

IMPACT OF DIGITAL DIVIDE ON HEALTHCARE ACCESS AND HEALTH OUTCOMES IN RURAL POPULATIONS

Original Article

Muhammad Israr^{1*}, Khan Bilal Akbar Hayat Khan Niazi², Ayesha Khan³, Ahmed Nawaz Kandhro⁴, Muhammad Zeeshan Ahmed⁵, Farhan Muhammad Qureshi⁶, Summaya Mehboob⁷

¹Vitreoretinal Fellow, Khyber Teaching Hospital, Peshawar, Pakistan.

²MS Scholar in Public Health, Department of Public Health, TIMES Institute, Multan, Pakistan.

³Medical Officer, Armed Forces Post Graduate Medical Institute (AFPGMI), National University of Medical Sciences (NUMS), Rawalpindi, Pakistan.

⁴University of Sindh, Jamshoro, Pakistan.

⁵Scholar of DHPE, Department of Health Professional Education, Health Services Academy, Islamabad, Pakistan.

⁶Associate Professor, Department of Community Medicine, Karachi Institute of Medical Sciences (KIMS), National University of Medical Sciences (NUMS), Pakistan.

⁷MBBS Graduate, Federal Medical College, Islamabad, Pakistan.

Corresponding Author: Muhammad Israr, Vitreoretinal Fellow, Khyber Teaching Hospital, Peshawar, Pakistan, israrmaluk@gmail.com

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ABSTRACT

Background: The global shift toward digital healthcare has the potential to improve service delivery; however, it has also amplified existing inequities for rural populations lacking access and literacy. In Pakistan, where rural healthcare access is already limited, the digital divide presents an additional barrier that may further deteriorate health outcomes.

Objective: To investigate the extent of digital health access disparities in rural Pakistan and examine their association with patient-reported health outcomes.

Methods: A mixed-methods study was conducted over eight months (August 2024–April 2025) in the rural districts of Punjab, Sindh and KPK. A total of 120 adult participants were enrolled through purposive and convenience sampling. Quantitative data were gathered using the eHealth Literacy Scale (eHEALS), the EQ-5D-5L, and EQ-VAS instruments. ANOVA and Pearson correlation were applied to assess associations. Additionally, semi-structured interviews with 20 participants were conducted to explore contextual barriers and experiences, with thematic analysis used for interpretation.

Results: Among participants, 72.5% had primary education or less, 39.2% owned a smartphone, and only 28.3% had internet access at home. eHEALS scores revealed low digital literacy in 40.8% of participants. Those with higher eHealth literacy reported better EQ-VAS scores (mean: 74.6) compared to the low literacy group (mean: 53.4), with statistical significance ($p < 0.001$). Qualitative findings identified digital exclusion, dependency on others for access, and preference for face-to-face care as major themes.

Conclusion: Digital health disparities are a significant determinant of rural health outcomes in Pakistan. Bridging this divide requires integrated efforts in infrastructure, education, and policy reform to ensure equitable access to digital healthcare.

Keywords: Digital Divide, eHealth Literacy, Health Disparities, Pakistan, Rural Health Services, Self-Reported Health, Telemedicine.

INTRODUCTION

Across the globe, digital technologies are revolutionizing how healthcare is accessed and delivered. Yet, not all communities benefit equally. In rural populations, limited digital infrastructure, socioeconomic disparities, and gaps in digital literacy collectively contribute to a persistent digital divide—an inequity that directly undermines healthcare access and health outcomes. This research is grounded in the pressing need to understand and address how this divide not only limits the adoption of digital health technologies but also widens existing health disparities, especially among marginalized rural groups (1,2). The healthcare landscape has undergone a dramatic transformation in recent years, driven in part by the increasing integration of digital tools such as telehealth, mobile health (mHealth) applications, and electronic health records. These innovations hold immense promise for improving healthcare delivery, especially in remote or underserved areas where traditional healthcare infrastructure is sparse. However, studies show that the deployment and utilization of these technologies remain significantly lower in rural settings. For instance, a study found that, while telemedicine has been successfully adopted in some rural oncology care models, widespread implementation is still lacking due to access limitations and socioeconomic barriers (3,4).

The COVID-19 pandemic intensified awareness of these inequities, as access to virtual healthcare became not just a convenience but a necessity. Yet, in countries like Russia, the crisis deepened rural-urban disparities in digital engagement with healthcare, with certain rural groups becoming even more isolated from services due to poor digital infrastructure and lack of digital literacy (5). Similarly, in China, digital access among older rural residents remains alarmingly low despite widespread mobile phone ownership, with internet use being a strong predictor of better health outcomes (6). These findings underline a critical truth: digital connectivity is not merely a technical issue but a determinant of health equity. Beyond infrastructure, other complex factors perpetuate the digital divide. A qualitative study of rural communities highlights how economic hardship, limited educational resources, and unreliable internet connectivity combine to limit access and usage of digital health resources. Interview participants described depending on school-based internet or shared family devices, leading to inconsistent and often insufficient engagement with digital healthcare services (7,8). A study further emphasized that, older adults in rural India face profound digital exclusion due to physical aging, illiteracy, and low confidence in using technology, despite moderate mobile phone ownership (9).

The consequences of this exclusion are far-reaching. A study found that in rural populations, the lack of digital integration is correlated with poorer mental health outcomes. While digital tools appear to enhance well-being through improved social participation in urban settings, these benefits do not extend evenly to rural populations, further entrenching health inequities (10). Additionally, another study pointed out that most digital healthcare initiatives are not designed with the rural context in mind, highlighting a need for policy realignment and targeted design strategies to close the rural health technology gap (11). As digital healthcare becomes increasingly embedded in health systems, the exclusion of rural populations threatens to deepen existing disparities, leading to worse outcomes in chronic disease management, mental health, and preventive care (12). Therefore, addressing this divide is not merely a matter of digital inclusion but one of health justice. Bridging this gap will require more than infrastructure investment; it demands thoughtful integration of education, policy, and culturally appropriate interventions tailored to rural realities. In response to this critical issue, the present study seeks to explore the qualitative dimensions of the digital divide in rural healthcare. Specifically, it aims to understand how disparities in digital access affect patient experiences and health outcomes. By employing a qualitative or mixed-methods approach, this research intends to illuminate the lived experiences of rural residents navigating digital healthcare systems, offering insights that can inform more equitable healthcare policies and technological interventions. **The objective of this study is to investigate how disparities in digital access among rural populations influence their ability to engage with healthcare services and, in turn, affect their health outcomes, thereby identifying key barriers and potential strategies for bridging this critical divide.**

METHODS

This study adopted a mixed-methods approach to investigate disparities in digital healthcare access and their influence on patient outcomes among rural populations in Pakistan. Conducted over an eight-month period from August 2024 to April 2025, the research was situated in two distinct rural districts: Bhakkar in Punjab and Dadu in Sindh. These regions were strategically selected due to their representative demographic diversity, limited digital infrastructure, and known healthcare access challenges, making them suitable for exploring the digital divide in a healthcare context. Participants included adult residents (≥ 18 years) from both genders who had resided in the selected districts for at least one year and had a self-reported history of accessing or attempting to access healthcare services in the past 12 months. Inclusion criteria emphasized participants' cognitive ability to provide informed consent and communicate in Urdu

or the local dialects. Individuals with severe psychiatric conditions impairing consent, or who were terminally ill, were excluded to minimize distress and ensure reliable data collection. To determine the required sample size, a power analysis was conducted using G*Power software, targeting a medium effect size ($f^2 = 0.15$), alpha of 0.05, and a power of 0.80. Assuming a multivariate analysis model with five predictors, the minimum required sample was 92. Accounting for an estimated 20% non-response or incomplete data rate, the final sample size was set at 120 participants. Additionally, to enrich the qualitative dimension, purposive sampling identified 20 individuals for in-depth interviews, ensuring diversity in age, gender, socioeconomic status, and digital literacy levels (13).

Quantitative data were collected using a structured questionnaire developed in Urdu, comprising four main sections: sociodemographic details, digital access variables, healthcare access patterns, and health outcomes. Digital access was assessed using an adapted version of the eHealth Literacy Scale (eHEALS), which evaluates confidence and capability in seeking, understanding, and using health information from electronic sources. Healthcare access and utilization were measured through items based on the Access to Health Care Instrument (AHCI), capturing frequency, delay, and perceived barriers to digital and non-digital health services. Health outcomes were assessed using the EQ-5D-5L, a validated instrument capturing five dimensions of health (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) with a visual analogue scale (VAS) to assess overall health status.

For qualitative data, semi-structured interviews were guided by an interview schedule exploring experiences with digital health access, challenges in healthcare navigation, and perceived impacts on health outcomes. Interviews were audio-recorded, transcribed verbatim, and translated into English for analysis. Field notes were maintained to contextualize non-verbal cues and environmental factors. Quantitative data were entered into SPSS version 28 for analysis. Descriptive statistics were used to summarize demographic and baseline characteristics. Independent t-tests and one-way ANOVA were applied to examine group differences in health outcomes based on levels of digital access. Pearson's correlation was employed to analyze relationships between eHealth literacy and EQ-5D-5L scores. Multiple linear regression was conducted to assess the predictive value of digital access variables on health outcomes while controlling for age, gender, and income level. All statistical tests were two-tailed with a significance threshold set at $p < 0.05$. Normality was assessed through histograms, Q-Q plots, and the Shapiro-Wilk test, confirming suitability for parametric analyses. Qualitative data were analyzed using thematic analysis following Braun and Clarke's six-step approach. NVivo 14 software was used to organize and code transcripts. The analysis involved familiarization with the data, generation of initial codes, searching for themes, reviewing themes, defining and naming themes, and producing a coherent narrative. Triangulation of qualitative insights with quantitative findings helped deepen the understanding of contextual barriers and perceptions around digital health access.

Ethical approval for this study was obtained from the corresponding Institutional Review Board (IRB). Written informed consent was obtained from all participants prior to data collection. For illiterate participants, the consent form was read aloud, and thumbprints were used in place of signatures. Confidentiality and anonymity were ensured by assigning unique identification numbers and storing data on password-protected systems. Participants were informed of their right to withdraw at any stage without any consequences. Through this comprehensive and context-sensitive methodological framework, the study aimed to produce empirically grounded insights into how digital exclusion shapes healthcare experiences and health outcomes in Pakistan's rural populations. This approach ensured rigor, cultural sensitivity, and reproducibility, laying the groundwork for future policy and intervention strategies aimed at reducing health disparities rooted in digital inequity.

RESULTS

Of the 120 participants enrolled in the study, the mean age was 41.7 years ($SD \pm 11.6$), with males constituting 58.3% and females 41.7% of the sample. A significant proportion of participants (72.5%) reported having primary education or less. Only 39.2% owned a smartphone, and even fewer (28.3%) had internet access at home, indicating a pronounced gap in digital resource availability within these rural communities. Assessment using the eHealth Literacy Scale (eHEALS) revealed that 40.8% of participants fell into the low literacy category (score 0–16), 31.7% demonstrated moderate literacy (score 17–24), and only 27.5% scored within the high literacy range (score 25–32). These findings reflect limited confidence and capability among participants in locating, evaluating, and using online health resources. The EQ-5D-5L instrument was employed to evaluate self-reported health status across five core dimensions. Results indicated that the highest burden of reported issues was in the pain/discomfort dimension, with 69.2% reporting slight to severe problems. In contrast, the self-care domain had the fewest reported issues, with only 45.0% indicating problems. Anxiety/depression (60.8%), usual activities (57.5%), and mobility (51.7%) also emerged as critical dimensions with reported impairments. Analysis of EQ-VAS scores stratified by digital access (eHEALS score category) showed a gradient association. Participants in the low eHEALS group

had the lowest mean VAS score of 53.4 (SD \pm 12.3), indicating poorer perceived overall health status. This increased progressively among those with moderate (65.2, SD \pm 10.7) and high (74.6, SD \pm 9.8) eHEALS scores, suggesting a potential relationship between digital health literacy and self-rated health outcomes. The differences in EQ-VAS scores across digital access groups were statistically significant ($p < 0.001$, ANOVA), reinforcing the observed trend that higher digital literacy is associated with better subjective health. Pearson correlation analysis revealed a moderate positive correlation ($r = 0.48$, $p < 0.01$) between eHEALS scores and EQ-VAS outcomes, further supporting this association.

In the qualitative phase of the study, thematic analysis of 20 semi-structured interviews revealed three dominant themes: *digital exclusion as a barrier to care*, *perceived helplessness and dependency*, and *trust in non-digital sources*. Participants consistently described significant challenges in accessing healthcare-related information due to poor internet connectivity, lack of digital skills, and unfamiliarity with mobile health platforms. Many relied on family members or local healthcare workers to interpret or access digital health content, often leading to delays in care-seeking or complete avoidance of digital options. A recurring sentiment among participants was a sense of exclusion and frustration, with several expressing feelings of helplessness when unable to navigate online portals or teleconsultation systems. Some older participants voiced strong distrust in digital tools, preferring face-to-face interactions, and citing fear of being misled or scammed. The absence of structured digital literacy initiatives and localized language support further compounded these barriers. These narratives underscore how digital health disparities are deeply intertwined with cultural norms, generational gaps, and structural inequalities in rural settings.

Table 1: Demographics

Characteristic	Value
Total Participants	120
Mean Age (SD)	41.7 \pm 11.6
Gender - Male (%)	58.30%
Gender - Female (%)	41.70%
Primary Education or Less (%)	72.50%
Own Smartphone (%)	39.20%
Internet Access at Home (%)	28.30%

Table 2: eHEALS Score Categories

Score Category	n	%
Low (0-16)	49	40.8
Moderate (17-24)	38	31.7
High (25-32)	33	27.5

Table 3: EQ-5D Problem Distribution

EQ-5D Dimension	No Problem (%)	Problem (%)
Mobility	48.3	51.7
Self-care	55	45
Usual Activities	42.5	57.5
Pain/Discomfort	30.8	69.2
Anxiety/Depression	39.2	60.8

Table 4: EQ-VAS Scores by eHEALS Category

eHEALS Category	Mean VAS	Standard Deviation
Low eHEALS	53.4	12.3
Moderate eHEALS	65.2	10.7
High eHEALS	74.6	9.8

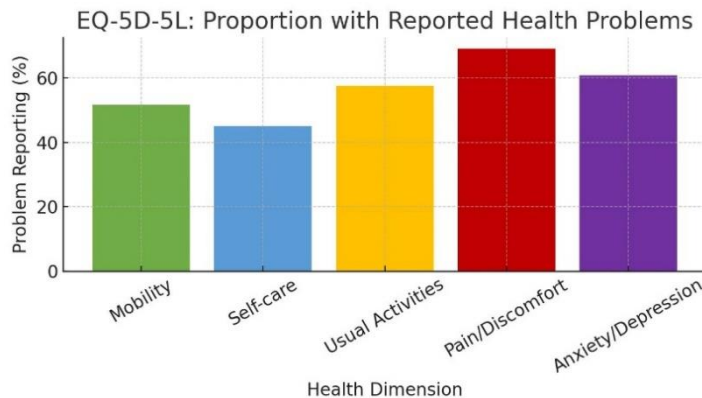


Figure 1 EQ-5D-5L: Proportion with Reported Health Problems

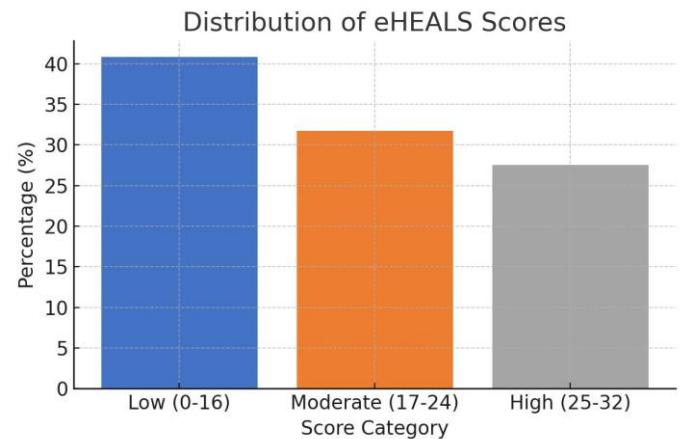
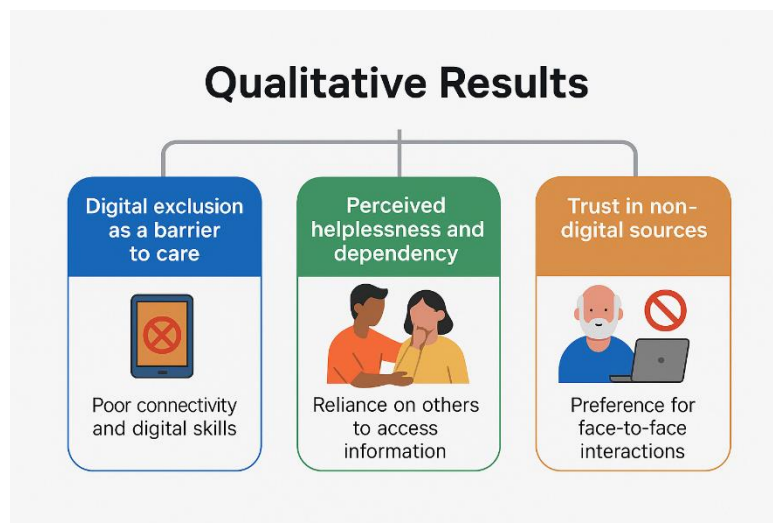


Figure 2 Distribution of eHEALS Scores



DISCUSSION

The findings from this mixed-methods study underscore the persistent and multifaceted impact of the digital divide on healthcare access and outcomes in rural Pakistan. A considerable portion of the study population lacked access to digital tools such as smartphones and reliable internet connectivity, while a majority exhibited low to moderate levels of digital health literacy. These limitations were significantly associated with poorer health outcomes, as evidenced by lower EQ-VAS scores and higher self-reported impairments across multiple EQ-5D-5L dimensions. This data affirms that digital exclusion in rural contexts is not merely a technological deficit but a public health concern that can reinforce existing health inequities (14,15). The association between low eHealth literacy and suboptimal self-rated health outcomes mirrors findings from global literature. Recent reported that, infrastructural deficits, limited digital literacy, and economic hardship consistently restrict rural populations from accessing digital health services, leading to compounded healthcare barriers (16-18). Similarly, a study highlighted how inadequate telehealth literacy in U.S. rural areas hampers the potential benefits of digital healthcare, reinforcing the notion that access without usability yields limited impact (19).

One strength of this study lies in its simultaneous use of quantitative health measures and qualitative insights to offer a comprehensive understanding of digital health inequity. By deploying validated instruments such as the eHEALS and EQ-5D-5L, the study provided quantifiable correlations between digital literacy and health outcomes, thereby enhancing the reliability and reproducibility of its conclusions. Additionally, contextualizing the research within real-world rural settings in Pakistan added depth and relevance to the observed patterns, reflecting the lived experiences of marginalized populations. Nevertheless, several limitations must be acknowledged. The cross-sectional design precludes causal inference, and the relatively small sample size may limit generalizability beyond the study regions. Furthermore, self-reported health outcomes, while validated, are inherently subjective and may not fully capture clinical severity or chronic disease burden. Language and literacy barriers may have also influenced the accuracy of responses, despite rigorous translation and consent procedures.

Recent international research corroborates the need to consider digital literacy not only as a skill set but also as a determinant of health equity. Recent studies emphasized that while digital tools like social media-based health platforms can expand access, disparities in literacy and misinformation management must be actively addressed to ensure equitable benefits (20,21). Another study further elaborated that, the digital divide in rural Bangladesh operates on two levels—access and utilization—with each influenced by different socio-demographic factors, including education, income, and gender (22). The implications of this study are twofold. First, digital health interventions must be tailored to the unique realities of rural populations. Infrastructure alone is insufficient without simultaneous investments in digital literacy, affordability, and culturally sensitive training programs. Second, policymakers must treat digital equity as a core component of health planning, particularly in low-resource settings where telemedicine and eHealth are rapidly expanding. Future research should adopt longitudinal or intervention-based designs to better elucidate causality between digital access and health trajectories. Additionally, exploring gendered dimensions of the digital divide may uncover unique challenges faced by women in patriarchal rural settings, an area underexplored in the current study. Interdisciplinary collaboration between technologists, public health experts, and community leaders will also be essential to develop inclusive and sustainable digital health ecosystems (23,24). In conclusion, this study reinforces that digital exclusion is a significant barrier to healthcare access and outcomes in rural Pakistan. Efforts to bridge this divide must extend beyond infrastructure to include education, affordability, and localized support, thereby transforming digital access into meaningful health equity.

CONCLUSION

This study concludes that digital health disparities, driven by limited access and low eHealth literacy, significantly affect healthcare engagement and health outcomes in rural Pakistan. The findings highlight digital inclusion as a critical determinant of health equity. Addressing this gap through targeted infrastructure development, digital literacy programs, and inclusive health policies is essential to ensure equitable access and improved well-being in underserved communities.

AUTHOR CONTRIBUTION

Author	Contribution
Muhammad Israr*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Khan Bilal Akbar Hayat Khan Niazi	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Ayesha Khan	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Ahmed Nawaz Kandhro	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Zeeshan Ahmed	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Farhan Muhammad Qureshi	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Summaya Mehboob	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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