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Research Article

Keywords: artificial intelligence, Bangladesh, digital health, empathy, medical education, telemedicine, technology-assisted care

Posted Date: September 30th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10874345/v1

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Additional Declarations: No competing interests reported.

Techno-Clinical Empathy in the Digital Age: A Mixed-Methods Study Among Physicians and Medical Students in Bangladesh

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Abstract

Background: Digital care can improve healthcare access but may weaken relational quality when clinicians are not prepared to communicate empathy through technology. This mixed-methods study assessed techno-clinical empathy among medical students and doctors in Bangladesh, identified associated factors, and explored how empathy is understood in technology-assisted care.

Methods: A cross-sectional survey was conducted among 477 medical students and doctors from January to June 2026. Techno-clinical empathy and related constructs were measured using Likert-based scales. Multivariable logistic regression identified predictors of high techno-clinical empathy. Eight focus group discussions and key-informant interviews were thematically analyzed and integrated with the quantitative findings.

Results: High techno-clinical empathy was present in 57.0% of participants, compared with 74.8% for high core empathy and 49.1% for high digital readiness. High techno-clinical empathy was independently associated with telemedicine experience (AOR 1.95, 95% CI 1.03–3.70), high core empathy (AOR 2.91, 95% CI 1.59–5.33), high digital readiness (AOR 3.49, 95% CI 2.05–5.95), strong communication skills (AOR 2.00, 95% CI 1.17–3.41), and positive attitudes toward technology-assisted care (AOR 4.24, 95% CI 2.57–6.99). Qualitative themes emphasized human attention, adaptation to reduced non-verbal cues, understandable language, privacy, trust, and structured training.

Conclusion: Techno-clinical empathy combines relational ability, communication competence, digital readiness, and practical experience. Medical education should explicitly prepare clinicians to preserve humane, trustworthy, and patient-centred communication across digital care environments.

Keywords: artificial intelligence, Bangladesh, digital health, empathy, medical education, telemedicine, technology-assisted care

Introduction

Medicine is becoming digital faster than medical education is becoming digitally humane [1, 2]. Telemedicine, electronic records, AI-supported triage, remote monitoring, and platform-based

consultations now shape how patients explain illness and how clinicians listen, document, decide, and reassure [3, 4]. The World Health Organization's Global Strategy on Digital Health 2020–2025 emphasizes that digital technologies should promote health and well-being for everyone, everywhere, rather than simply increase platform adoption [5]. This distinction matters because digital care can expand access, reduce travel, support follow-up, and connect patients with services beyond facility walls, but it can also weaken communication when clinicians are not trained to express empathy through screens, audio calls, chat messages, electronic records, or AI-supported workflows [6].

Empathy is not a soft extra in clinical care; it is a measurable quality-of-care factor [7]. A systematic review of empathy in general practice found that clinician empathy was associated with patient satisfaction, adherence, and reduced anxiety or distress [8]. Telephone and remote consultations also require specific empathic behaviors because clinicians have fewer visual and contextual cues than in face-to-face care [9, 10]. In a video consultation, empathy may depend on voice tone, facial framing, pacing, explanation, and digital etiquette. In chat-based or asynchronous care, tone and facial cues may disappear almost completely, requiring clinicians to communicate warmth, reassurance, and respect through written language [11, 12]. The educational question is therefore not whether empathy remains important in digital care, but whether future clinicians are prepared to make empathy visible when technology mediates the encounter.

Bangladesh provides a timely setting for this question. Internet connectivity has expanded rapidly: by May 2026, Bangladesh had approximately 134.07 million internet subscribers, including 119.12 million mobile internet subscribers [13]. At the same time, the Bangladesh Digital Health Strategy 2023–2027 presents digital health as a roadmap for transforming healthcare delivery, not merely as a technical modernization agenda [14]. Bangladesh also has a large medical and dental workforce pipeline: BMDC-linked figures reported 134,568 registered physicians and 14,323 dentists in 2024, while BMDC's institutional mandate includes maintaining standards of medical education and practice [15]. Together, these numbers show why digital empathy is not a minor educational issue. If digital health expands across a large mobile-connected population while clinicians are not trained in digitally mediated communication, access may improve without equivalent gains in patient-centeredness [16, 17].

The concept of techno-clinical empathy responds to this gap. It refers to the ability to preserve human concern, emotional recognition, dignity, and therapeutic communication while using digital tools in clinical care. It is broader than general empathy because it considers the technological mediation of the encounter, and broader than digital readiness. After all, a clinician may know how to use digital tools but still fail to maintain relational quality through them [18, 19]. This distinction is increasingly relevant as AI and digital communication tools enter clinical workflows. Recent evidence comparing AI-generated and clinician responses has even raised the question of whether written digital communication may be judged as more empathic when it is structured, responsive, and emotionally attentive, although such findings require careful interpretation because many studies rely on text-only scenarios and proxy ratings [20–22].

Existing digital-health discussions often measure coverage, cost, efficiency, platform use, or technical readiness. These indicators are necessary but incomplete. A digital health system that patients do not trust, understand, or feel respected by will not deliver its full value [23]. The evidence gap in Bangladesh is therefore not simply whether medical students and doctors use digital tools, but whether they can remain clinically empathic while using them. This is particularly important in a setting with rapid mobile internet expansion, variable digital literacy, high patient load, uneven infrastructure, and increasing public familiarity with remote consultation and online health information. This mixed-methods study addressed that gap by assessing techno-clinical empathy among medical students and doctors in Bangladesh and examining its association with professional status, communication training, telemedicine experience, digital-health training, digital-tool use, core empathy, digital readiness, communication skills, and attitudes toward technology-assisted care. The aim of this study was to assess techno-clinical empathy among medical students and doctors in Bangladesh, identify its associated factors, and explore how empathy is understood in technology-assisted care. The novelty of the study lies in treating empathy as a digital-era clinical competency rather than a fixed personal trait, and in combining quantitative measurement with qualitative stakeholder perspectives to inform medical curricula, telemedicine training, and human-centered digital-health policy in Bangladesh.

Methods

Study design and setting

This study used a mixed-methods design combining a cross-sectional quantitative survey with a qualitative exploratory component. Data collection was conducted from January to June 2026 among medical students, doctors, and selected stakeholders in Bangladesh. The quantitative component measured techno-clinical empathy and related constructs among medical students and doctors, while the qualitative component explored how digital empathy, telemedicine communication, technology-assisted care, and training needs were understood across different professional and institutional contexts. A mixed-methods approach was selected because techno-clinical empathy is an emerging construct. Quantitative scoring was useful for estimating the level of techno-clinical empathy and identifying associated factors, whereas qualitative inquiry was necessary to understand how participants interpreted empathy when clinical communication was mediated by screens, platforms, telemedicine systems, electronic records, artificial intelligence tools, and other forms of digital health technology. Integration of both components allowed the study to move beyond scale scores and examine the educational, communication, ethical, and service-delivery meanings of empathy in technology-assisted care.

Study population and sampling

The quantitative target population included medical students in clinical years and doctors with MBBS/BDS qualifications, postgraduate training, or a completed postgraduate qualification. Participants were recruited from different parts of Bangladesh using convenience sampling. This approach was considered appropriate because the study focused on an emerging area of medical education and digital-health practice, where no complete national sampling frame was available for medical students and doctors with varying exposure to telemedicine, digital tools, and technology-assisted care. Convenience sampling also allowed recruitment across a broader range of professional stages and geographic settings within the available study period. Participation was voluntary and anonymous. The response pool contained 485 submitted records. Three records were excluded before data reconstruction because digital consent was absent or screening was incomplete. Five additional records were excluded during the audit because of duplicate or repeated response profiles, missing key outcome data, or implausible/internal inconsistency. The final quantitative analytical sample included 477 participants, corresponding to an analytical retention rate of 98.3%. The full response screening, exclusion, data reconstruction, and final analytical retention process are presented in **Figure 1**.

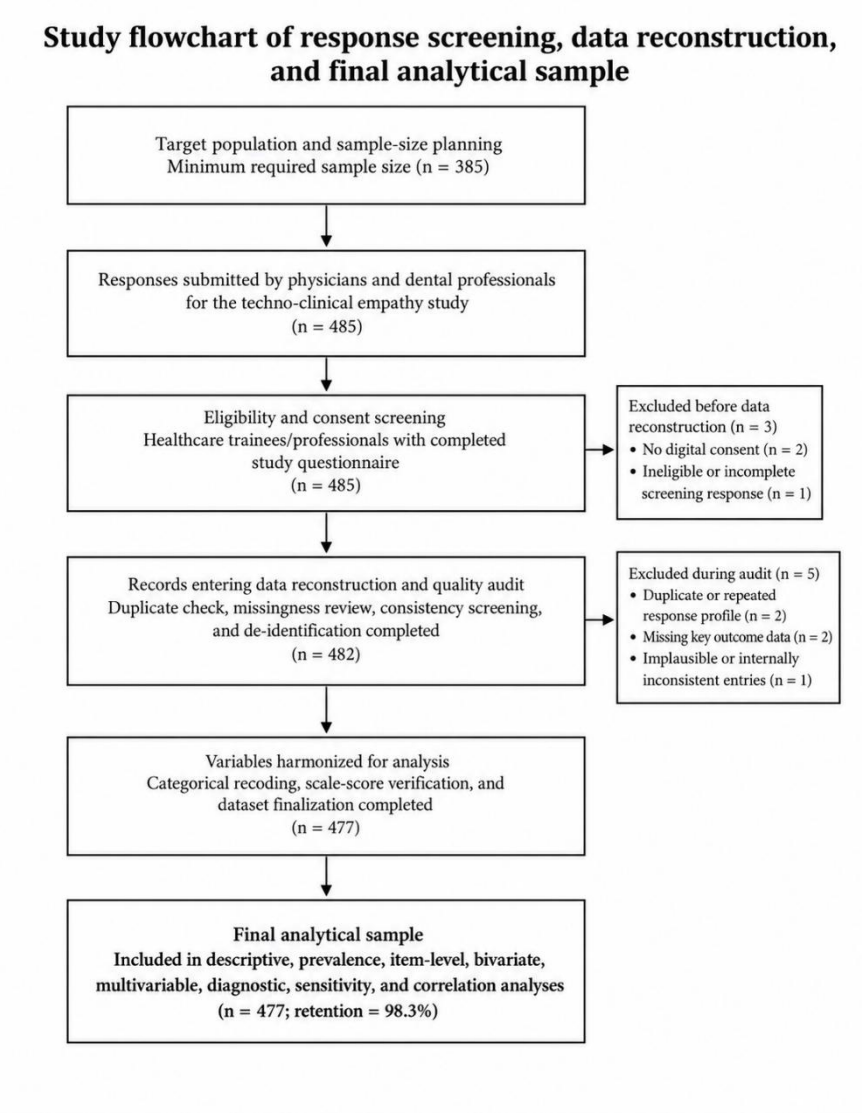


Figure 1: The flowchart summarizes sample-size planning, response screening, exclusions, data reconstruction, and the final analytical sample with overall retention.

Sample size calculation

The minimum sample size for estimating the prevalence of high techno-clinical empathy was calculated using the single-proportion formula:

$$n = \frac{Z^2 p(1-p)}{d^2}$$

where n is the required sample size, Z is the standard normal deviate for a 95% confidence level, $p$is the anticipated prevalence, and d is the margin of error. Because no prior Bangladesh estimate

of high techno-clinical empathy was available, a conservative prevalence of $p = 0.50$ was used to produce the maximum required sample size. With $Z = 1.96$and $d = 0.05$, the required sample size was:

$$n = \frac{1.96^2 \times 0.50 \times 0.50}{0.05^2} = 384.16$$

This was rounded up to 385 participants. The final quantitative analytical sample of 477 exceeded the minimum required sample size and allowed exclusions during screening and data-quality audit without reducing the sample below the planned requirement.

Quantitative instrument and scoring

The quantitative questionnaire covered sociodemographic and educational characteristics, technology-use background, core empathy, techno-clinical empathy, digital health readiness, communication skills, and attitudes toward technology-assisted care. All Likert-scale items were scored from 1 to 5, where 1 indicated strongly disagree, and 5 indicated strongly agree. Higher scores consistently represented stronger endorsement of the measured construct.

The primary outcome was high techno-clinical empathy. Techno-clinical empathy was measured using six items addressing compassionate behaviour during telemedicine communication, preservation of human communication while using technology, recognition of emotions through digital tools, ability to maintain empathy without face-to-face interaction, adaptation of empathy in the digital-health era, and perceived need for digital empathy training. The total score was calculated as:

$$\text{TCE total score} = TC1 + TC2 + TC3 + TC4 + TC5 + TC6$$

The total score ranged from 6 to 30. A mean item score was also calculated:

$$\text{TCE mean score} = \frac{\text{TCE total score}}{6}$$

High techno-clinical empathy was defined as a mean score of at least 4, equivalent to a total score of at least 24:

$$\text{High TCE} = \begin{cases} 1, & \text{TCE mean score} \geq 4 \\ 0, & \text{TCE mean score} < 4 \end{cases}$$

This threshold was selected because a score of 4 represents agreement across the construct and is more interpretable for Likert-based measures than a median split. In the final sample, the mean techno-clinical empathy score was 23.44 ± 3.92 on the 6–30 scale, and the techno-clinical empathy domain showed strong internal consistency with Cronbach's alpha = 0.885 and McDonald's omega = 0.918.

Secondary constructs and predictors

Core empathy was measured using 10 items. Digital health readiness, communication skill, and attitude toward technology-assisted care were each measured using five items. For each domain, total scores and mean item scores were calculated. Agreement-level binary categories were then created using a mean score threshold of at least 4: high core empathy, high digital readiness, strong communication skills, and positive attitude toward technology-assisted care.

The construct-level internal consistency was high across domains. Core empathy had Cronbach's alpha = 0.958 and omega = 0.964; digital health readiness had alpha = 0.866 and omega = 0.904; communication skills had alpha = 0.919 and omega = 0.941; and attitude toward technology-assisted care had alpha = 0.879 and omega = 0.914. The full quantitative instrument also showed high reliability, with alpha = 0.970 and omega = 0.973.

Predictor variables included age group, gender, professional status, communication-skill training, telemedicine experience, formal digital-health training, digital tool-use frequency, and primary digital tool used in clinical work. Multiple-tool responses were retained as a separate category because they reflected real-world clinical digital practice rather than a data-entry error.

Qualitative component

The qualitative component was designed to provide contextual understanding of the quantitative findings. Eight focus group discussions were conducted across Dhaka, Sylhet, and Khulna districts

to capture differences in training environment, clinical exposure, digital-health familiarity, and patient-contact experience. Participants were purposively selected to include variation by student/doctor status, experience with digital tools, and exposure to telemedicine or technology-assisted care.

In addition, key informant interviews were conducted with a teacher involved in medical education, an Assistant Director of Health at the policy-maker level, and an experienced physician working with telemedicine services. These informants were selected because they could provide perspectives on curriculum, health-system implementation, digital-health policy, telemedicine practice, and training needs. The qualitative guides explored perceived changes in empathy during digital care, barriers to emotionally responsive telemedicine, communication cues lost or gained through technology, training needs, ethical concerns, patient trust, platform limitations, and policy implications for digital-health education.

Qualitative data management and analysis

Focus group discussions and key informant interviews were conducted using semi-structured guides. Field notes and transcripts were reviewed for completeness before analysis. Qualitative data were organized and analyzed using **NVivo 14**. A thematic analysis approach was used. First, the transcripts and notes were read repeatedly to identify meaning units related to digital empathy, telemedicine communication, patient trust, technology barriers, training needs, and ethical concerns. Second, initial codes were developed and grouped into broader categories. Third, recurrent themes were refined by comparing patterns across participant groups, districts, and stakeholder types. The qualitative component was not used to generate statistical estimates. Instead, it was used to interpret and explain the quantitative findings. Particular attention was given to themes such as loss of non-verbal cues, digital communication etiquette, time pressure, patient literacy, privacy, platform limitations, training gaps, and the tension between efficiency and human presence in digital care. Open-ended quantitative responses also supported these themes, with common issues including communication or non-verbal cue gaps, technical/infrastructure barriers, time pressure or workload, patient literacy/access barriers, digital communication training, telemedicine platform training, ethics/privacy concerns, and AI or digital-health literacy needs.

Data processing and quality control

Direct identifiers, contact information, and free-text institutional identifiers were removed before analysis. Bangla response categories were translated and recoded into English-labelled numeric variables. All Likert responses were checked to ensure that higher scores consistently represented stronger endorsement of the construct being measured. Repeated or similar identifiers were flagged during audit and removed only when the response profile could not be retained without risking duplicate or invalid participation. The final quantitative dataset contained no missing values in variables used for the planned analyses. The audit process documented consent screening, incomplete screening, duplicate profiles, missing key outcome data, and implausible or internally inconsistent records. **Supplementary File S1** retained the diagnostic and correlation outputs.

Statistical analysis

Quantitative analyses were conducted using Stata version 17.0. Continuous variables were summarized as mean with standard deviation and median with interquartile range. Categorical variables were summarized as frequencies and percentages. Prevalence estimates were reported with Wilson 95% confidence intervals. Internal consistency was assessed using Cronbach's alpha and McDonald's omega for each domain and for the full quantitative instrument. The Cronbach's alpha formula was expressed as:

$$\alpha = \frac{k}{k-1}\left(1-\frac{\sum\sigma_i^2}{\sigma_T^2}\right)$$

where $k$is the number of items, $\sigma_i^2$is the variance of each item, and $\sigma_T^2$is the variance of the total score.

Bivariate associations with high techno-clinical empathy were examined using Pearson's chi-square test or Fisher's exact test when expected cell counts were small. Crude odds ratios were estimated using univariable logistic regression. Two multivariable logistic regression models were fitted. Model 1 included sociodemographic, educational, and technology-exposure variables. Model 2 additionally included high core empathy, high digital readiness, strong communication skills, and a positive attitude toward technology-assisted care. Adjusted odds ratios, 95% confidence intervals, and p-values were reported.

The general logistic regression model was specified as:

$$\text{logit}\{P(Y=1)\} = \beta_0 + \sum_{j=1}^{k} \beta_j X_j$$

where Yrepresents high techno-clinical empathy, $P(Y=1)$is the probability of high techno-clinical empathy, $\beta_0$is the intercept, and $\beta_j$represents the coefficient for the predictor X_j.

Model diagnostics and integration of findings

Model calibration was assessed using the Hosmer–Lemeshow goodness-of-fit test, discrimination using the area under the receiver operating characteristic curve, explanatory performance using McFadden's pseudo R^2, and multicollinearity using variance inflation factors. Spearman correlation was used to assess monotonic associations among continuous construct mean scores.

Model 1 showed AUC = 0.652 and McFadden's pseudo $R^2 = 0.049$, while Model 2 showed improved discrimination and explanatory performance, with AUC = 0.850 and McFadden's pseudo $R^2 = 0.305$. Hosmer–Lemeshow p-values were greater than 0.05 for both models, indicating no statistical evidence of poor calibration. Maximum VIF values were approximately 10, suggesting that multicollinearity among related empathy, readiness, communication, and attitude constructs should be considered when interpreting adjusted associations. Spearman correlations showed moderate to strong positive associations among construct mean scores, including techno-clinical empathy with digital readiness, communication skill, and technology-assisted care attitude.

Quantitative and qualitative findings were integrated at the interpretation stage. Quantitative analysis identified measurable predictors of high techno-clinical empathy, while qualitative analysis helped explain why those predictors may matter in medical education and service delivery. For example, associations involving telemedicine experience, digital readiness, communication skills, and technology-assisted care attitude were interpreted alongside qualitative themes related to non-verbal cue loss, trust, patient literacy, platform constraints, and the need for structured digital empathy training.

Result

Participant profile

Table 1 shows 477 medical students and doctors. The sample was young overall, with 295 participants (61.9%) aged <=29 years, and 260 participants (54.5%) were male. Professional status was mixed: 132 participants (27.7%) were medical students, 220 (46.1%) were MBBS/BDS graduates, 76 (15.9%) were postgraduate trainees, and 49 (10.3%) had completed postgraduate degrees. Communication-skill training was common (337/477, 70.6%), but telemedicine experience (164/477, 34.4%) and formal digital-health training (79/477, 16.6%) were less frequent. Nearly half of participants reported no primary digital tool use in clinical work (219/477, 45.9%).

Table 1. Sociodemographic, educational, technology-use, and score characteristics of participants

Variable and category	Mean (SD) or n (%)
Age group	
≤24 years	123 (25.8%)
25–29 years	172 (36.1%)
30–34 years	99 (20.8%)
≥35 years	83 (17.4%)
Gender	
Male	260 (54.5%)
Female	217 (45.5%)
Professional status	
Medical student	132 (27.7%)
MBBS/BDS graduate	220 (46.1%)
Postgraduate trainee	76 (15.9%)
Postgraduate degree completed	49 (10.3%)
Communication-skill training	
No	140 (29.4%)
Yes	337 (70.6%)
Telemedicine experience	
No	313 (65.6%)
Yes	164 (34.4%)
Digital-health training	
No	398 (83.4%)
Yes	79 (16.6%)
Digital tool-use frequency	
Never	160 (33.5%)
Sometimes	249 (52.2%)
Regularly	68 (14.3%)
Primary digital tool	
Telemedicine	80 (16.8%)
EHR	28 (5.9%)
AI-based clinical support	86 (18.0%)
Remote monitoring	8 (1.7%)
None	219 (45.9%)
Multiple digital tools	39 (8.2%)
Other	17 (3.6%)

Prevalence and domain pattern

Figure 2 shows that high core empathy was the most frequent agreement-level construct (74.8%), followed by strong communication skill (68.1%), positive attitude toward technology-assisted care (61.8%), high

techno-clinical empathy (57.0%), and high digital readiness (49.1%). Mean domain scores clustered near the agreement threshold of 4 on the 1-5 scale, with the highest mean for core empathy and communication skills. High techno-clinical empathy was visibly more common among participants with telemedicine experience, high digital readiness, strong communication skills, and positive technology-assisted attitude.

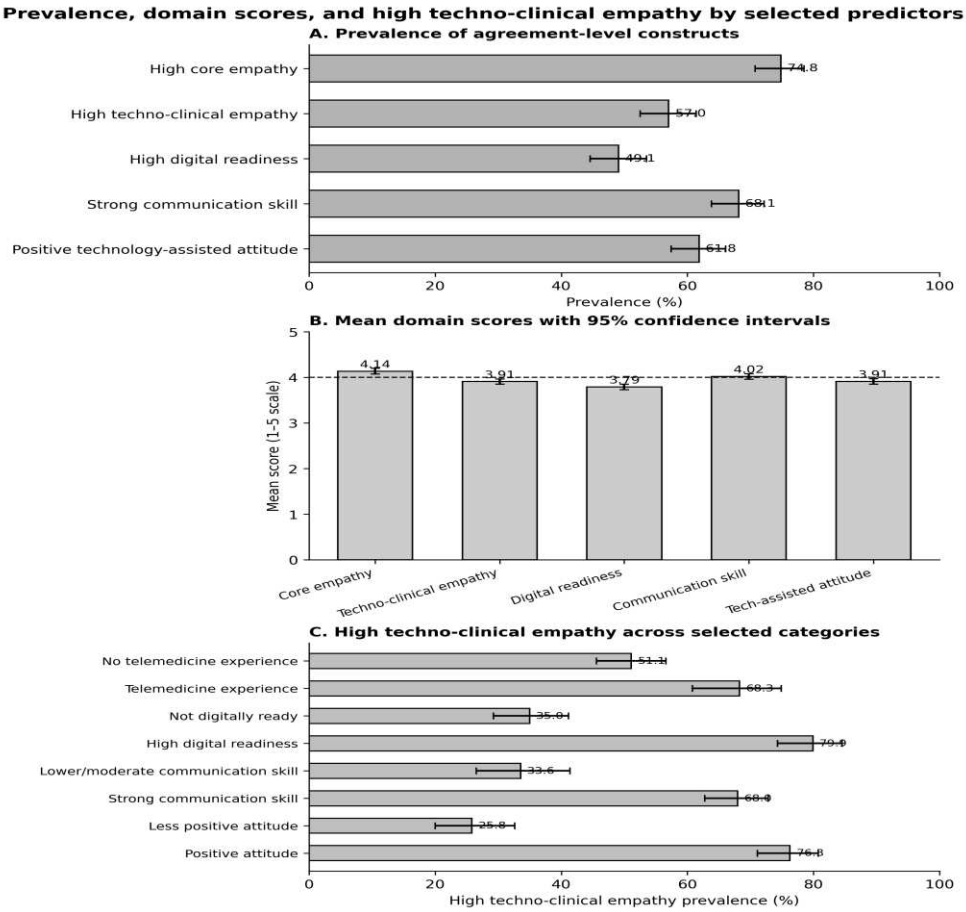


Figure 2: Prevalence, domain scores, and high techno-clinical empathy by selected predictors

Scale distribution and reliability

Table 2 shows high internal consistency across all quantitative domains. Techno-clinical empathy had a mean total score of 23.44 (SD 3.92) on a 6-30 scale and demonstrated strong reliability (Cronbach's alpha 0.885; McDonald's omega 0.918). Core empathy (alpha 0.958; omega 0.964), digital health readiness (alpha 0.866; omega 0.904), communication skill (alpha 0.919; omega 0.941), and attitudes toward technology-assisted care (alpha 0.879; omega 0.914) also showed strong internal consistency. These reliability estimates support the use of the domain scores in the main adjusted models; item-level and crude outputs are provided in **Supplementary File S1**.

Table 2. Distribution and internal consistency of quantitative scales/domains

Scale/domain	Mean ± SD	Score range	Cronbach's alpha	McDonald's omega
Core empathy	41.35 ± 6.84	10–50	0.958	0.964

Techno-clinical empathy	23.44 ± 3.92	6–30	0.885	0.918
Digital health readiness	18.95 ± 3.35	5–25	0.866	0.904
Communication skill	20.09 ± 3.39	5–25	0.919	0.941
Attitude toward technology-assisted care	19.55 ± 3.40	5–25	0.879	0.914
Full quantitative instrument			0.970	0.973

Adjusted predictors of high techno-clinical empathy

Table 3 shows the multivariable predictors of high techno-clinical empathy. In Model 1, which included sociodemographic, educational, and technology-exposure variables, no predictor was statistically significant at $p<0.05$, although telemedicine experience showed a positive but imprecise association (AOR 1.56, 95% CI 0.94-2.61). After adding psychosocial and readiness constructs in Model 2, telemedicine experience became independently associated with high techno-clinical empathy (AOR 1.95, 95% CI 1.03-3.70). High core empathy (AOR 2.91, 95% CI 1.59-5.33), high digital readiness (AOR 3.49, 95% CI 2.05-5.95), strong communication skill (AOR 2.00, 95% CI 1.17-3.41), and positive attitude toward technology-assisted care (AOR 4.24, 95% CI 2.57-6.99) were also independently associated with high techno-clinical empathy. Diagnostics, correlations, and the data-quality audit are retained in **Supplementary File S1**.

Table 3. Multivariable binary logistic regression models for high techno-clinical empathy

Predictor and category	Model 1 AOR (95% CI)	Model 2 AOR (95% CI)
Age group		
≤24 years	Ref	Ref
25–29 years	0.56 (0.23–1.36)	0.47 (0.15–1.52)
30–34 years	0.68 (0.25–1.84)	0.45 (0.12–1.65)
≥35 years	0.61 (0.21–1.73)	0.43 (0.11–1.67)
Gender		
Male	Ref	Ref
Female	0.78 (0.53–1.15)	1.04 (0.63–1.70)
Professional status		
Medical student	Ref	Ref
MBBS/BDS graduate	1.43 (0.59–3.43)	1.32 (0.42–4.15)
Postgraduate trainee	0.98 (0.37–2.64)	1.09 (0.31–3.92)
Postgraduate degree completed	1.10 (0.36–3.42)	1.52 (0.36–6.45)
Communication-skill training		
No	Ref	Ref
Yes	0.69 (0.44–1.06)	0.78 (0.46–1.34)
Telemedicine experience		
No	Ref	Ref
Yes	1.56 (0.94–2.61)	1.95 (1.03–3.70)
Digital-health training		
No	Ref	Ref
Yes	1.66 (0.91–3.03)	0.89 (0.42–1.87)
Digital tool-use frequency		
Never	Ref	Ref
Sometimes	1.32 (0.83–2.09)	1.04 (0.59–1.85)
Regularly	1.27 (0.63–2.56)	0.98 (0.42–2.32)
Primary digital tool		
Telemedicine	Ref	Ref
EHR	0.74 (0.29–1.88)	0.75 (0.24–2.34)
AI-based clinical support	0.92 (0.45–1.90)	0.81 (0.33–1.96)
Remote monitoring	0.64 (0.14–2.90)	1.33 (0.18–9.52)
None	0.94 (0.48–1.84)	1.19 (0.52–2.71)
Multiple digital tools	2.04 (0.80–5.20)	1.35 (0.45–4.03)
Other	0.58 (0.18–1.82)	0.82 (0.19–3.49)
Core empathy level		
Lower/moderate core empathy	—	Ref

High core empathy	—	2.91 (1.59–5.33) ***
Digital health readiness		
Not digitally ready	—	Ref
High digital readiness	—	3.49 (2.05–5.95) ***
Communication skill level		
Lower/moderate communication skill	—	Ref
Strong communication skill	—	2.00 (1.17–3.41)
Technology-assisted care attitude		
Less positive attitude	—	Ref
Positive attitude	—	4.24 (2.57–6.99) ***

Selected adjusted associations

Figure 3 displays the main adjusted predictors from the fully adjusted model. The strongest association was observed for positive attitude toward technology-assisted care (AOR 4.24, 95% CI 2.57-6.99), followed by high digital readiness (AOR 3.49, 95% CI 2.05-5.95) and high core empathy (AOR 2.91, 95% CI 1.59-5.33). The figure complements Table 3 by showing that the main independent associations were concentrated in readiness, empathy, communication, and attitude constructs rather than age or professional-status categories.

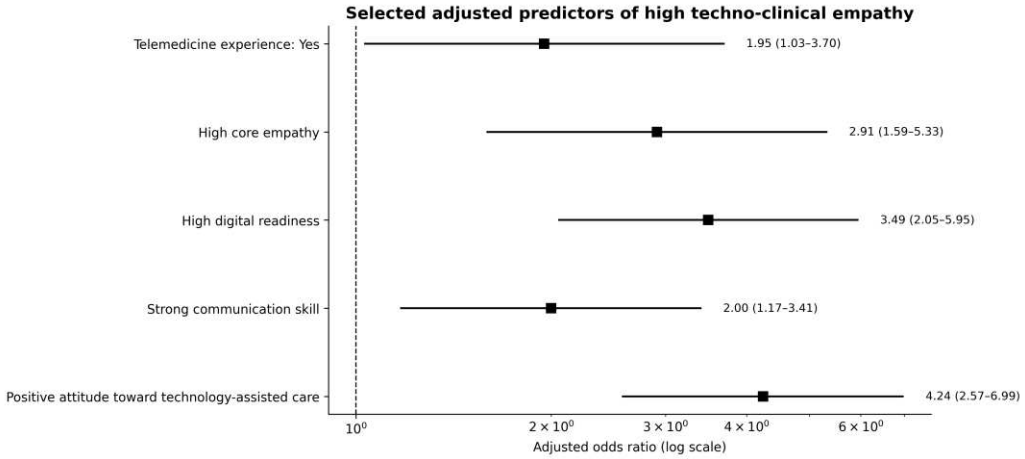


Figure 3: Adjusted predictors of high techno-clinical empathy from the fully adjusted model.

Qualitative findings

The qualitative component explored how participants and key informants understood empathy in digitally mediated care. Analysis of the focus group and interview materials identified themes: maintaining human empathy in digital care, loss and adaptation of non-verbal communication, clear and locally understandable language, digital access with relational limitations, privacy and trust, and the need for structured digital empathy training. These themes helped contextualize the quantitative finding that high techno-clinical empathy was more common among participants with telemedicine experience, high core empathy, high digital readiness, strong communication skills, and positive attitudes toward technology-assisted care.

Focus group discussion findings

Digital care should not remove human attention

Participants repeatedly emphasized that digital tools may support care delivery, but they should not reduce the clinician's human presence. Empathy was described as something that must be actively preserved when the patient is not physically present. Participants viewed digital empathy not as a separate behaviour, but as the continuation of ordinary clinical concern through a different medium.

One participant expressed this directly:

"Human empathy and attention to the patient's feelings must be maintained in digital care." Another participant similarly noted that technology should remain supportive rather than replace the relational role of the clinician:

"AI or digital technology should not replace the clinician's human empathy."

This theme supports the idea that techno-clinical empathy is broader than digital skill alone. Participants did not define good digital care only by speed, access, or platform use; they linked it to whether patients still felt heard, respected, and emotionally understood.

Non-verbal cues become harder but remain central

A major concern across participant narratives was the difficulty of recognizing emotion when clinical interaction occurs through video, audio, or other digital platforms. Participants highlighted that eye contact, facial expression, tone of voice, and attentive listening remain important even when the consultation is remote. One participant stated:

"In video or face-to-face calls, understanding a patient's eye expressions and feelings can be challenging."

Another emphasized:

"Eye contact, facial cues, and tone of voice are important in digital consultations."

This theme shows that digital empathy requires adaptation rather than simple transfer of bedside communication skills. In physical consultations, clinicians can observe posture, hesitation, family dynamics, and distress. In telemedicine, these cues may be reduced or distorted. Participants

therefore framed techno-clinical empathy as the ability to compensate for reduced non-verbal information by using careful listening, tone, pacing, and explicit reassurance.

Clear language is a form of empathy

Participants also connected empathy with clarity. They emphasized that patients should receive explanations in Bangla or in a language they can understand. Clear communication was seen not only as a technical requirement, but also as a respectful and patient-centered act. One participant stated:

"In my opinion, clear communication in Bangla or the patient's local language is important." Another said:

"It is important to communicate with the patient in clear, understandable language."

This theme is important for Bangladesh because digital care often involves patients with different levels of health literacy, digital literacy, and comfort with medical terminology. Participants suggested that digital empathy is weakened when clinicians use unclear instructions, rushed explanations, or language that patients cannot follow. In this sense, understandable language became a practical expression of respect.

Digital care improves access but does not automatically ensure patient-centeredness

Participants recognized the value of telemedicine for reducing travel, cost, and access barriers. One participant said:

"Telemedicine can reduce travel and costs and improve access to healthcare."

This benefit was particularly relevant in a country where patients may face distance, time, cost, and service availability barriers.

However, participants did not equate access with quality. The qualitative data suggested that digital platforms can improve the reach of care while still leaving gaps in emotional connection, explanation, trust, and follow-up. This distinction is important because it supports the study's central argument: digital health should be assessed not only by whether it connects patients to clinicians, but also by whether the interaction remains humane and clinically meaningful.

Privacy and responsible data use influence trust

Participants described privacy and data security as essential to trust in digital care. One participant stated:

"Responsible use of patient data is important for maintaining trust."

Another emphasized:

"In my opinion, protecting the privacy and security of patient data is essential."

This theme expands the meaning of techno-clinical empathy beyond communication style. Participants indicated that patients may not feel respected if their personal health information is not handled responsibly. Thus, empathy in digital care includes ethical sensitivity: protecting confidentiality, explaining how information is used, and creating a safe environment for patients to share concerns.

Training is needed for digital communication and empathy

A repeated participant-level theme was the need for formal training. Participants did not assume that clinicians automatically know how to communicate empathically in telemedicine or on digital platforms. One participant stated:

"Clinicians and students need training and guidance on digital communication and empathy."

This supports the quantitative finding that communication skills and technology-assisted-care attitudes were associated with high techno-clinical empathy. The qualitative data suggest that training should not be limited to platform operation; it should include digital etiquette, emotional recognition through limited cues, written reassurance, privacy-sensitive communication, and patient-centered explanation.

Key-informant interview findings

Policy-level perspective: digital health needs communication standards, not only platforms

The policy-level key informant emphasized that digital care can improve access but requires structured preparation of clinicians and students. The informant noted:

"Telemedicine can reduce travel and costs and improve access to healthcare."

However, the same perspective also highlighted training needs:

"Clinicians and students need training and guidance on digital communication and empathy."

This suggests that digital-health implementation should not be judged only by service availability or the number of users. From a policy perspective, digital empathy requires standards, training, and institutional support. Without these, digital services may become efficient but impersonal.

Telemedicine physician perspective: empathy depends on communication cues and patient trust

The telemedicine-experienced physician emphasized practical communication behaviours within remote care. The physician stated:

"Eye contact, facial cues, and tone of voice are important in digital consultations."

The same interview also emphasized that

"Human empathy and attention to the patient's feelings must be maintained in digital care."

This perspective is important because it comes from clinical experience with telemedicine. It shows that empathy is not lost automatically in remote care, but it requires deliberate communication practices. The telemedicine physician's account supports the quantitative finding that telemedicine experience was independently associated with high techno-clinical empathy. In other words, exposure to real digital consultation may help clinicians recognize which communication behaviours matter most.

Medical education perspective: digital empathy should be taught as a competency

The education-related key-informant perspective supported the need to integrate digital communication into medical training. The repeated emphasis on training suggests that techno-clinical empathy should be treated as a teachable competency rather than an assumed personality trait. Digital empathy training should include how to open and close telemedicine encounters, how to express concern through voice or text, how to check patient understanding, how to handle emotional distress remotely, and how to maintain confidentiality in digital communication.

Triangulation with quantitative findings

The qualitative themes helped explain the quantitative results. In the adjusted model, high techno-clinical empathy was independently associated with telemedicine experience, high core empathy,

high digital readiness, strong communication skills, and a positive attitude toward technology-assisted care. The qualitative findings showed why these associations were meaningful: telemedicine experience exposed clinicians to the practical challenge of reading limited cues; core empathy was reflected in the repeated insistence that human concern must remain central; digital readiness mattered because participants saw technology as useful for access and follow-up; communication skill mattered because clear language, tone, facial cues, and listening were repeatedly identified as essential; and positive attitudes toward technology-assisted care aligned with the belief that digital tools can support care when used responsibly.

At the same time, the qualitative findings added dimensions that were not fully captured by the quantitative scale. Privacy, trust, local-language communication, digital etiquette, and the risk of technology replacing human presence emerged as important contextual issues. Together, the findings suggest that techno-clinical empathy in Bangladesh should be understood as a combined competency involving emotional presence, clear communication, ethical digital behaviour, technical confidence, and patient-centered use of technology.

Discussion

This mixed-methods study found that techno-clinical empathy was present at a meaningful but incomplete level among medical students and doctors in Bangladesh. Although 74.8% demonstrated high core empathy, only 57.0% met the threshold for high techno-clinical empathy, while fewer than half demonstrated high digital readiness. In the fully adjusted model, techno-clinical empathy was independently associated with telemedicine experience, core empathy, digital readiness, communication skills, and a positive attitude toward technology-assisted care. The qualitative findings reinforced these relationships by showing that participants understood digital empathy as the deliberate preservation of human attention, clear communication, emotional recognition, privacy, and trust when technology mediates clinical care [6, 24].

The difference between core empathy and techno-clinical empathy is important. Most participants appeared to value compassionate clinical care, yet a smaller proportion felt able to express that empathy through digital platforms. This suggests that bedside empathy does not transfer automatically to telemedicine, written messaging, electronic records, or AI-assisted communication [25, 26]. Reviews of telephone and telemedicine consultations similarly show that empathy can be conveyed remotely, but reduced visual information, interruptions, unfamiliar

technology, and limited opportunities to observe non-verbal behaviour can make empathic communication more difficult [27, 28].

Telemedicine experience was independently associated with almost twice the odds of high techno-clinical empathy. Practical exposure may help clinicians recognize the importance of voice, pacing, eye contact, explicit reassurance, and confirmation of patient understanding when usual bedside cues are limited. This interpretation was supported directly by the qualitative accounts, in which experienced participants emphasized facial expression, tone of voice, and attentive listening. The finding suggests that techno-clinical empathy is partly experiential: clinicians may develop it through repeated encounters in which they learn how to compensate for the limitations of the medium [29, 30].

High digital readiness showed one of the strongest associations with techno-clinical empathy. Digital confidence may allow clinicians to focus on the patient rather than struggle with platform operation, documentation, connectivity, or navigation. Recent conceptual work similarly describes digital empathy as requiring both emotional engagement and technological proficiency, together with adaptability, trust-building, and cultural sensitivity [31, 32]. Digital readiness should therefore not be viewed solely as technical competence. Inadequate familiarity with technology may indirectly weaken relational care by dividing attention, disrupting conversational flow, or making the clinician appear hurried and disengaged.

Core empathy and strong communication skills were also independently associated with techno-clinical empathy. This supports the view that digital empathy is not a separate personality trait but an adaptation of established clinical communication to a different environment. Participants repeatedly described understandable language, active listening, reassurance, and respect as central to digital care [6]. These behaviours are consistent with established communication pathways through which clinicians promote shared understanding, therapeutic relationships, patient agency, and emotional support. The qualitative emphasis on Bangla and locally understandable language was particularly relevant because digital consultations may magnify misunderstanding when visual cues, physical examination, and immediate clarification are limited.

A positive attitude toward technology-assisted care was the strongest adjusted predictor. Participants who viewed technology as beneficial may have been more willing to adapt their communication and use digital tools in a patient-centered manner. However, the qualitative

findings showed that acceptance of technology was conditional rather than uncritical. Participants appreciated improved access and reduced travel but rejected the idea that efficiency alone represented quality. This aligns with the broader principle that digital health should strengthen equitable and people-centered health systems rather than focus only on platforms and devices [33, 34].

Neither professional status nor age was independently associated with techno-clinical empathy. This indicates that progression through medical education or clinical seniority does not necessarily ensure competence in digitally mediated empathy. Formal digital-health training was also uncommon and was not independently associated with the outcome. One possible explanation is that existing training, where available, may emphasize technology operation rather than relational communication. Similarly, reported communication-skills training alone was not significant after adjustment, whereas participants' measured communication competence remained important. Attendance at training may therefore be less influential than the skills participants actually develop and retain [35, 36].

The qualitative findings expanded the quantitative results by identifying privacy and responsible data use as components of empathy. Participants regarded confidentiality not merely as regulatory compliance but as evidence that the clinician respected the patient. Digital relationships may be weakened when patients are uncertain about who can hear a consultation, where data are stored, or how information may be used [37, 38]. Trust and ethical digital behaviour should therefore be considered part of techno-clinical empathy rather than separate technical concerns.

Participants also expressed concern that AI or digital tools could appear attentive while weakening genuine clinical presence. Some studies have found that written chatbot responses were rated as more empathic than brief physician responses, largely because they were detailed, responsive, and emotionally supportive. However, these findings were based mainly on text-based scenarios and do not establish that AI possesses human understanding or can replace therapeutic responsibility. The present findings instead support using technology to assist communication while retaining clinician oversight, accountability, contextual judgment, and human connection [39–41]. Therefore, the convergence of quantitative and qualitative evidence indicates that techno-clinical empathy is a combined competency involving core empathy, communication, digital confidence, ethical awareness, and practical exposure. It should therefore be treated as a teachable component of

digital-era clinical practice rather than assumed to develop naturally from either medical seniority or technology use alone.

Strengths, Limitations, and Future Directions

This study has several strengths. It examined an emerging clinical-educational construct using a mixed-methods design, allowing statistical associations to be interpreted alongside the experiences of students, doctors, educators, policymakers, and telemedicine practitioners. The analytical sample exceeded the required size and achieved high data retention. The techno-clinical empathy scale and the related domains demonstrated strong internal consistency. The use of two multivariable models also helped distinguish the contribution of technology exposure from that of core empathy, communication, readiness, and attitudes. Qualitative triangulation strengthened interpretation by identifying practical issues including non-verbal cue loss, local-language communication, privacy, trust, and training needs that were not fully represented by numerical scores.

Several limitations should be acknowledged. The cross-sectional design prevents conclusions about causality. Telemedicine experience may strengthen techno-clinical empathy, but individuals with greater empathy or more positive attitudes may also be more likely to participate in telemedicine. Convenience sampling limits national representativeness, and participants with an interest in digital health may have been more likely to respond. All quantitative measures were self-reported and may reflect confidence or socially desirable attitudes rather than objectively observed behaviour.

The techno-clinical empathy measure was developed for this study and has not yet undergone external validation. Although internal consistency was strong, further assessment of construct validity, measurement invariance, test–retest reliability, and predictive validity is required. The use of an agreement-based threshold was interpretable but does not represent an established clinical or educational cutoff. Strong correlations among empathy, communication, readiness, and attitude constructs, together with maximum variance inflation factors approaching 10, indicate conceptual overlap and require cautious interpretation of individual adjusted effects.

The qualitative component included several professional and geographic perspectives, but the number of key informants was limited, and patient perspectives were not included. The study

therefore describes how healthcare trainees, professionals, and stakeholders understand digital empathy but cannot establish whether patients experienced their communication as empathic.

Future studies should validate the instrument in diverse professional and cultural settings and compare self-reported scores with observed telemedicine consultations, simulated encounters, patient ratings, and communication coding. Longitudinal and intervention studies should test whether structured training improves empathic behaviour in video, telephone, text-based, and AI-supported care. Patient perspectives should be included, particularly those of individuals with limited digital literacy, language barriers, disabilities, or restricted internet access. Training interventions should examine digital etiquette, management of reduced non-verbal cues, written empathy, privacy, informed use of AI, and communication during technical failure.

Conclusion

This study shows that techno-clinical empathy is an important but incompletely developed competency among medical students and doctors in Bangladesh. While core empathy and communication competence were relatively common, only slightly more than half of participants demonstrated high empathy specifically within technology-mediated care, and fewer than half demonstrated high digital readiness. Techno-clinical empathy was not determined primarily by age, gender, or professional seniority. Instead, it was associated with telemedicine experience, core empathic orientation, communication ability, digital readiness, and a positive but patient-centred attitude toward technology-assisted care.

The qualitative findings clarify what these associations mean in practice. Participants described digital empathy as maintaining human attention despite physical distance, recognizing emotion through limited cues, communicating in clear and locally understandable language, protecting privacy, and ensuring that technology supports rather than replaces the clinician–patient relationship. These findings indicate that technical competence alone is insufficient for humane digital care. A clinician may operate a platform successfully yet still fail to make a patient feel heard, reassured, respected, or safe.

Medical education and digital-health programmes should therefore treat techno-clinical empathy as a structured and assessable competency. Training should combine telemedicine practice with communication, emotional recognition, digital etiquette, privacy, and responsible AI use.

Simulated remote consultations and supervised real-world exposure may help learners translate traditional clinical empathy into digital environments. As digital health expands in Bangladesh, its quality should be judged not only by access, speed, or technological adoption, but also by whether patients continue to experience care as understandable, trustworthy, respectful, and genuinely human.

List of Abbreviations

Abbreviation	Full Form
AOR	Adjusted Odds Ratio
AUC	Area Under the Receiver Operating Characteristic Curve
BDT	Bangladeshi Taka
BMI	Body Mass Index
BP	Blood Pressure
CI	Confidence Interval
HbA1c	Glycated Hemoglobin
IQR	Interquartile Range
IRB	Institutional Review Board
ISI	Insomnia Severity Index
LMIC	Low- and Middle-Income Country
OSA	Obstructive Sleep Apnea
PSQI	Pittsburgh Sleep Quality Index
SD	Standard Deviation
STOP-BANG	Snoring, Tiredness, Observed Apnea, High Blood Pressure, Body Mass Index, Age, Neck Circumference, and Gender
VIF	Variance Inflation Factor
WHO	World Health Organization

Supplementary Materials

Supplementary File S1.

This file includes:

Supplementary Table S1(a). Item-level distribution of Likert responses.

Supplementary Table S1(b). Crude logistic regression for high techno-clinical empathy.

Supplementary Table S1(c). Preliminary keyword-assisted summary of open-ended responses.

Supplementary Table S1(d). Logistic regression diagnostics and sensitivity analysis for high techno-clinical empathy.

Supplementary Table S1(e). Spearman correlations among continuous construct mean scores.

Supplementary Figure S1. Spearman correlation matrix of construct mean scores.

Declarations

Funding

The authors received no specific funding for this research.

Conflicts of interest

The authors declare that they have no competing interests.

Ethics approval

The study protocol was reviewed and approved by the Institutional Review Board of Sheikh Fazilatunnesa Mujib Eye Hospital and Training Institute, Gopalganj, Bangladesh (Approval No. 2026-27/2408). Data collection was conducted in accordance with the approved protocol.

Consent to participate

Informed consent was obtained from all participants prior to participation in the study. Participants in the qualitative component also provided informed consent before participating in focus group discussions or key-informant interviews. Participation was voluntary, and no individual-level identifying information was retained in the analytical dataset or qualitative reporting.

Written Consent for publication

Not applicable.

Availability of data and material

The datasets are available from the corresponding author upon reasonable request.

Code availability

Not applicable.

Authors' contributions

MD Nahid Hassan Nishan and Farhana Parveen contributed equally to the conception and design of the study, methodology, data analysis, interpretation of findings, and preparation of the original manuscript. Gazi Md Ehsanul Alam, Tasmin Jahan Hazari, Dewan Ibna Al Sakir, Syeda Sara Nasir, Md Monzur Rahman Bhuiyan, and M M Aeorangajeb Al Hossain contributed to the critical review, editing, and refinement of the manuscript. All authors reviewed and approved the final version of the manuscript.

Acknowledgments

The authors sincerely thank all participants for their valuable time and contributions to this study. Their participation and support made this research possible.

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Supplementary Files

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- SupplementaryFileS1.docx