commonly found in resource-limited settings (Adler-Milstein et al., 2020). Designing HIS with these considerations in mind can help ease the workload of healthcare staff and enhance the quality of care they provide in challenging environments. To address these challenges, a user-centered design (UCD) approach is essential. UCD involves engaging end-users—such as healthcare workers, administrators, and sometimes patients—throughout the design and testing process. This approach helps ensure that HIS meet the actual needs of users and fit the specific context in which they will be implemented (Archer et al., 2021). For example, systems may include customizable tools for disease monitoring that focus on conditions prevalent in a particular region, thus making the technology more relevant and useful in daily practice. Usability challenges are particularly evident in rural and underserved areas, where the healthcare environment differs significantly from that of well-resourced urban settings. Healthcare workers in these regions may lack familiarity with digital systems, making it difficult for them to adopt HIS without intuitive interfaces and adequate training. Without careful attention to usability, HIS may be underutilized or even abandoned (Magrabi et al., 2021). This area of research is critical for advancing global health equity. Well-designed HIS

* Corresponding Author.
Email Address: aalageed@uhb.edu.sa (A. S. A. Osman)
https://doi.org/10.21833/ijaas.2025.07.017
Corresponding author's ORCID profile:
https://orcid.org/0000-0003-3444-6249

have the potential to reduce disparities in healthcare access, improve public health surveillance, and provide communities with better tools for health management. By addressing the unique challenges of rural and low-resource settings, HIS can become a key resource for delivering reliable, high-quality care and supporting data-driven healthcare decisions.

2. Literature review

The usability of HIS in rural and low-resource settings has become a critical research area as digital technologies are increasingly adopted in healthcare systems globally. HIS have the potential to transform healthcare delivery, improve patient outcomes, and optimize health management processes. However, their implementation in rural and underserved regions introduces unique challenges that demand a focused approach to usability.

In many low-resource settings, particularly rural areas, infrastructural barriers such as poor internet connectivity, unreliable electricity, limited hardware, and a lack of trained personnel impede the effective use of HIS (Sanders et al., 2023). Moreover, healthcare workers in these regions often have limited digital literacy and may face language and cultural barriers that standard HIS designs frequently overlook (Adler-Milstein et al., 2020). These challenges result in low adoption rates, inefficient system use, and reduced impact on healthcare outcomes. Addressing usability is therefore essential to tailor HIS to users' needs by ensuring they are user-friendly, language-inclusive, culturally sensitive, and functional under resource constraints (Archer et al., 2021).

The World Health Organization (WHO, 2024) provides comprehensive guidelines for implementing digital health systems in low-resource environments, emphasizing usability and sustainability. For instance, Benson et al. (2023) studied HIS usability challenges in Kenya and highlighted the importance of adapting systems to local needs. Similarly, Muller et al. (2020) examined the role of HIS in improving maternal and child health in rural environments, identifying usability barriers and proposing solutions to enhance system accessibility and adoption.

Global disparities in health spending amplify the importance of designing HIS for low-resource settings. In 2004, global health expenditures totaled $4.1 trillion, with the 30 OECD countries—representing only 20% of the world's population—accounting for 90% of this amount (WHO, 2007). High-income countries spent an average of $3,724 per capita on healthcare, while low-income countries spent just $32 per capita (WB, 2007). The WHO estimated that a minimum of $60 per person annually is required for a functioning health system, a level most low-income countries cannot meet. This funding gap makes it vital for HIS to support efficient resource allocation and decision-making in these regions (WB, 2007). Winter et al. (2010) described an HIS as the socio-technical subsystem of a healthcare institution, encompassing all processes and people involved in gathering, processing, storing, and sharing health data. Automated HIS (AHIS) aim to improve management decisions at all levels by facilitating data collection, processing, reporting, and use (Lippeveld et al., 2000). However, common obstacles in low-resource settings include redundant data entry, lack of timely feedback, and delays that render data outdated by the time decisions are made. Healthcare providers often lack clear guidelines and adequate tools for data collection, leading to incomplete, inaccurate, or irrelevant records (Muller et al., 2020). Centralized health systems further limit data utilization at district and community levels.

Research shows that community-based care models have been effective in resource-constrained settings, especially for managing HIV, tuberculosis, and maternal health (Bulut et al., 1991; Farmer and Kim, 1998; Farmer et al., 2001). Mobile technologies are increasingly recognized as enablers of such care. For example, community health workers using mobile devices contributed significantly to improving child nutrition outcomes in developing countries (Sahay and Walsham, 2017). However, limitations such as lack of training, inadequate infrastructure, and financial constraints remain significant hurdles. HIS design in these contexts must embrace simplicity and frugality to ensure systems are both practical and sustainable (Sahay et al., 2017).

Despite global healthcare spending reaching $9.8 trillion in 2021 (10.3% of GDP), low-income countries—comprising 8% of the world's population—accounted for only 0.24% of this total (WHO, 2024). Per capita healthcare expenditure in these countries remains below $50 annually, compared to over $4,000 in high-income countries. This stark disparity underscores the necessity of well-designed HIS to strengthen health systems and promote equitable healthcare access.

Lippeveld et al. (2000) identified five key challenges for HIS in such contexts: (1) data requirements set at management levels often overlook the technical capacity of local health workers; (2) health facilities frequently lack the tools for accurate data collection; (3) uniform data collection guidelines are seldom provided; (4) feedback to data collectors is rare, reducing motivation for maintaining data quality; and (5) delays in processing often render data obsolete for decision-making. These systemic issues often result in incomplete, duplicated, and low-quality data that fails to support effective healthcare management (Muller et al., 2020).

3. Methodology

Many challenges faced by users while using HIS were identified through observation and usability testing during their work. This paper focuses on examining the usability of HIS from the user's perspective. Usability and accessibility issues were evaluated, and user needs were identified by performing various tasks.

3.1. Participants

The focus group comprised individuals from rural areas, and the usability of various mobile applications was evaluated from their perspective. Participation in the study was entirely voluntary. A pre-experiment interview was conducted to assess participants' familiarity with and proficiency in using mobile applications. This evaluation helped identify individuals capable of effectively interacting with and navigating mobile interfaces. Based on the interview results, thirty-three participants were excluded from the initial pool of 113. Specifically, thirteen participants were completely illiterate; ten had significant difficulty using touch-screen interfaces, particularly in controlling the on-screen keyboard; twelve had no prior experience with touch-screen mobile applications; and eight were excluded because their age fell outside the required range of 20 to 50 years.

3.2. Material

Each participant used a touch-screen Android smartphone running Android 7.1. To ensure they understood the tasks, audio and video demonstrations were provided before the start of each activity. The study involved various health-related mobile applications and was conducted in a controlled laboratory setting. Participants were informed that they could withdraw from the experiment at any time if they wished or if they felt a task exceeded their abilities or expectations. In such cases, they were instructed to inform their mentor before leaving. The tasks assigned to participants included:

1. Creating and managing a user profile
2. Booking appointments
3. Accessing medical records
4. Receiving notifications and reminders

Table 1 lists these tasks along with their corresponding mobile applications.

Table 1: Tasks with assigned applications

Tasks	Tasks	Description
1	Create and manage profile	It is related to registering using personal details (name, age, gender, contact, etc.) and updating medical history or personal health records.
2	Book appointments	It is related to searching for doctors or specialists, viewing availability, and booking appointments.
3	Access medical records	It is related to viewing past and ongoing prescriptions and accessing diagnostic reports or lab results.
4	Receive notifications and reminders	It is related to getting reminders for medications or follow-up visits and receiving vaccination schedules.

After completing each task on the mobile applications, participants were interviewed, and their behavior patterns were analyzed to gain deeper insights into their experiences and emotional responses during the study. Participants were required to perform each of the specified tasks. The outcomes of the observations included the time taken to complete each task and the number of tasks successfully completed. Recordings were stopped when participants indicated that they had finished the assigned activities.

3.3. Usability evaluation

The usability performance was assessed using three key metrics: effectiveness, efficiency, and satisfaction (Harrison et al., 2013). The ISO 9241-11 standard was applied to evaluate effectiveness and efficiency. User satisfaction was measured using the After-Scenario Questionnaire (ASQ). During task execution, users may encounter mishaps, slips, or errors, which were also considered in the evaluation.

Effectiveness reflects the proportion of tasks successfully completed and is calculated as:

$$Effectiveness = (Total\ numbers\ of\ task\ completed\ successfully)/(Total\ number\ of\ task\ undertaken) * 100. \quad (1)$$

Efficiency refers to the resources—such as time, effort, and cognitive load—required to achieve the desired outcomes. It is measured as:

$$Efficiency = \frac{\sum_{j=1}^{R} \sum_{i=1}^{N} \frac{n_{ij}}{t_{ij}}}{N \times R} \quad (2)$$

In this context, N refers to the total number of tasks or goals assigned in the study, and R represents the total number of users who participated. The variable n_{ij} indicates the outcome of task i for user j, where a value of 1 means the task was successfully completed and a value of 0 means it was not. The variable t_{ij} represents the amount of time taken by user j to complete task i. If a task was not completed, the time was recorded up to the point when the participant stopped attempting the task.

To assess user satisfaction, the ASQ was employed due to its simplicity and ability to provide a quick evaluation. The questionnaire uses a 7-point Likert scale ranging from 0 (strongly disagree) to 6 (strongly agree) (Lewis, 2006).

4. Results and discussion

This section presents the findings on the effectiveness, efficiency, and user satisfaction of the HIS as perceived by rural residents. Fig. 1 illustrates the effectiveness of different tasks performed by users. The effectiveness rates for Task 1, Task 2, Task 3, and Task 4 are 87%, 48%, 40%, and 70%, respectively. Fig. 2 presents the efficiency of different tasks performed by users. The efficiency rates for Task 1, Task 2, Task 3, and Task 4 are 77%, 38%, 25%, and 87%, respectively.

Fig. 3 shows the satisfaction levels for different tasks performed by users. The satisfaction scores for Task 1, Task 2, Task 3, and Task 4 are 7.62, 4.2, 3.71, and 9.52, respectively.

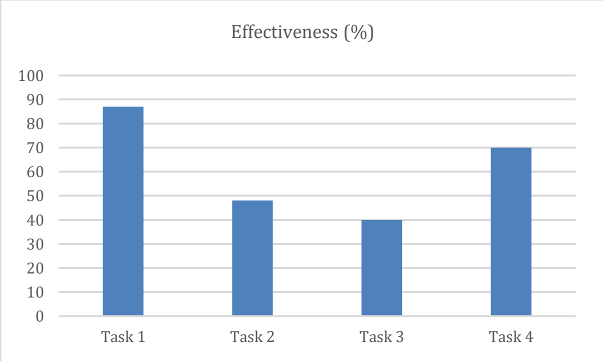

Fig. 1: Overall percentage of usability effectiveness of tasks

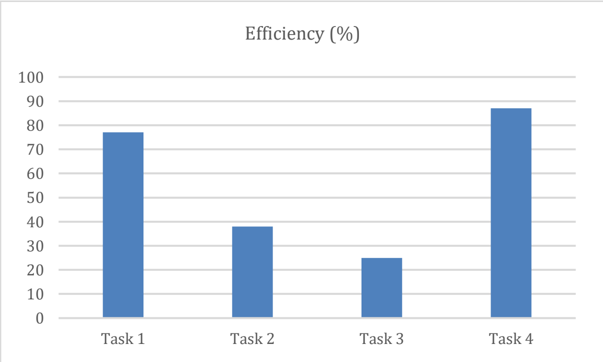

Fig. 2: Overall percentage of usability efficiency of tasks

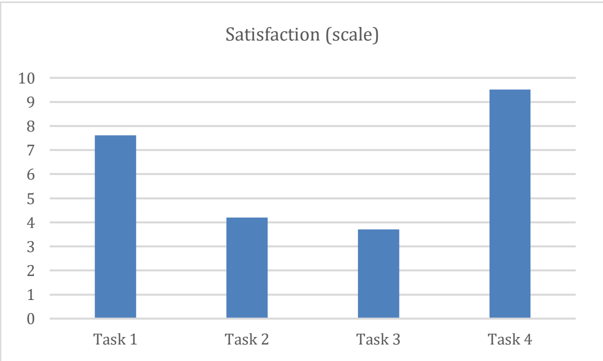

Fig. 3: Overall usability satisfaction of tasks

5. Conclusion

In the context of HIS, the usability evaluation of tasks for people living in rural areas was conducted using a structured experimental procedure; however, certain limitations remain. This study focused mainly on the basic tasks of HIS accessed through mobile applications. User background information, such as medical history, was not included in the analysis. Furthermore, the study considered only participants from rural areas. Usability testing was carried out in a controlled laboratory environment, without addressing diverse real-world conditions. Influential factors such as walking, time pressure, and crowded settings—common in everyday smartphone use—were not examined. Despite these limitations, the study provides a detailed investigation of user interaction and usability across various HIS tasks. It also explores user expectations and key usability factors related to health information systems. The findings offer valuable insights for improving the design of mobile applications to better meet the needs and preferences of users. Future work should focus on developing user-centered HIS solutions tailored to the needs of people in Sudan.

List of abbreviations

HIS	Health information systems
LMICs	Low- and middle-income countries
UCD	User-centered design
ASQ	After-scenario questionnaire
WHO	World Health Organization
OECD	Organization for Economic Co-operation and Development
GDP	Gross domestic product
AHIS	Automated health information system
HIV	Human immunodeficiency virus
TB	Tuberculosis
ISO	International Organization for Standardization

Compliance with ethical standards

Ethical considerations

All participants were informed about the objectives and procedures of the study and provided their informed consent prior to participation. They were assured of their right to withdraw from the study at any stage without any consequences. Furthermore, all data collected were anonymized to protect participants' identities and ensure confidentiality. The study adhered to ethical standards in accordance with the Declaration of Helsinki.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

Adler-Milstein J, Zhao W, Willard-Grace R, Knox M, and Grumbach K (2020). Electronic health records and burnout: time spent on the electronic health record after hours and message volume associated with exhaustion but not with cynicism among primary care clinicians. Journal of the American Medical Informatics Association, 27(4): 531-538. https://doi.org/10.1093/jamia/ocz220 **PMid:32016375 PMCid:PMC7647261**

Archer N, Lokker C, Ghasemaghaei M, and DiLiberto D (2021). eHealth implementation issues in low-resource countries: model, survey, and analysis of user experience. Journal of Medical Internet Research, 23(6): e23715. https://doi.org/10.2196/23715 **PMid:34142967 PMCid:PMC8277330**

Benson J, Brand T, Christianson L, and Lakeberg M (2023). Localisation of digital health tools used by displaced populations in low and middle-income settings: A scoping review and critical analysis of the participation revolution.

Conflict and Health, 17(1): 20.
https://doi.org/10.1186/s13031-023-00518-9
PMid:37061703 PMCid:PMC10105546

Bulut A, Uzel N, Kutluay T, and Neyzi O (1991). Experiences of a health team working in a new urban settlement area in Istanbul. Journal of Community Health, 16(5): 251-258. https://doi.org/10.1007/BF01320333 **PMid:1955576**

Farmer P and Kim JY (1998). Community based approaches to the control of multidrug resistant tuberculosis: Introducing "DOTS-plus." BMJ, 317: 671.
https://doi.org/10.1136/bmj.317.7159.671
PMid:9728004 PMCid:PMC1113843

Farmer P, Léandre F, and Mukherjee JS et al. (2001). Community-based approaches to HIV treatment in resource-poor settings. The Lancet, 358(9279): 404-409.
https://doi.org/10.1016/S0140-6736(01)05550-7
PMid:11502340

Harrison R, Flood D, and Duce D (2013). Usability of mobile applications: Literature review and rationale for a new usability model. Journal of Interaction Science, 1: 1.
https://doi.org/10.1186/2194-0827-1-1

Lewis JR (2006). Sample sizes for usability tests: Mostly math, not magic. Interactions, 13(6): 29-33.
https://doi.org/10.1145/1167948.1167973

Lippeveld T, Sauerborn R, and Bodart C (2000). Design and implementation of health information systems. World Health Organization, Geneva, Switzerland.

Magrabi F, Ammenwerth E, and Craven CK et al. (2021). Managing pandemic responses with health informatics–challenges for assessing digital health technologies. Yearbook of Medical Informatics, 30(1): 56-60.
https://doi.org/10.1055/s-0041-1726490
PMid:33882604 PMCid:PMC8416188

Muller N, McMahon SA, and De Neve JW et al. (2020). Facilitators and barriers to the implementation of a mobile health wallet for pregnancy-related health care: A qualitative study of stakeholders' perceptions in Madagascar. PLOS ONE, 15(1): e0228017.
https://doi.org/10.1371/journal.pone.0228017
PMid:32004331 PMCid:PMC6993972

Sahay S and Walsham G (2017). Information technology, innovation and human development: Hospital information systems in an Indian state. Journal of Human Development and Capabilities, 18(2): 275-292.
https://doi.org/10.1080/19452829.2016.1270913

Sahay S, Sundararaman T, and Braa J (2017). Public health informatics: Designing for change-a developing country perspective. Oxford University Press, Oxford, UK.
https://doi.org/10.1093/med/9780198758778.003.0001

Sanders C, Gibson K, Byrd AR, Markosyan T, and Lamm AJ (2023). Exploring the social media health information seeking patterns of rural residents to provide communication strategies for extension. Journal of Applied Communications, 107(4): 1. https://doi.org/10.4148/1051-0834.2499

WB (2007). World development indicators. World Bank, London, UK.

WHO (2007). World health statistics. World Health Organization, Geneva, Switzerland.

WHO (2024). WHO results report 2023: Notable health achievements and calls for concerted drive toward sustainable development goals. World Health Organization, Geneva, Switzerland.

Winter A, Haux R, Ammenwerth E, Brigl B, Hellrung N, and Jahn F (2010). Quality of health information systems. In: Winter A, Haux R, Ammenwerth E, Brigl B, Hellrung N, and Jahn F (Eds.), Health information systems: 201-236. Springer, London, UK.
https://doi.org/10.1007/978-1-84996-441-8_8