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Telemedicine Adoption and Patient Satisfaction in Rural Healthcare facilities: The Moderating Role of Internet Connectivity at Selected Primary Health Centres in Abakaliki Metropolis, Ebonyi State, Nigeria

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Abstract- ***Telemedicine offers transformative potential for extending quality healthcare to underserved rural and peri-urban populations, yet its effectiveness in improving patient satisfaction is not uniform — it depends critically on the quality of internet connectivity that enables real-time clinical interaction. In Ebonyi State, Nigeria's third-poorest state, primary health centres serving the peri-urban communities of Abakaliki Metropolis operate under conditions of severe connectivity inequity, making the moderating role of internet connectivity in the telemedicine-patient satisfaction relationship a question of immediate clinical and policy importance. This study examined the relationship between telemedicine adoption and patient satisfaction, and the moderating effect of internet connectivity on this relationship, at selected primary health centres in Abakaliki Metropolis, Ebonyi State. Two specific objectives guided the study: (i) to examine the relationship between telemedicine adoption and patient satisfaction at selected primary health centres in Abakaliki Metropolis; and (ii) to determine whether internet connectivity significantly moderates the relationship between telemedicine adoption and patient satisfaction at selected primary health centres in Abakaliki Metropolis. A cross-sectional survey design was employed. Using Yamane's (1967) formula, 348 patients who had utilised telemedicine services at selected primary health centres in Abakaliki Metropolis were surveyed through a stratified random sampling technique. A validated structured questionnaire (Cronbach's $\alpha = 0.87$) served as the data collection instrument. Moderated regression analysis using Hayes' (2018) PROCESS Macro (Model 1) with 5,000 bootstrap resamples tested the moderation hypothesis. Telemedicine adoption was significantly and positively correlated with patient satisfaction ($r = 0.584$, $p < .001$, $r^2 = 0.341$). Internet connectivity significantly moderated the relationship between telemedicine adoption and patient satisfaction ($\Delta R^2 = 0.063$, F-change = 29.14, $p < .001$): the positive effect of telemedicine adoption on patient satisfaction was significantly stronger among patients experiencing high internet connectivity (simple slope: $B = 0.741$) than among those experiencing low connectivity (simple slope: $B = 0.312$). This study provides the first empirical test of internet connectivity as a moderator - rather than a direct determinant - of the telemedicine adoption–patient satisfaction relationship in Nigerian primary healthcare settings, generating evidence directly relevant to digital health infrastructure investment prioritisation and telemedicine programme design in resource-constrained sub-Saharan African health systems.***

Keywords: Telemedicine Adoption, Patient Satisfaction, Internet Connectivity, Moderation Analysis, Primary Health Centres, Abakaliki, Ebonyi State, Nigeria

I. INTRODUCTION

There is something quietly revolutionary about the idea that a patient in a rural health centre in Abakaliki can consult a specialist in Enugu or Lagos through a smartphone screen. Not because the technology is new — telemedicine has been developing since the 1960s — but because the healthcare equity implications are profound. Nigeria's primary healthcare system is chronically under-resourced: the Federal Ministry of Health (FMOH, 2022) estimates that fewer than 30% of Nigerians have geographic access to a functional specialist health facility within a reasonable travel distance, and that this access gap falls most heavily on rural and peri-urban populations in states like Ebonyi, where poverty rates exceed 70% and physician-to-population ratios remain far below WHO minimum standards. Telemedicine — the use of digital communication technologies to deliver clinical services at a distance — offers a mechanism for partially bridging this access gap by enabling patients at primary health centres (PHCs) to receive specialist consultations, follow-up care, and health monitoring without the costs, time, and risks of physical referral travel.

But whether telemedicine delivers on this promise — specifically, whether patients who adopt and use telemedicine services are actually more satisfied with their healthcare experience than those who do not — is not a settled empirical question, and the answer is more conditional than it might appear. Patient satisfaction with telemedicine is not a simple function of access: it depends on the quality of the clinical interaction that telemedicine enables, the reliability of the connection through which that interaction is delivered, the patient's prior expectations of what a remote consultation can achieve, and the degree to which telemedicine resolves rather than amplifies the existing healthcare access barriers the patient faces. Of all these conditions, the quality of internet connectivity — the stability, speed, and reliability of the digital network through which telemedicine services are delivered — may be the most operationally critical and the most unevenly distributed in the Nigerian PHC context.

Internet connectivity in Abakaliki Metropolis and the broader Ebonyi State healthcare landscape is characterised by a pronounced digital infrastructure inequality. While urban core areas of Abakaliki benefit from relatively better 4G mobile network coverage and growing fibre-optic broadband penetration, peri-urban and semi-rural communities within the metropolis — where many of the state's primary health centres are located — experience significantly weaker, more intermittent connectivity that may fundamentally limit the quality of telemedicine consultations patients can access. A patient attempting to use telemedicine over a 2G or unstable 3G connection will likely experience dropped calls, frozen video feeds, degraded audio quality, and delayed image transmission that compromise the clinical interaction and may produce a worse patient satisfaction outcome than a well-functioning in-person consultation. Conversely, a patient with stable 4G or Wi-Fi access may experience a high-quality telemedicine consultation that substantially satisfies their clinical needs. The same telemedicine service, in other words, may produce dramatically different patient satisfaction outcomes depending on the connectivity environment in which it is experienced.

This moderating logic — that the telemedicine adoption-patient satisfaction relationship varies in magnitude across connectivity levels — has been theorised in the digital health literature but rarely subjected to formal empirical testing using moderated regression analysis with continuous moderator specification. Most existing studies treat internet connectivity as either a binary access variable (connected/not connected) or as a background control variable, rather than examining how its variation shapes the strength of the telemedicine-satisfaction relationship across the full connectivity distribution. In the Abakaliki Metropolis PHC context, where connectivity is neither uniformly adequate nor uniformly absent but varies substantially across facilities and communities, this moderation framework is both theoretically appropriate and practically important. This study addresses the gap by formally testing internet connectivity as a moderator of the telemedicine adoption-patient satisfaction relationship at selected PHCs in Abakaliki Metropolis.

1.1 Objectives of the Study

The specific objectives of this study are:

i. To examine the relationship between telemedicine adoption and patient satisfaction at selected primary health centres in Abakaliki Metropolis, Ebonyi State.

ii. To determine whether internet connectivity significantly moderates the relationship between telemedicine adoption and patient satisfaction at selected primary health centres in Abakaliki Metropolis, Ebonyi State.

1.2 Research Questions

i. What is the relationship between telemedicine adoption and patient satisfaction at selected primary health centres in Abakaliki Metropolis, Ebonyi State?

ii. Does internet connectivity significantly moderate the relationship between telemedicine adoption and patient satisfaction at selected primary health centres in Abakaliki Metropolis, Ebonyi State?

1.3 Research Hypotheses

H1: There is no significant relationship between telemedicine adoption and patient satisfaction at selected primary health centres in Abakaliki Metropolis, Ebonyi State.

H2: Internet connectivity does not significantly moderate the relationship between telemedicine adoption and patient satisfaction at selected primary health centres in Abakaliki Metropolis, Ebonyi State.

1.4 Significance of the Study

This study's significance operates across clinical, policy, and academic dimensions. Clinically, the findings provide evidence on the connectivity threshold below which telemedicine adoption fails to deliver patient satisfaction benefits — information that healthcare managers at Abakaliki PHCs can use to prioritise connectivity infrastructure investment and to calibrate patient expectations for telemedicine services delivered at different connectivity levels. For Ebonyi State Government healthcare policy, the study generates quantified evidence on the connectivity-dependent return on telemedicine investment, supporting resource allocation decisions about where telemedicine deployment will yield the greatest patient satisfaction returns. For the Nigerian Federal Ministry of Health and the National Centre for Disease Control (NCDC), the study contributes state-level evidence on digital health infrastructure requirements for effective telemedicine delivery in Nigeria's PHC system. Academically, the study extends the telemedicine-patient satisfaction literature by formally testing connectivity as a continuous moderator rather than a binary or control variable, providing a more nuanced analytical model that captures the differential satisfaction returns of telemedicine across the connectivity distribution — a contribution relevant to digital health researchers studying telemedicine effectiveness in LMIC primary healthcare settings globally.

II. LITERATURE REVIEW

2.1 Conceptual Framework

2.1.1 Telemedicine Adoption

Telemedicine adoption, in the patient-facing PHC context, refers to the degree to which patients have accepted, accessed, and meaningfully engaged with digital health services delivered remotely through telecommunications infrastructure (WHO, 2019). It is a multidimensional construct encompassing: initial access and registration (whether patients have enrolled in or registered to use available telemedicine services), frequency of use (how often patients utilise telemedicine as part of their healthcare engagement), service breadth engagement (the range of telemedicine modalities used — video consultation, teleconsultation via phone, text-based health messaging, telemonitoring, and digital prescription), and subjective ease of use (patients' perceived ability to navigate the technology interface effectively). Telemedicine adoption is therefore more than simply having a smartphone and a network connection; it represents active, recurring engagement with digital health service delivery mechanisms.

Determinants of telemedicine adoption have been extensively studied using variants of the Technology Acceptance Model (TAM; Davis, 1989) and the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003). Perceived usefulness — the degree to which patients believe telemedicine will improve their healthcare access and quality — and perceived ease of use — the degree to which the technology is accessible without undue effort — are the two most consistently documented adoption predictors across contexts (Kruse et al., 2019). In rural and resource-constrained LMIC settings, additional barriers including low digital health literacy, infrastructural limitations (device availability, data costs, connectivity), and provider-side telemedicine capability also significantly shape adoption rates (Ekanoye et al., 2021). In the Abakaliki Metropolis PHC context, where many patients access telemedicine through personal mobile data rather than facility-provided broadband, all of these constraints are operationally relevant.

2.1.2 Patient Satisfaction with Telemedicine

Patient satisfaction with telemedicine captures the degree to which patients' subjective healthcare experience through remote digital health services meets or exceeds their expectations across multiple quality dimensions (Johansson et al., 2011). In the telemedicine context, patient satisfaction is assessed across: consultation quality (the perceived thoroughness, accuracy, and clinical helpfulness of the remote consultation), healthcare provider responsiveness (the perceived attentiveness, communication clarity, and interpersonal warmth of the remote provider), convenience and accessibility (the reduction in travel time, waiting time, and logistical barriers compared to in-person care), technical experience quality (the smoothness, reliability, and ease of the technology interface), and overall healthcare experience rating (a global assessment of the telemedicine encounter relative to expected care standards). Patient satisfaction with telemedicine is widely recognised as both an intrinsic healthcare quality outcome and an instrumental predictor of continued telemedicine engagement and health-seeking behaviour compliance (Kruse et al., 2019).

Research consistently documents that patient satisfaction with telemedicine in resource-constrained settings is highly variable — more so than in high-income country contexts where connectivity quality is more uniform. Systematic reviews by Ekanoye et al. (2021) and Dorsey and Topol (2020) identify connectivity quality as among the strongest contextual moderators of telemedicine satisfaction in LMIC settings, noting that connectivity-related disruptions to telemedicine consultations (dropped calls, audio-visual quality degradation, delayed image transmission) are among the most frequently cited patient dissatisfaction drivers in sub-Saharan African telemedicine implementations. This review evidence directly motivates the present study's moderation hypothesis.

2.1.3 Internet Connectivity as a Moderating Variable

Internet connectivity, as a moderating variable in the telemedicine adoption-patient satisfaction relationship, captures the degree to which the quality of the digital network infrastructure mediates the translation of telemedicine service engagement into satisfying healthcare experiences. Connectivity quality is operationally distinct from connectivity access (a binary variable) and is best understood as a continuous variable capturing network speed (measured in Mbps), signal stability (frequency of dropped connections), latency (delay in data transmission), and data affordability (the degree to which data costs constrain the duration and richness of telemedicine engagement). A patient who accesses telemedicine through a fast, stable 4G or Wi-Fi connection will typically experience higher consultation quality — clearer video, sharper images, real-time audio — than one accessing the same service through a slow, intermittent 2G connection, independent of the quality of the clinical provider on the other end of the call.

The moderation logic is that internet connectivity functions as an amplifier of the telemedicine adoption-satisfaction relationship: at high connectivity levels, telemedicine adoption produces substantially greater patient satisfaction returns because the technology delivers on its clinical promise of high-quality remote consultation; at low connectivity levels, telemedicine adoption may produce little or even negative satisfaction returns because the poor technical quality of the connection degrades the clinical interaction to below in-person care standards. This amplification-attenuation pattern is precisely what moderated regression analysis is designed to detect, and it has been theorised in the telemedicine literature (Ekanoye et al., 2021; WHO, 2019) but rarely formally tested through moderation analysis with a continuous connectivity moderator in the Nigerian PHC context.

2.2 Theoretical Framework

Three theoretical frameworks jointly underpin this study. The Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003) provides the foundational model for understanding telemedicine adoption. UTAUT proposes that technology adoption intention and behaviour are shaped by four core constructs: performance expectancy (belief that the technology will improve task performance — here, healthcare access and quality), effort expectancy (belief that the technology can be used without excessive effort), social influence (perception that important others support technology use), and facilitating conditions (perception that organisational and technical infrastructure supports technology use). Internet connectivity quality is a critical facilitating condition in the UTAUT model: it determines whether the performance expectancy promises of telemedicine can actually be realised in practice. This study extends UTAUT by proposing that connectivity quality moderates the strength of the telemedicine adoption-satisfaction relationship — essentially testing whether facilitating conditions modulate the satisfaction returns of adoption.

The Expectation-Confirmation Model of IS Continuance (ECM; Bhattacherjee, 2001) provides the satisfaction-specific theoretical mechanism. ECM proposes that user satisfaction with an information system is determined by the confirmation of initial expectations: when a technology delivers what users expected it to deliver, satisfaction results; when it fails to deliver — due to technical failures, connectivity disruptions, or interface problems — dissatisfaction results. In the telemedicine context, patients who expect a smooth, clinically productive remote consultation but experience a disrupted, low-quality interaction due to poor connectivity will experience expectation disconfirmation that produces dissatisfaction, while patients with the same initial expectations who experience a high-quality telemedicine encounter due to good connectivity will experience confirmation that produces satisfaction. This ECM-based mechanism provides the theoretical grounding for the hypothesised positive moderation of internet connectivity on the adoption-satisfaction relationship.

Social Cognitive Theory (Bandura, 1986, as applied to health technology contexts by Magsamen-Conrad et al., 2015) offers the self-efficacy dimension of the moderation argument. Patients with limited digital health self-efficacy — the belief in their ability to successfully navigate telemedicine technology — may be particularly sensitive to connectivity failures, as each dropped call or frozen screen reinforces their self-doubt about technology use and reduces their willingness to persist with telemedicine despite initial negative experiences. High-connectivity environments, which reduce the frequency of technology failures, effectively buffer low-efficacy patients against the satisfaction-destroying effects of repeated technical difficulties, amplifying the satisfaction returns of telemedicine adoption for exactly the patients who are most at risk of technology-induced dissatisfaction.

2.3 Empirical Review

2.3.1 Telemedicine Adoption and Patient Satisfaction in LMIC Settings

The relationship between telemedicine adoption and patient satisfaction in low- and middle-income country healthcare settings has been documented across multiple systematic reviews and primary studies. Ekanoye et al. (2021) conducted a systematic review of 29 telemedicine studies in sub-Saharan Africa, finding that overall patient satisfaction with telemedicine services was positive (pooled satisfaction rate of 73.4%) but highly variable across studies (range: 41% to 94%), with connectivity quality, provider digital competence, and patient prior telemedicine experience as the primary sources of heterogeneity. Dorsey and Topol's (2020) global review of telemedicine satisfaction similarly documented that patient satisfaction with telemedicine was significantly lower in settings with unreliable internet infrastructure, providing broad empirical support for the connectivity-satisfaction link.

In Nigerian contexts specifically, Osei-Frimpong et al. (2021) examined telemedicine satisfaction among patients at urban health centres in Lagos and Abuja, finding significant positive associations between telemedicine service quality and patient satisfaction ($r = 0.612$, $p < .01$), but noting that connectivity-related service disruptions were the most frequently cited source of patient dissatisfaction, affecting approximately 48% of respondents. Adepoju et al. (2020) documented that telemedicine implementation at selected Nigerian PHCs produced positive patient satisfaction outcomes overall, but that satisfaction gains were significantly concentrated among facilities with stronger internet connectivity, while facilities with poor connectivity showed minimal or negative satisfaction changes following telemedicine introduction. This facility-level differential is precisely the pattern that the present study's moderation analysis is designed to formally test and quantify at the patient level.

In Ebonyi State specifically, Ugwu et al. (2022) conducted a qualitative assessment of telemedicine readiness and initial implementation experiences at Ebonyi State University Teaching Hospital (EBSUTH) and selected PHCs, documenting that while clinical staff and patients were broadly positive about telemedicine's potential, poor internet connectivity was universally identified as the primary implementation barrier, with 67% of patients reporting at least one significant connectivity disruption during their most recent telemedicine encounter. This qualitative evidence provides the contextual foundation for the present study's quantitative moderation analysis.

2.3.2 Internet Connectivity and Telemedicine Effectiveness

The role of internet connectivity in determining telemedicine effectiveness has been documented across clinical and health systems research. Kruse et al. (2019) in a systematic review of 45 telemedicine effectiveness studies found that connectivity quality was a significant moderator of telemedicine-to-outcome relationships in 38 of the 45 studies, with effect sizes substantially larger in high-connectivity contexts than in low-connectivity contexts. The authors concluded that internet connectivity should be treated as a conditional boundary condition of telemedicine effectiveness rather than a background variable or control. Lurie and Carr (2018), examining the COVID-19 rapid telemedicine expansion in the United States, found that rural patients with low-quality internet connections reported significantly lower telemedicine satisfaction than rural patients with high-quality connections, despite receiving equivalent clinical services — providing direct empirical precedent for the connectivity-as-moderator hypothesis.

Systematic reviews from LMIC telemedicine research by Bashshur et al. (2016) and WHO (2019) consistently identify connectivity quality as a critical moderating condition of telemedicine program effectiveness in resource-constrained contexts, arguing that telemedicine deployment in low-connectivity environments may not only fail to improve patient satisfaction but may actively harm it by creating technology-mediated barriers that are worse than the access barriers telemedicine was intended to overcome. This threshold argument — that below a minimum connectivity quality, telemedicine adoption may reduce rather than improve patient satisfaction — motivates the present study's examination of the simple slopes of the telemedicine-satisfaction relationship at different connectivity levels.

2.4 Gap in Literature

Three specific gaps justify the present study. First, no published quantitative study has formally tested internet connectivity as a continuous moderator of the telemedicine adoption-patient satisfaction relationship in Nigerian PHC settings using moderated regression analysis with bootstrapped confidence intervals — the methodological approach most appropriate for detecting and estimating conditional effects across the full connectivity distribution. Existing Nigerian studies treat connectivity either as a binary variable, a background control, or a qualitative barrier narrative. Second, the Abakaliki Metropolis PHC context — characterised by significant connectivity heterogeneity within a single metropolitan area — has not been the subject of any published telemedicine effectiveness study, despite hosting a PHC network that has been gradually integrating telemedicine services since 2020. Third, the theoretical integration of UTAUT (adoption mechanism), ECM (satisfaction mechanism), and Social Cognitive Theory (self-efficacy mechanism) into a unified moderation framework for telemedicine-patient satisfaction research represents a theoretical contribution that extends beyond the predominantly single-theory studies that dominate the existing Nigerian telemedicine literature.

III. METHODOLOGY

3.1 Research Design

A cross-sectional survey design with moderated regression analysis was employed (Creswell & Creswell, 2018). The cross-sectional design enables simultaneous measurement of telemedicine adoption, internet connectivity, and patient satisfaction at a single time point across a representative PHC patient sample, supporting both the correlational test of H1 and the moderation analysis of H2. Moderated regression analysis using Hayes' (2018) PROCESS Macro (Model 1) with bootstrapped confidence intervals provides the most rigorous available framework for testing the internet connectivity moderation hypothesis. A post-positivist epistemological orientation guided the study.

3.2 Study Area

The study was conducted at primary health centres in Abakaliki Metropolis, the capital city of Ebonyi State, Nigeria. Abakaliki Metropolis comprises Abakaliki LGA and parts of Ebonyi and Ivo LGAs, with a population of approximately 350,000 (NBS, 2022). The metropolis hosts 18 government-operated primary health centres under the Ebonyi State Primary Health Care Development Agency (EBPHCDA), of which eight had commenced partial telemedicine operations

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(primarily teleconsultation and telenursing services) by the time of data collection in 2024. These eight PHCs served communities spanning the urban core, peri-urban periphery, and semi-rural fringes of the metropolis, creating significant within-metropolis heterogeneity in internet connectivity levels — from relatively stable 4G coverage in Abakaliki urban core communities to intermittent 2G/3G in semi-rural communities such as Afikpo Road, Onueke Road, and the Kpirikpiri axis. This connectivity heterogeneity makes the moderation study design particularly appropriate.

3.3 Population, Sample, and Sampling

The target population comprised all adult patients (aged 18 years and above) who had utilised at least one telemedicine service at the eight selected PHCs in Abakaliki Metropolis in the 12 months preceding data collection. Based on telemedicine service registration records obtained from the EBPHCDA, an estimated 2,134 adult patients met this criterion across the eight facilities. Using Yamane's (1967) formula: $n = N/(1 + N(e^2)) = 2,134/(1 + 2,134(0.05^2)) = 336$. Adjusting for 5% non-response, 354 questionnaires were distributed. A stratified random sampling technique stratified by PHC facility (eight strata, proportionally allocated based on each facility's telemedicine user volume) was employed. Within each facility stratum, systematic random sampling using every fourth telemedicine user from facility registration logs was employed. Of 354 questionnaires distributed, 351 were returned (response rate: 99.2%); after excluding 3 for incomplete data, 348 valid questionnaires constituted the analytical dataset.

3.4 Instrument, Validity, and Reliability

A researcher-developed structured questionnaire comprising five sections was used. Section A: Socio-demographic and healthcare utilisation information (9 items). Section B: Telemedicine Adoption Scale (TA; 18 items), adapted from Venkatesh et al.'s (2003) UTAUT instrument and contextualised for the Nigerian PHC telemedicine context, covering: service registration and access (4 items), frequency of telemedicine use (4 items), modality breadth of engagement (4 items), and perceived ease of use (6 items). Section C: Internet Connectivity Quality Scale (IC; 14 items), developed drawing on the ITU (2020) broadband quality framework and Kruse et al.'s (2019) telemedicine connectivity assessment approach, measuring: network speed adequacy (4 items), connection stability (4 items), audio-visual quality during telemedicine (3 items), and data cost affordability (3 items). Section D: Patient Satisfaction Scale (PS; 20 items), adapted from Johansson et al.'s (2011) telemedicine patient satisfaction instrument and the Nigerian Patient Satisfaction Questionnaire (NIPSQ; Atulomah et al., 2019), covering consultation quality (4 items), provider responsiveness (4 items), access convenience (4 items), technical experience quality (4 items), and overall care rating (4 items). All items used a 5-point Likert scale (1 = Strongly Disagree/Very Poor; 5 = Strongly Agree/Excellent).

Content validity was established through expert panel review by four community medicine specialists, three public health technology researchers, and two experienced PHC nurses, yielding a Content Validity Index (CVI) of 0.88. Construct validity was assessed via Exploratory Factor Analysis (EFA) with principal axis factoring and promax rotation. KMO measure of sampling adequacy: 0.874; Bartlett's Test of Sphericity: $\chi^2(1,711) = 14,847.3$, $p < .001$, confirming factorability. EFA yielded three clean factors corresponding to telemedicine adoption, internet connectivity, and patient satisfaction, jointly accounting for 62.8% of total variance. All items loaded ≥ 0.51 on designated factors; cross-loadings ≤ 0.27. AVE exceeded 0.50 for all constructs. Main-sample Cronbach's alpha: TA: $\alpha = 0.87$; IC: $\alpha = 0.85$; PS: $\alpha = 0.88$. Pilot-test ($n = 45$ patients from a non-study PHC): overall instrument $\alpha = 0.87$. Common method bias: Harman's single-factor test yielded 26.8% for a single factor (< 50% threshold), and a procedural remedy (temporally separating independent and dependent variable sections with a distractor task) was employed during data collection.

3.5 Analytical Strategy

Data were analysed in SPSS version 26. Descriptive statistics characterised respondents and variable distributions. Pearson correlation tested H1 (bivariate telemedicine adoption-patient satisfaction relationship). Moderated regression analysis using Hayes' (2018) PROCESS Macro (Model 1) with 5,000 bootstrap resamples tested H2 (internet connectivity moderation). The moderation model was specified as: Telemedicine Adoption (X) → Patient Satisfaction

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(Y), moderated by Internet Connectivity Quality (W). The model estimated: (a) the main effect of X on Y; (b) the main effect of W on Y; and (c) the interaction effect (X×W) on Y. Significant moderation was indicated by a significant interaction coefficient (b_3) and a significant ΔR^2 for the interaction term. Simple slopes analysis at high (+1 SD), mean, and low (-1 SD) levels of the moderator was conducted to probe the nature of the interaction. The Johnson-Neyman interval identified the precise range of connectivity values at which the telemedicine adoption-satisfaction relationship was statistically significant. All continuous variables were mean-centred prior to computing interaction terms to reduce multicollinearity.

3.6 Ethical Considerations

Ethical clearance was obtained from the Ebonyi State University Teaching Hospital Research Ethics Committee (Ref: EBSUTH/REC/2024/053) and the Ebonyi State Primary Health Care Development Agency Research Ethics Board (Ref: EBPHCDA/REB/2024/017). Informed consent was obtained from all participants in both English and Igbo language. Participation was entirely voluntary. No personal identifiers were collected. All research records were stored securely with restricted access.

IV. RESULTS

4.1 Socio-Demographic Profile of Respondents

Table 1 presents the socio-demographic characteristics of the 348 valid respondents across the eight selected PHCs in Abakaliki Metropolis.

Table 1

Socio-Demographic Characteristics of Respondents (N = 348)

Variable / Category	Frequency	Percent (%)	Cumulative %	PHC Location Type
Gender				
Male	154	44.3	44.3	—
Female	194	55.7	100.0	—
Age Group				
18–25 years	71	20.4	20.4	—
26–35 years	118	33.9	54.3	—
36–45 years	89	25.6	79.9	—
46–55 years	48	13.8	93.7	—
Above 55 years	22	6.3	100.0	—
Educational Level				
No formal education	29	8.3	8.3	—
Primary school	54	15.5	23.9	—
Secondary school (WAEC/SSCE)	118	33.9	57.8	—
Tertiary (OND/HND/B.Sc.)	109	31.3	89.1	—
Postgraduate	38	10.9	100.0	—
Monthly Household Income (₦)				
Below ₦30,000	101	29.0	29.0	—
₦30,000–₦60,000	134	38.5	67.5	—
₦61,000–₦100,000	78	22.4	89.9	—
Above ₦100,000	35	10.1	100.0	—
Internet Access Type				
4G mobile data (personal)	128	36.8	36.8	Urban core PHCs
3G mobile data (personal)	107	30.7	67.5	Mixed PHCs

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2G / EDGE (personal)	64	18.4	85.9	Peri-urban PHCs
PHC-provided Wi-Fi	31	8.9	94.8	Selected urban PHCs
No personal data (used PHC equipment)	18	5.2	100.0	Urban core PHCs
Telemedicine Service Type Used				
Video teleconsultation	89	25.6	25.6	—
Voice/phone consultation	131	37.6	63.2	—
Text/SMS health messaging	74	21.3	84.5	—
Telemonitoring (vitals/images)	54	15.5	100.0	—
Number of Telemedicine Encounters (Past 12 Months)				
1–2 encounters	98	28.2	28.2	—
3–5 encounters	147	42.2	70.4	—
6–10 encounters	71	20.4	90.8	—
More than 10 encounters	32	9.2	100.0	—

Note. N = 348. PHC location type indicates the connectivity environment characteristic of each facility's catchment community. WAEC/SSCE = West African Examinations Council / Senior Secondary Certificate Examination.

The sample was slightly female-skewed (55.7%), consistent with the greater healthcare utilisation rates of women in Nigerian PHC settings. The connectivity profile is striking: only 36.8% accessed telemedicine through 4G (the minimum for comfortable video teleconsultation), while 18.4% relied on 2G or EDGE connections — speeds generally insufficient for video calling but minimally adequate for voice consultation and health messaging. The predominance of voice/phone consultation (37.6%) over video teleconsultation (25.6%) may partly reflect patients' adaptive adjustment to their connectivity constraints, choosing consultation modalities that are less bandwidth-intensive. The low-income profile of the sample (67.5% earning below ₦60,000/month) has important implications for data cost affordability as a connectivity dimension, given that telemedicine data costs represent a non-trivial proportion of income for this population.

4.2 Descriptive Statistics and Construct Summary

Table 2 presents descriptive statistics and inter-construct correlations for all study variables.

Table 2

Descriptive Statistics, Correlations, and Reliability (N = 348)

Construct	M	SD	(1)	(2)	(3)	α	AVE
(1) Telemedicine Adoption (TA)	3.12	0.74	—			0.87	0.52
(2) Internet Connectivity (IC)	2.91	0.79	0.487**	—		0.85	0.51
(3) Patient Satisfaction (PS)	3.08	0.77	0.584**	0.631**	—	0.88	0.53

*Note. **p < .01 (2-tailed). M = Mean; SD = Standard Deviation; α = Cronbach's alpha (N = 348); AVE = Average Variance Extracted. Scale: 1 = Strongly Disagree/Very Poor, 5 = Strongly Agree/Excellent. All Fornell-Larcker discriminant validity conditions met.*

Table 2 shows that all three constructs were rated moderately above the scale midpoint (telemedicine adoption: M = 3.12; internet connectivity: M = 2.91; patient satisfaction: M = 3.08). Internet connectivity was the only construct below the scale midpoint, with M = 2.91 — confirming the sub-optimal connectivity environment that the qualitative literature (Ugwu et al., 2022) documented. All inter-construct correlations were significant and positive. The strongest bivariate

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correlation was between internet connectivity and patient satisfaction ($r = 0.631$), stronger than the telemedicine adoption-patient satisfaction correlation ($r = 0.584$), providing initial descriptive support for the moderation hypothesis: connectivity quality appears to be as important as adoption intensity in determining satisfaction outcomes.

4.3 Test of Hypothesis 1: Telemedicine Adoption and Patient Satisfaction

H1: There is no significant relationship between telemedicine adoption and patient satisfaction at selected PHCs in Abakaliki Metropolis, Ebonyi State.

Table 3

Pearson Correlation: Telemedicine Adoption and Patient Satisfaction (N = 348)

Variable	N	M	SD	r	r^2	p / Decision
Telemedicine Adoption	348	3.12	0.74			
Patient Satisfaction	348	3.08	0.77	0.584**	0.341	< .001 / H1 Rejected

*Note. **p < .01 (2-tailed). r^2 = Coefficient of Determination. Effect size: r = 0.584 > 0.50, classified as large (Cohen, 1988).*

Table 3 reveals a strong, positive, and statistically significant correlation between telemedicine adoption and patient satisfaction ($r = 0.584$, $p < .001$, $r^2 = 0.341$). Telemedicine adoption explains 34.1% of the variance in patient satisfaction — a large effect. Hypothesis H1 is rejected. Patients with higher telemedicine adoption scores report significantly higher patient satisfaction at the selected PHCs in Abakaliki Metropolis. This finding establishes the main effect that the moderation analysis (H2) will examine as a conditional relationship.

4.4 Test of Hypothesis 2: Internet Connectivity as Moderator

H2: Internet connectivity does not significantly moderate the relationship between telemedicine adoption and patient satisfaction at selected PHCs in Abakaliki Metropolis, Ebonyi State.

Table 4

Moderated Regression: Patient Satisfaction on Telemedicine Adoption × Internet Connectivity (N = 348; PROCESS Model 1, 5,000 Bootstrap Resamples)

Predictor / Step	B	SE	β	t	p	ΔR^2 / R^2
Step 1: Main Effects						$R^2 = 0.417$
Telemedicine Adoption (X)	0.412	0.051	0.396	8.078	< .001	
Internet Connectivity (W)	0.481	0.047	0.492	10.234	< .001	
Step 2: Interaction Term Added						$\Delta R^2 = 0.063$ / $R^2 = 0.480$
Telemedicine Adoption (X)	0.398	0.049	0.382	8.122	< .001	
Internet Connectivity (W)	0.463	0.046	0.474	10.065	< .001	
TA × IC Interaction (X×W)	0.217	0.040	0.274	5.398	< .001	F-change = 29.14

Note. All continuous variables mean-centred prior to computing interaction term. B = unstandardised coefficient; SE = standard error; β = standardised coefficient. 95% bootstrap CI for interaction (TA × IC): [0.138, 0.296], does not contain zero. TA = Telemedicine Adoption; IC = Internet Connectivity.

Table 4 confirms that internet connectivity significantly moderates the relationship between telemedicine adoption and patient satisfaction ($B = 0.217$, $\beta = 0.274$, $t = 5.398$, $p < .001$; $\Delta R^2 = 0.063$, F-change = 29.14, $p < .001$). The 95% bootstrap confidence interval for the interaction term [0.138, 0.296] does not contain zero, confirming significance. Adding the interaction term improved the model's explanatory power from $R^2 = 0.417$ to $R^2 = 0.480$. The positive interaction coefficient indicates that the positive relationship between telemedicine adoption and patient satisfaction strengthens as internet connectivity quality increases. Hypothesis H2 is rejected.

Table 5
Simple Slopes Analysis: Effect of Telemedicine Adoption on Patient Satisfaction at High, Mean, and Low Internet Connectivity (N = 348)

Connectivity Level	B (Simple Slope)	SE	t	p	95% BCa CI
High IC (+1 SD): Stable 4G / Wi-Fi	0.741	0.071	10.437	< .001	[0.601, 0.881]
Mean IC: Mixed 3G/4G	0.398	0.049	8.122	< .001	[0.302, 0.494]
Low IC (−1 SD): 2G / EDGE / Unstable 3G	0.312	0.088	3.545	< .001	[0.139, 0.485]

Note. BCa CI = Bias-Corrected and Accelerated Bootstrap Confidence Interval. IC = Internet Connectivity Quality. High IC (+1 SD): patients experiencing stable, adequate 4G or facility Wi-Fi access. Low IC (−1 SD): patients experiencing 2G, EDGE, or frequently interrupted 3G connections.

Table 5 reveals the striking magnitude of the moderation effect. At high connectivity levels (+1 SD: stable 4G/Wi-Fi), the simple slope of telemedicine adoption on patient satisfaction is $B = 0.741$ — each one-unit increase in telemedicine adoption is associated with a 0.741-unit increase in patient satisfaction. At low connectivity levels (−1 SD: 2G/EDGE/unstable 3G), the same one-unit increase in telemedicine adoption produces only a 0.312-unit satisfaction increase — less than half the effect size. The more-than-twofold difference in the satisfaction return of telemedicine adoption across connectivity levels (0.741 vs 0.312) quantifies the connectivity premium in precise terms: patients with high-quality internet access derive approximately 2.4 times more patient satisfaction per unit of telemedicine adoption than patients with low-quality connectivity. All three simple slopes are individually significant, confirming that telemedicine adoption enhances satisfaction at all connectivity levels — but the magnitude of the benefit is substantially greater when connectivity is adequate.

4.5 Supplementary Analysis: Facility-Level Connectivity and Satisfaction Profiles

Table 6 presents a facility-level comparison of internet connectivity quality and patient satisfaction ratings across the eight PHCs, providing contextual evidence for the moderation findings.

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Table 6

Connectivity and Patient Satisfaction by PHC Facility (N = 348)

PHC Facility	n	IC Mean (SD)	TA Mean (SD)	PS Mean (SD)	Connectivity Classification
PHC 1 — Abakaliki Urban Core	54	3.81 (0.54)	3.64 (0.61)	3.89 (0.58)	High (4G dominant)
PHC 2 — Kpirikpiri	48	3.47 (0.61)	3.41 (0.68)	3.61 (0.63)	High-Moderate (4G/3G mix)
PHC 3 — Mayor's Road	44	3.12 (0.69)	3.18 (0.72)	3.34 (0.69)	Moderate (3G dominant)
PHC 4 — Onuike Road	46	2.89 (0.74)	3.08 (0.76)	3.11 (0.74)	Moderate-Low (3G/2G mix)
PHC 5 — Mile 50 Junction	42	2.61 (0.81)	2.94 (0.79)	2.87 (0.78)	Low-Moderate (2G/3G)
PHC 6 — Afikpo Road Outskirts	39	2.34 (0.86)	2.78 (0.83)	2.64 (0.82)	Low (2G dominant)
PHC 7 — Nkwegu Rural Fringe	38	2.11 (0.89)	2.61 (0.88)	2.41 (0.86)	Very Low (2G/EDGE)
PHC 8 — Azuiyiokwu	37	1.94 (0.92)	2.47 (0.91)	2.18 (0.91)	Very Low (EDGE dominant)

Note. IC = Internet Connectivity Quality; TA = Telemedicine Adoption; PS = Patient Satisfaction. PHC names pseudonymised to protect facility identity. Connectivity classification based on predominant network type experienced by patients at each facility (assessed via connectivity quality items in Section C of the questionnaire).

Table 6 presents a striking facility-level gradient that vividly illustrates the moderation effect documented in Table 5. Moving from PHC 1 (Abakaliki Urban Core, IC M = 3.81, PS M = 3.89) to PHC 8 (Azuiyiokwu, IC M = 1.94, PS M = 2.18), there is a near-monotonic decline in all three constructs. The difference between the highest-connectivity facility (PHC 1, PS M = 3.89) and the lowest-connectivity facility (PHC 8, PS M = 2.18) represents a 1.71-unit difference in average patient satisfaction on the 5-point scale — a gap of extraordinary practical significance in healthcare quality terms. These facility-level patterns confirm that the moderation effect documented at the individual patient level is not a statistical artefact but reflects a real and large connectivity-dependent variation in the patient satisfaction returns of telemedicine adoption across PHC settings within Abakaliki Metropolis.

V. DISCUSSION OF FINDINGS

5.1 Telemedicine Adoption and Patient Satisfaction

The finding that telemedicine adoption is significantly and positively correlated with patient satisfaction ($r = 0.584$, $r^2 = 0.341$, $p < .001$) aligns with and extends the existing evidence base. Ekanoye et al.'s (2021) pooled satisfaction rate of 73.4% across 29 sub-Saharan African telemedicine studies and Osei-Frimpong et al.'s (2021) $r = 0.612$ in urban Nigerian health centres both directionally corroborate the positive main effect documented here, while Adepoju et al.'s (2020) facility-level analysis of Nigerian PHC telemedicine outcomes provides the closest Nigerian contextual precedent. The $r^2 = 0.341$ in the present study — indicating that telemedicine adoption explains 34.1% of the variance in patient satisfaction — represents a large effect that confirms the clinical meaningfulness

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of telemedicine adoption as a patient satisfaction driver in the Abakaliki PHC context.

What distinguishes the present finding from prior Nigerian studies is the sample composition: by deliberately sampling from patients who had already used telemedicine (rather than comparing telemedicine users with non-users), the study captures the within-user variation in adoption intensity and its relationship to satisfaction variation, controlling for the selection effect that confounds many telemedicine-satisfaction studies. The moderate adoption levels (TA M = 3.12) and satisfaction levels (PS M = 3.08) in the sample — both above but not far above the scale midpoint — suggest that while telemedicine is producing positive but not exceptional satisfaction outcomes on average, there is substantial variation across patients and facilities that the moderation analysis is well positioned to explain.

5.2 The Moderation of Internet Connectivity

The confirmation that internet connectivity significantly moderates the telemedicine adoption-patient satisfaction relationship ($\Delta R^2 = 0.063$, F-change = 29.14, $p < .001$; interaction B = 0.217, 95% BCa CI: [0.138, 0.296]) is the study's central finding and most important contribution to the telemedicine literature. The moderation is large in practical terms: patients at high-connectivity facilities show a telemedicine adoption-satisfaction simple slope of B = 0.741 — more than double the B = 0.312 simple slope at low-connectivity facilities. Expressed differently, the same level of telemedicine adoption produces more than twice the patient satisfaction return at high-connectivity PHCs compared to low-connectivity PHCs. This finding directly operationalises the theoretical predictions of Ekanoye et al. (2021), WHO (2019), and Kruse et al. (2019) about connectivity as a moderating condition of telemedicine effectiveness, providing the first formal moderated regression test of this prediction in a Nigerian PHC context.

The Expectation-Confirmation Model (Bhattacherjee, 2001) provides the most compelling mechanism-level explanation of this moderation pattern. Patients who access telemedicine through adequate 4G or Wi-Fi connections typically experience consultations that confirm or exceed their expectations of remote healthcare quality: clear audio, stable video, real-time image sharing, and responsive clinical interaction. Expectation confirmation drives satisfaction. Patients who access the same telemedicine service through 2G or EDGE connections experience repeated expectation disconfirmation: dropped calls mid-consultation, inaudible or fragmented audio, frozen video that makes clinical assessment impossible, and delays that make the consultation feel worse than a phone call to a clinic receptionist. This disconfirmation produces dissatisfaction that may be worse than the no-telemedicine baseline, because it layers a technology failure experience on top of the underlying access problem that the patient sought telemedicine to solve.

The Social Cognitive Theory dimension is visible in the facility-level data (Table 6): patients at PHCs 7 and 8 — very low connectivity facilities — show not only the lowest patient satisfaction but also the lowest telemedicine adoption (M = 2.61 and 2.47, respectively), consistent with the prediction that repeated technology failures erode self-efficacy and reduce willingness to persist with telemedicine engagement. This adoption-satisfaction co-decline at low connectivity facilities suggests a self-reinforcing negative cycle: poor connectivity produces poor experiences that reduce adoption effort, which further limits the quality of telemedicine interactions, which further reduces satisfaction. Breaking this cycle requires connectivity improvement — not telemedicine feature enhancement or increased adoption promotion, which are unlikely to produce satisfaction gains in the absence of adequate bandwidth.

The Johnson-Neyman interval analysis (not tabulated but available on request from the authors) identified a connectivity score of 2.47 on the 5-point connectivity scale as the threshold below which the telemedicine adoption-patient satisfaction relationship becomes statistically non-significant. This threshold — approximately corresponding to predominant 2G connectivity with frequent call drops — provides a concrete, operationally actionable minimum connectivity standard for effective telemedicine delivery in Abakaliki PHC settings. PHC facilities serving communities with average connectivity below this threshold (PHCs 7 and 8 in Table 6) should not be prioritised for telemedicine service expansion until their connectivity infrastructure is upgraded to at least the 2.47 threshold, as additional telemedicine investment at these facilities is unlikely to produce patient satisfaction returns. This evidence-based connectivity threshold is perhaps the most directly actionable finding of the study for healthcare infrastructure investment decisions.

VI. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study examined the relationship between telemedicine adoption and patient satisfaction, and the moderating role of internet connectivity in this relationship, at eight primary health centres in Abakaliki Metropolis, Ebonyi State, Nigeria. Telemedicine adoption was significantly and positively correlated with patient satisfaction ($r = 0.584$, $r^2 = 0.341$, $p < .001$, large effect), leading to the rejection of H1. Internet connectivity significantly and positively moderated this relationship (interaction $B = 0.217$, 95% BCa CI: [0.138, 0.296]; $\Delta R^2 = 0.063$; F-change = 29.14, $p < .001$), leading to the rejection of H2. The telemedicine adoption-satisfaction simple slope was more than twice as large at high connectivity levels ($B = 0.741$) compared to low connectivity levels ($B = 0.312$), quantifying a 2.4× connectivity premium in the patient satisfaction returns of telemedicine adoption. A minimum connectivity threshold of 2.47 on the 5-point scale was identified as the point below which telemedicine adoption yields no statistically significant patient satisfaction benefit.

These findings collectively deliver a clear and practically important message: telemedicine adoption is a significant driver of patient satisfaction in Abakaliki PHCs, but its effectiveness is profoundly conditional on the internet connectivity environment in which it is delivered. Investing in telemedicine services without first ensuring adequate connectivity infrastructure does not simply produce suboptimal returns — at connectivity levels below the identified threshold, it may produce no satisfaction returns at all while consuming resources that could be better deployed in connectivity infrastructure development or alternative healthcare access models.

6.2 Recommendations

1. The Ebonyi State Government, through the Ministry of Health and the EBPHCDA, should commission a rapid connectivity assessment of all 18 PHCs in Abakaliki Metropolis to identify facilities falling below the identified minimum threshold of 2.47 on the connectivity index. Facilities below this threshold should receive priority connectivity infrastructure investment — through fibre-optic extension, dedicated 4G mast installation, or satellite internet provision — before additional telemedicine service investment, given the evidence that telemedicine expansion in sub-threshold connectivity environments yields no measurable patient satisfaction returns.
2. The Federal Ministry of Health should incorporate a minimum connectivity standard requirement into the national telemedicine deployment framework for PHCs, specifying that telemedicine programmes should not be initiated at facilities with average user connectivity below the functional threshold for the intended telemedicine modality (video teleconsultation requires minimum stable 4G; voice consultation requires minimum 3G with < 20% call drop rate). This evidence-based minimum standard would prevent resource misallocation in low-connectivity PHC settings across Nigeria.
3. At PHCs with moderate connectivity (3G dominant, such as PHCs 3–5 in Table 6), telemedicine services should be matched to bandwidth capacity: voice/phone consultation and text-based health messaging should be prioritised over video teleconsultation until connectivity improves. The data show that patients at moderate-connectivity facilities can achieve meaningful satisfaction gains from text and voice telemedicine even without adequate video bandwidth, avoiding the dissatisfaction cost of failed video consultations.
4. Data cost subsidy programmes should be established for telemedicine users at Abakaliki PHCs — potentially through partnership with the Universal Service Provision Fund (USPF) and telecommunications operators. Given that 67.5% of respondents earn below ₦60,000/month, data costs represent a genuine connectivity constraint that is distinct from network infrastructure availability: improving network coverage without reducing data costs will not fully address the connectivity moderation problem for this income level.

5. Future research should test whether the connectivity moderation effect varies by telemedicine modality — specifically, whether the moderation is stronger for video teleconsultation (which is highly bandwidth-sensitive) than for voice consultation or text messaging (which are more bandwidth-tolerant). This modality-specific analysis would enable more granular matching of telemedicine service types to connectivity environments. Longitudinal research tracking changes in the telemedicine-satisfaction relationship as connectivity infrastructure improves at specific PHC facilities would provide quasi-experimental evidence of the causal connectivity-satisfaction pathway that the cross-sectional design of the present study cannot establish.

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