



Community-based digital health platforms in preventive health care for underserved areas

Faseeh Iqbal¹ , Sami Iqbal², Umar Farooq³, Sadia Nawaz¹, Muhammad Hammad^{1*} , Khadija Shakoor⁴, Fatima Noreen⁵

¹Riphah International University, Islamabad 46000, Pakistan

²Khyber Medical University, Peshawar 25100, Pakistan

³Psychiatric Clinic and Rehabilitation Center, Islamabad 44000, Pakistan

⁴HBS Medical and Dental College, Islamabad 45550, Pakistan

⁵Faculty of Allied Health Sciences, The University of Lahore, Lahore 54000, Pakistan

***Correspondence:** Muhammad Hammad, Riphah International University, Islamabad 46000, Pakistan. mhammad497@gmail.com

Academic Editor: James M. Flanagan, Imperial College London, UK

Received: November 26, 2025 **Accepted:** January 15, 2026 **Published:** February 26, 2026

Cite this article: Iqbal F, Iqbal S, Farooq U, Nawaz S, Hammad M, Shakoor K, et al. Community-based digital health platforms in preventive health care for underserved areas. *Explor Digit Health Technol.* 2026;4:101187. <https://doi.org/10.37349/edht.2026.101187>

Abstract

Aim: To assess healthcare professionals' awareness, attitudes, and utilization of community-based digital health platforms for preventive care in underserved districts of Khyber Pakhtunkhwa, Pakistan, and to identify key barriers associated with routine use.

Methods: A cross-sectional survey was conducted between December 2024 and February 2025 among 400 healthcare professionals (doctors, nurses, and allied health practitioners) working in primary, secondary, and tertiary facilities in Swabi and Mardan. Participants were recruited using purposive, stratified (quota-based) sampling. The questionnaire captured knowledge/awareness, attitudes, self-reported utilization, and perceived barriers (infrastructure, training, and privacy). Descriptive statistics were produced, and multivariable regression was used to examine factors associated with utilization.

Results: Among the 400 respondents, 332 (83.0%) reported awareness of digital health platforms and 312 (78.0%) reported positive attitudes toward their use. Overall, 297 (74.3%) reported using digital health platforms in practice. The most frequently reported barriers were lack of infrastructure ($n = 309$, 77.3%), limited training ($n = 297$, 74.3%), and data privacy concerns ($n = 295$, 73.8%). In the adjusted logistic regression model, greater knowledge of digital health platforms was associated with higher odds of routine use (aOR = 10.56, 95% CI: 2.36–47.35; $p = 0.002$), whereas attitude and infrastructure barriers were not significant ($p > 0.05$).

Conclusions: Healthcare professionals in Swabi and Mardan reported high awareness and favorable attitudes toward community-based digital health platforms, but infrastructure gaps, limited training, and data privacy concerns were common barriers. Greater platform knowledge predicted routine use. Strengthening facility readiness, workflow-based training, and practical safeguards to address data privacy



concerns may enable safer, more equitable scale-up; findings are context-specific due to non-probability sampling.

Keywords

preventive health care, underserved districts, infrastructure, training, data privacy concerns, awareness, attitudes, Pakistan

Introduction

Health disparities remain marked in underserved regions due to intersecting geographic, socio-economic, and health-system constraints. Rural and low-income communities commonly experience long travel distances, shortages of skilled providers and specialists, limited continuity of care, and high out-of-pocket costs, which collectively contribute to delayed diagnosis, reduced uptake of preventive services, and poorer control of chronic conditions [1, 2]. These gaps are particularly consequential in preventive health care, where timely screening, early risk identification, counseling, and follow-up are essential but often difficult to deliver consistently in resource-constrained settings. Community-based digital health platforms such as mobile health (mHealth) applications, teleconsultation services, digital registries, and distributed care networks have been proposed as practical approaches to extend preventive health services beyond facility walls and closer to communities [3, 4]. When aligned with community programs, such platforms can support patient education, reminders for immunization and screening, monitoring for chronic diseases, and referral coordination, thereby improving opportunities for early detection and ongoing prevention-oriented care [4, 5]. Digital tools can also strengthen self-care by enabling individuals to track symptoms and behaviors, receive tailored feedback, and engage more actively with preventive advice [6]. In addition, analytics-enabled functions (including rule-based triage and AI/ML-supported risk estimation where feasible) may help identify individuals at increased risk and support earlier preventive actions, especially when provider time and diagnostic capacity are limited [7, 8]. Despite these potential benefits, implementation remains uneven in low-resource contexts. A persistent digital divide limited broadband coverage, unstable electricity, affordability barriers to smartphones and data packages, and variable digital literacy reduces reach and sustained use of digital solutions in rural and underserved areas [9]. Data privacy concerns related to confidentiality, data governance, and trust may influence acceptance, particularly when digital systems collect personally identifiable health information and when privacy safeguards are unclear to users and providers [10]. Importantly, adoption is not determined by technology alone; it also depends on workflow fit, organizational readiness, and whether frontline workers perceive the tools as useful, usable, and supportive of their daily clinical responsibilities. Healthcare professionals are central to digital health adoption because they often decide whether and how digital platforms are incorporated into routine preventive care. Community health workers (CHWs) and other frontline providers can play a pivotal role in translating digital functions into community-level impact by delivering health education, facilitating referrals, and using digital tools to support follow-up and continuity of care [11, 12]. However, achieving durable benefits requires more than initial deployment; it depends on training, supervision, supportive infrastructure, and integration into health-system processes such as reporting, referral pathways, and performance monitoring [13, 14]. Without these enabling conditions, digital health platforms risk becoming parallel systems that increase workload without improving outcomes. To help move the field from promise to practice, particularly in underserved settings, implementation pathways should be grounded in tangible, context-appropriate levers. For connectivity constraints, programs may need “low-bandwidth” or “offline-first” designs (e.g., store-and-forward data capture, periodic syncing, and simple interfaces), use of SMS/USSD messaging where smartphones or data plans are limited, and deployment models that allow shared devices or community-based digital access points. In some contexts, complementary connectivity options (e.g., local low-power networks or hybrid architectures that reduce reliance on continuous broadband) may be explored as part of broader digital infrastructure strategies. For adoption barriers within the workforce, training should move beyond one-

time orientations to include role-specific competency building, ongoing refreshers, and practical guidance on privacy-preserving workflows (e.g., consent procedures, secure logins, and appropriate handling of sensitive information). For sociocultural fit, programs should consider gender- and culture-sensitive delivery modes (for example, preferences for in-person support supplemented by messaging, or privacy-preserving options for sensitive topics) and acknowledge hierarchical dynamics that may shape whether staff feel comfortable using or recommending digital tools. Together, these considerations can strengthen the likelihood that digital platforms are used consistently and safely and can inform policy and program design in similar low-resource environments [15]. The present study examines awareness/knowledge, attitudes, and self-reported use of community-based digital health platforms among healthcare professionals working in primary, secondary, and tertiary facilities in Swabi and Mardan districts, Khyber Pakhtunkhwa, Pakistan districts characterized by mixed rural and semi-urban populations and commonly reported service delivery constraints. While the study is geographically specific, it provides evidence that can inform hypotheses and future implementation planning for comparable settings where preventive care delivery faces similar structural and organizational challenges. To interpret adoption-related patterns, this study draws conceptually on technology adoption frameworks. The Technology Acceptance Model (TAM) highlights perceived usefulness and perceived ease of use as key determinants of uptake [16, 17], while the Unified Theory of Acceptance and Use of Technology (UTAUT) emphasizes performance expectancy, effort expectancy, and social influence, along with facilitating conditions that enable routine use [18]. These lenses are relevant for understanding why awareness may not translate into consistent utilization and why barriers such as limited training, infrastructure constraints, and data privacy concerns may shape real-world adoption. Accordingly, the primary aim of this study is to assess healthcare providers' knowledge, attitudes, and utilization of community-based digital health platforms in Swabi and Mardan and to identify key barriers and factors associated with their use in routine preventive practice.

Materials and methods

A cross-sectional survey was conducted between December 2024 and February 2025 in the Swabi and Mardan districts of Khyber Pakhtunkhwa, Pakistan. These districts were purposively selected because they include underserved populations and encompass a mix of primary, secondary, and tertiary healthcare facilities serving rural and semi-urban catchment areas, providing an appropriate context for examining the adoption of digital health platforms in resource-constrained settings.

A purposive, stratified quota-based sampling approach was used to recruit healthcare professionals from public and private facilities in Swabi and Mardan. Stratification was defined by facility level (primary, secondary, tertiary) and professional role (doctors, nurses, allied health professionals) to ensure representation across key service levels and cadres. Facilities were selected purposively within each district to capture variation by level and sector. Within facilities, eligible staff were approached consecutively during duty hours and invited to participate voluntarily after receiving study information; written informed consent was obtained.

A total of 450 eligible staff were invited; 32 declined, and 18 returned incomplete questionnaires, yielding a final analytic sample of 400 (response rate: 88.9%). Given the non-probability quota design, results are reported as unweighted descriptive estimates (denominator $N = 400$) and are not intended as population prevalence estimates; design-based standard errors, margins of error, and survey weights were not calculated.

Inclusion criteria

Healthcare workers aged ≥ 18 years who were actively practicing in government or private facilities in Swabi or Mardan during the data collection period and who provided informed consent.

Exclusion criteria

Healthcare workers who were not currently practicing (e.g., on extended leave), declined consent, or returned questionnaires that were incomplete for the primary outcome (use of digital health platforms).

Data were collected using a structured, self-administered questionnaire administered in person to eligible healthcare professionals. The instrument was adapted from established items in the digital health and technology adoption literature and refined for the local context through expert review. The questionnaire comprised a total of 16 close-ended items across five domains: (1) demographics (age group, gender, profession, years of experience, facility level, and sector public/private); (2) knowledge/awareness of digital health platforms and tool types; (3) attitudes toward integrating digital health into routine practice; (4) current use and patterns of use (e.g., tools used and frequency); and (5) perceived barriers (infrastructure limitations, training gaps, data privacy concerns). The questionnaire comprised a total of 16 close-ended items. All binary items were coded as 1 = Yes and 0 = No, and summarized using frequencies and percentages. The knowledge/awareness domain comprised two binary items (Q6–Q7); respondents were classified as aware/knowledgeable if they answered “Yes” to at least one knowledge item. Attitudes toward digital health comprised three binary items (Q8–Q10); an overall attitude score was calculated by summing responses (range: 0–3) and categorized as positive if the score was ≥ 2 , and neutral/negative otherwise (thresholds prespecified a priori). Routine utilization of digital health platforms (primary outcome) was measured as self-reported current use in practice (Q11) and dichotomized as 1 = Yes and 0 = No. Perceived barriers were captured using three binary items: lack of infrastructure (Q14), limited training (Q15), and data privacy concerns (Q16), recorded as Yes/No for each barrier domain. For terminology consistency, throughout the manuscript, data privacy concerns refer to perceived risks regarding confidentiality and potential misuse of data.

Statistical analysis

Data were analyzed using IBM SPSS Statistics (version 26.0). Descriptive statistics were used to summarize participant characteristics and study variables; categorical data are presented as frequencies and percentages (unweighted; $N = 400$). Binary logistic regression was conducted to examine factors associated with routine digital health platform use (outcome coded 1 = Yes, 0 = No). Profession was entered as a categorical predictor using dummy variables (reference category specified in the model). Predictors included knowledge of digital health platforms, attitudes toward digital health, perceived lack of infrastructure, limited training opportunities, and data privacy concerns. Results are reported as unstandardized coefficients (B) with two-sided p -values, and statistical significance was set at $p < 0.05$. Questionnaires missing the primary outcome were excluded, and analyses were performed using a complete-case approach for variables included in the regression model.

Ethical approval

The study was conducted in accordance with institutional ethical standards outlined by the institutional research committee and in compliance with the 2024 Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board (IRB) of the University of Lahore (Ref No: REC-UOL-584/08/24). All participants provided informed consent, and confidentiality was maintained throughout.

Results

A total of 400 healthcare professionals were included in the final analysis. In Swabi and Mardan, 332 (83.0%) participants reported awareness of digital health platforms, and 312 (78.0%) reported a positive attitude toward their use. In routine practice, 297 (74.3%) reported using digital health platforms, whereas 103 (25.8%) did not. The most frequently reported barriers were lack of infrastructure ($n = 309$, 77.3%), limited training ($n = 297$, 74.3%), and data privacy concerns ($n = 295$, 73.8%). In the multivariable logistic regression model, knowledge of digital health platforms was the only statistically significant predictor of routine platform use (aOR = 10.56, 95% CI: 2.36–47.35; $p = 0.002$). Profession, attitude toward digital health, and lack of infrastructure were not statistically significant after adjustment ($p > 0.05$). As data were collected only in Swabi and Mardan using a non-probability sampling approach, findings should be interpreted as descriptive of the surveyed sample; however, the identified barriers may inform implementation planning and hypothesis generation in comparable low-resource settings.

Participant characteristics

Table 1 presents the demographic distribution of participants by gender, profession, and facility level. The sample included 230 (57.5%) male and 170 (42.5%) female participants. The largest group was doctors ($n = 158$, 39.5%), followed by nurses ($n = 126$, 31.5%) and allied health professionals ($n = 116$, 29.0%). Nearly half worked in primary healthcare facilities ($n = 190$, 47.5%), with 92 (23.0%) in secondary and 118 (29.5%) in tertiary care.

Table 1. Demographic characteristics of participants ($N = 400$).

Characteristic	Frequency (n)	Percentage (%)
Gender		
Male	230	57.5
Female	170	42.5
Profession		
Doctor	158	39.5
Nurse	126	31.5
Allied health professional	116	29.0
Healthcare facility level		
Primary	190	47.5
Secondary	92	23.0
Tertiary	118	29.5

Awareness, attitudes, and use of digital health platforms

Table 2 summarizes participants' reported awareness/knowledge, attitudes, and utilization. Most participants reported awareness/knowledge of digital health platforms ($n = 332$, 83.0%) and positive attitudes ($n = 312$, 78.0%). Utilization in practice was reported by 297 participants (74.3%), while 103 (25.8%) reported non-use.

Table 2. Awareness/knowledge, attitudes, and use of digital health platforms ($N = 400$).

Variable	Frequency (n)	Percentage (%)
Awareness/Knowledge of digital health platforms		
Yes	332	83.0
No	68	17.0
Attitudes toward digital health		
Positive	312	78.0
Neutral/Negative	88	22.0
Use of digital health in practice		
Yes	297	74.3
No	103	25.8

Barriers to adoption

Table 3 shows barriers reported by participants. Lack of infrastructure was most frequently reported ($n = 309$, 77.3%), followed by limited training ($n = 297$, 74.3%) and data privacy concerns ($n = 295$, 73.8%).

Table 3. Barriers to adoption of digital health platforms ($N = 400$).

Barrier	Frequency (n)	Percentage (%)
Lack of infrastructure	309	77.3
Limited training	297	74.3
Data privacy concerns	295	73.8

Multiple binary logistic regression

As shown in Table 4, multivariable binary logistic regression was used to examine factors associated with routine digital health platform use (0 = No, 1 = Yes). Candidate predictors were profession, knowledge of digital health platforms, attitudes toward digital health, lack of infrastructure, limited training opportunities, and data privacy concerns; however, because models including all barrier variables showed convergence/estimation instability, results are presented for the final converged adjusted model (profession, knowledge, attitude, and lack of infrastructure). In this model, greater knowledge of digital health platforms was independently associated with higher odds of routine use ($B = 2.357, p = 0.002$; aOR = 10.56, 95% CI: 2.36–47.35), whereas profession, attitude, and lack of infrastructure were not statistically significant after adjustment ($p > 0.05$). Model explanatory power was moderate (Nagelkerke $R^2 = 0.651$), with 91.3% overall classification accuracy (cut-off = 0.50); the Hosmer–Lemeshow test was significant ($p < 0.001$), indicating imperfect calibration.

Table 4. Multivariable logistic regression predicting routine digital health platform use ($N = 400$).

Predictor	B	SE	p	aOR	95% CI for aOR
Profession	-0.199	0.263	0.448	0.819	0.490–1.371
Knowledge of digital health	2.357	0.765	0.002	10.564	2.357–47.347
Attitude toward digital health	1.378	1.316	0.295	3.968	0.301–52.309
Lack of infrastructure	1.586	1.268	0.211	4.883	0.406–58.678
Constant	-2.509	0.949	0.008	0.081	—

Outcome: Routine use in digital health practice (0 = No, 1 = Yes)

Discussion

In this cross-sectional survey of healthcare professionals in Swabi and Mardan, knowledge and attitudes toward digital health were generally high, and approximately three-quarters of participants reported routine platform use. The observed pattern whereby knowledge and positive attitudes were associated with use is consistent with established technology adoption frameworks, including the TAM, which emphasize perceived usefulness and readiness as drivers of uptake in practice [17].

This study was designed to characterize adoption within two underserved districts rather than to estimate population prevalence across Khyber Pakhtunkhwa or Pakistan. Because facilities and participants were recruited purposively within strata, the reported percentages should be interpreted as unweighted sample proportions, and findings should not be generalized beyond Swabi and Mardan without additional probability-based studies. Nevertheless, the implementation levers highlighted here reliable connectivity and power, practical workforce training, and measures to address data privacy concerns through clear governance are widely discussed across low-resource settings; therefore, these findings may inform planning hypotheses and implementation priorities, while acknowledging that prevalence estimates require probability-based sampling.

In the multivariable binary logistic regression model, knowledge of digital health platforms was the only factor independently associated with routine use ($B = 2.357, p = 0.002$; aOR = 10.56, 95% CI: 2.36–47.35), indicating that greater platform knowledge and familiarity substantially increase the likelihood of adoption in routine practice. In contrast, profession, attitude toward digital health, and lack of infrastructure were not statistically significant in the adjusted model ($p > 0.05$). Although infrastructure limitations and data privacy concerns were frequently reported barriers in descriptive analyses, the adjusted findings suggest that such system constraints may influence adoption indirectly, for example by limiting opportunities to build knowledge and practical skills; wide CIs for some predictors also indicate imprecision. Overall, the findings support implementation strategies that prioritize structured onboarding, practical hands-on training, and continuous user support to strengthen routine use of digital health platforms in comparable low-resource settings.

Implementation considerations for scale-up

In low-resource settings such as rural districts in Pakistan, including Swabi and Mardan, digital health platforms should be designed for low-bandwidth workflows and user preferences. Offline-capable (“offline-first”) applications, store-and-forward workflows, and low-bandwidth channels (e.g., SMS/USSD, lightweight app interfaces, or secure asynchronous messaging) can support reminders, reporting, and follow-up when real-time video communication is not feasible. In areas with very limited connectivity, complementary options such as low-power wide-area networking (e.g., LoRa/LoRaWAN) have been explored for transmitting basic, low-data signals over long distances and may be considered alongside mobile networks where appropriate [19]. Scale-up should also account for gender and sociocultural factors, including comfort in sharing sensitive health information, language needs, and hierarchical decision-making norms that may shape who uses digital tools and how information is communicated within facilities. These considerations should be assessed explicitly in future work and incorporated into governance and implementation planning to support equitable adoption.

Workforce enablement

Workforce support should prioritize brief, modular, and role-specific training (e.g., tailored for nurses, CHWs, and physicians), reinforced through on-site “digital champions,” job aids, and periodic refresher sessions. Implementation should align digital tasks with routine preventive-care workflows (e.g., screening, immunization follow-up, antenatal care follow-up, and NCD monitoring) to minimize duplication and perceived workload and to improve sustained use.

Privacy, governance, and trust

Data privacy concerns were commonly reported as a barrier in this study, indicating that concerns about confidentiality and potential misuse of data may affect willingness to engage with digital health platforms. Although privacy concerns were not retained as an independent predictor in the final converged adjusted model, strengthening visible governance measures may still support adoption by improving trust and acceptability. In Pakistan, national policy documents emphasize coordinated digital health development and data governance [20], and draft legislation has proposed requirements for handling personal data [21]. At the facility and program level, practical measures include role-based access control, secure authentication, encryption in transit and at rest, audit trails, and clear patient-facing communication on what data are collected, why they are collected, and how they are protected.

Future research and limitations

Future studies should include implementation-focused designs (e.g., staged pilots and co-design with frontline staff and communities) and track pragmatic indicators such as uptake, data completeness, workflow burden, service coverage, and equity; research across additional districts, including urban centers, may help distinguish context-dependent from more widely relevant barriers. This study is limited by purposive, stratified quota sampling (limiting generalizability and population inference; we therefore report unweighted proportions for the sampled professionals in Swabi and Mardan), its cross-sectional design, several single-item measures with potential response bias, and the absence of facility-level assessments of infrastructure and policy environments that may influence adoption. Because several constructs were assessed using single items, future studies should consider validated multi-item scales and report psychometric properties to strengthen measurement precision.

Implications for policy and practice

These findings highlight priorities for strengthening preventive-care digital health in low-resource settings: investment in basic infrastructure (connectivity, power, and access to devices), workflow-aligned training and ongoing support for diverse cadres of health workers, and clear, enforceable data-governance measures to address privacy concerns and build trust among providers and patients. Community engagement and awareness activities may further support appropriate use and sustained adoption.

Recommendations

1. **Invest in enabling infrastructure:** Improve connectivity, power reliability, and device availability at facilities; adopt low-bandwidth/offline-capable workflows where broadband access is limited.
2. **Enhance training and capacity building:** Provide continuous, workflow-based training for all cadres, complemented by refresher courses and on-the-job support.
3. **Strengthen data privacy and security:** Implement clear privacy regulations and practical safeguards (e.g., authentication, role-based access, secure storage, consent procedures, and facility SOPs) and train staff in confidentiality practices.
4. **Foster interdisciplinary integration:** Involve doctors, nurses, and allied professionals in planning and implementation to ensure workflow fit, shared ownership, and consistent use.
5. **Promote community engagement and awareness:** Expand community outreach to address concerns, build trust, and increase digital health literacy to encourage participation in preventive services.

Conclusion

Healthcare professionals in Swabi and Mardan, Pakistan reported high knowledge and generally positive attitudes toward digital health platforms, and nearly three-quarters indicated routine use in practice. Nonetheless, key system barriers particularly infrastructure gaps, limited training opportunities, and data privacy concerns were commonly reported and may hinder broader and sustained adoption. Strengthening facility readiness, delivering workflow-based training, and addressing data privacy concerns through clear, practical safeguards could support safer and more equitable scale-up of digital health platforms for preventive care in comparable underserved settings.

Abbreviations

AI/ML: artificial intelligence/machine learning

aOR: Adjusted Odds Ratio

CHWs: community health workers

CI: confidence interval

IRB: Institutional Review Board

mHealth: mobile health

NCD: non-communicable disease

SMS: short message service

SPSS: Statistical Package For The Social Sciences

TAM: Technology Acceptance Model

USSD: Unstructured Supplementary Service Data

UTAUT: Unified Theory of Acceptance and Use of Technology

Declarations

Acknowledgments

The authors sincerely acknowledge the participating healthcare facilities in Swabi and Mardan for their valuable support in facilitating data collection. The authors declare that there are no conflicts of interest associated with these institutions.

Author contributions

FI: Conceptualization, Investigation, Methodology, Writing—original draft, Project administration, Writing—review & editing. SI: Data curation, Validation, Investigation, Visualization, Writing—original draft, Project administration, Writing—review & editing. UF: Resources, Data curation, Software, Validation, Investigation, Visualization, Writing—original draft, Writing—review & editing. SN: Writing—original draft, Writing—review & editing. MH: Resources, Data curation, Software, Formal analysis, Supervision, Validation, Investigation, Visualization, Methodology, Writing—original draft, Project administration, Writing—review & editing. KS: Resources, Data curation, Software, Formal analysis, Investigation, Visualization, Methodology, Writing—original draft, Project administration, Writing—review & editing. FN: Conceptualization, Resources, Software, Investigation, Methodology, Writing—original draft, Project administration, Writing—review & editing. All authors read and approved the final version of the manuscript.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical approval

The study was conducted in accordance with the ethical standards of the institutional research committee and in compliance with the 2024 Declaration of Helsinki. Ethical approval was obtained from the Institutional Review Board (IRB) Ref No: REC-UOL-/584/08/24 from University of Lahore, 54000, Pakistan.

Consent to participate

Informed consent was obtained from all participants, and data confidentiality and anonymity were maintained throughout the study.

Consent to publication

Not applicable.

Availability of data and materials

Survey data are available from the corresponding author on reasonable request.

Funding

Not applicable.

Copyright

© The Author(s) 2026.

Publisher's note

Open Exploration maintains a neutral stance on jurisdictional claims in published institutional affiliations and maps. All opinions expressed in this article are the personal views of the author(s) and do not represent the stance of the editorial team or the publisher.

References

1. Akhtar MH, Ramkumar J. Primary Health Center: Can it be made mobile for efficient healthcare services for hard to reach population? A state-of-the-art review. *Discov Health Syst.* 2023;2:3. [DOI] [PubMed] [PMC]
2. Healthcare Access in Rural Communities [Internet]. Grand Forks (ND): Rural Health Information Hub; c2002–2026 [cited 2025 Nov 11]. Available from: <https://www.ruralhealthinfo.org/topics/healthcare-access>

3. Maita KC, Maniaci MJ, Haider CR, Avila FR, Torres-Guzman RA, Borna S, et al. The Impact of Digital Health Solutions on Bridging the Health Care Gap in Rural Areas: A Scoping Review. *Perm J*. 2024;28:130–43. [DOI] [PubMed] [PMC]
4. Asif M, Gaur P. The Impact of Digital Health Technologies on Chronic Disease Management. *Telehealth Med Today*. 2025;10:556. [DOI]
5. Chaturvedi U, Chauhan SB, Singh I. The impact of artificial intelligence on remote healthcare: Enhancing patient engagement, connectivity, and overcoming challenges. *Intel Pharm*. 2025;3:323–9. [DOI]
6. Balasubramanian GV, Beaney P, Chambers R. Digital personal assistants are smart ways for assistive technology to aid the health and wellbeing of patients and carers. *BMC Geriatr*. 2021;21:643. [DOI] [PubMed] [PMC]
7. Dixon D, Sattar H, Moros N, Kesireddy SR, Ahsan H, Lakkimsetti M, et al. Unveiling the Influence of AI Predictive Analytics on Patient Outcomes: A Comprehensive Narrative Review. *Cureus*. 2024;16:e59954. [DOI] [PubMed] [PMC]
8. Munir MM, Ahmed N. Using Social Media Platforms to Raise Health Awareness and Increase Health Education in Pakistan: Structural Equation Modeling Analysis and Questionnaire Study. *JMIR Hum Factors*. 2025;12:e65745. [DOI] [PubMed] [PMC]
9. Raihan MMH, Subroto S, Chowdhury N, Koch K, Ruttan E, Turin TC. Dimensions and barriers for digital (in)equity and digital divide: a systematic integrative review. *Digit Transform Soc*. 2025;4:111–27. [DOI]
10. Mantena S, Celi LA, Keshavjee S, Beratarrechea A. Improving community health-care screenings with smartphone-based AI technologies. *Lancet Digit Health*. 2021;3:e280–2. [DOI] [PubMed] [PMC]
11. D’Ambruoso L, Abruquah NA, Mabetha D, van der Merwe M, Goosen G, Sigudla J, et al.; Verbal Autopsy with Participatory Action Research (VAPAR)/Wits/Mpumalanga Department of Health Learning Platform. Expanding Community Health Worker decision space: learning from a Participatory Action Research training intervention in a rural South African district. *Hum Resour Health*. 2023;21:66. [DOI] [PubMed] [PMC]
12. Ahmed S, Chase LE, Wagnild J, Akhter N, Sturridge S, Clarke A, et al. Community health workers and health equity in low- and middle-income countries: systematic review and recommendations for policy and practice. *Int J Equity Health*. 2022;21:49. [DOI] [PubMed] [PMC]
13. Ibeneme S, Ukor N, Ongom M, Dasa T, Muneene D, Okeibunor J. Strengthening capacities among digital health leaders for the development and implementation of national digital health programs in Nigeria. *BMC Proc*. 2020;14:9. [DOI] [PubMed] [PMC]
14. Phuong J, Ordóñez P, Cao J, Moukheiber M, Moukheiber L, Caspi A, et al. Telehealth and digital health innovations: A mixed landscape of access. *PLOS Digit Health*. 2023;2:e0000401. [DOI] [PubMed] [PMC]
15. Vicente AM, Ballensiefen W, Jönsson J. How personalised medicine will transform healthcare by 2030: the ICPeMed vision. *J Transl Med*. 2020;18:180. [DOI] [PubMed] [PMC]
16. Marikyan D, Papagiannidis S. Technology Acceptance Model: A review. In: Papagiannidis S, editor. *Theory Hub Book*. Newcastle University; 2024.
17. Giebel GD, Speckemeier C, Abels C, Plescher F, Borchers K, Wasem J, et al. Problems and Barriers Related to the Use of Digital Health Applications: Scoping Review. *J Med Internet Res*. 2023;25:e43808. [DOI] [PubMed] [PMC]
18. Blut M, Chong AYL, Tsigna Z, Venkatesh V. Meta-analysis of the Unified Theory of Acceptance and Use of Technology (UTAUT): Challenging its validity and charting a research agenda in the Red Ocean. *J Assoc Inf Syst*. 2022;23:13–95. [DOI]
19. Alghamdi A. Simultaneous mobility of gateways and nodes in LoRaWAN. *Front Commun Netw*. 2025;6:1621431. [DOI]

20. Government of Pakistan Ministry of National Health Services, Regulations & Coordination. National Digital Health Framework 2022–2030. Government of Pakistan; 2022.
21. Ministry of Information Technology & Telecommunication (MoITT), Government of Pakistan. Draft Personal Data Protection Bill. Government of Pakistan; 2023.