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Cost Analysis of Telemedicine vs. In-Person Consultations of Stroke Patients in Primary Healthcare

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Abstract

Background: To evaluate the perceived costs and feasibility of telemedicine consultations, compared with in-person consultations among patients with stroke, in primary healthcare settings in Pakistan. The study aimed to assess the potential costs and time savings to provide evidence-based information to inform decisions for the implementation of telemedicine in a low-resource environment.

Methods: A cross-sectional survey design was used, involving a convenience sample of 30 stroke patients recruited from Al Nafees Medical College and Hospital, Islamabad, and Ikram Hospital, Gujrat. Data was collected through a structured survey which captured patient demographics, patient clinical characteristics, cost of in-person consultations, technology access, and perceived costs of telemedicine consultations. Independent t-tests were used to compare mean costs and time differences between in-person and telemedicine consultation models. Significance was set at $p < 0.05$.

Results: The average total cost of an in-person consultation was PKR 7,440±2,680, while telemedicine was estimated to cost around PKR 1,200 ± 480, representing an average cost saving of PKR 6,240 ± 2,300 ($p< 0.001$). In addition, telemedicine consultations reduced consultation time from 6.8±3.2 hours to 1.2±0.6 hours ($p< 0.001$). The vast majority of families (93.3%) felt that telemedicine would be both time and cost-efficient, with particularly strong support from families residing in rural areas, who faced higher travel and overnight accommodation costs.

Conclusion: The study revealed that telemedicine may increase equity in access to services for patients, and will reduce the economic burden on families, while increasing access to services, which presents a strong rationale for its inclusion in national stroke management systems low- and middle-income countries.

Keywords: Cost-effectiveness, Pakistan, Primary healthcare, Stroke, Telemedicine.

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1. INTRODUCTION

Stroke remains a leading cause of death and disability globally, with approximately 5.5 million deaths annually and a substantial economic burden on healthcare systems (Feigin et al., 2025). The timely administration of evidence-based treatments, including intravenous thrombolysis and endovascular thrombectomy, can significantly reduce post-stroke morbidity and mortality (Gao et al., 2022). However, the dispersed distribution of populations in many countries disadvantages people living outside metropolitan areas in terms of access to diagnosis and treatment (Gao et al., 2022). This disparity is particularly pronounced in low- and middle-income countries (LMICs), where approximately 70% of strokes occur, yet patients frequently experience severe strokes, have limited access to services, and receive fewer investigations and treatments compared to high-income countries (Tan et al., 2021).

Pakistan, classified as a lower-middle-income country, faces significant challenges in providing equitable stroke care across its predominantly rural population. With limited access to neurologists and stroke specialists in regional areas, patients often experience substantial delays in receiving critical interventions such as thrombolysis, which is optimally administered within 4.5 hours of symptom onset (Gao et al., 2022). The incidence of stroke is often greater among people living in regional areas, creating a strong need for improving access to specialist stroke care (Gao et al., 2022).

Telemedicine for stroke has emerged as a noteworthy solution to bridge this gap in access to specialist care. The programs utilize real-time audio-visual technology to enable staff at local hospitals to share patient data and brain imaging with stroke specialists based elsewhere, facilitating expedited diagnosis and treatment planning (Tan et al., 2021). Telemedicine consultations have been demonstrated to result in more accurate decision-making for acute stroke patients (Demaerschalk et al., 2024).

From an economic perspective, the value proposition of telemedicine programs has been increasingly documented in high-income countries. Stroke telemedicine programs can reduce long-term healthcare costs and improve patient outcomes (Gao et al., 2022). Systematic reviews have indicated that telemedicine represents a cost-effective solution, with studies from various high-income settings demonstrating cost savings ranging from approximately US$627 per patient alongside quality-adjusted life year gains (Tan et al., 2021). The cost savings primarily arise from reduced hospitalizations, decreased need for nursing home care, and avoided inter-hospital transfers (Gao et al., 2022). However, the economic evidence for telemedicine in LMICs remains limited, with no published cost-effectiveness analyses specifically examining telemedicine implementation in Pakistan or similar resource-constrained settings.

The empirical foundations suggest that telemedicine interventions in primary care are generally as effective and cost-effective as traditional care, with patient and provider acceptance increasing worldwide (Bashshur et al., 2016). Teleconsultations have been identified as an effective alternative to face-to-face consultations for many patients in primary care and mental health services, offering time-efficient and lower-cost healthcare access (Carrillo de Albornoz et al., 2021). Nevertheless, the unique contextual factors present in Pakistan's healthcare system—including infrastructure limitations, reimbursement policies, workforce distribution, and patient socioeconomic characteristics—necessitate country-specific economic evaluation to inform evidence-based policy decisions.
The present study aims to conduct a comprehensive cost analysis comparing telemedicine consultations with traditional in-person consultations for stroke patients in primary healthcare settings in Pakistan. By examining both

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direct healthcare costs and broader societal costs, this research seeks to provide essential evidence to support decision-making regarding the potential implementation and scaling of telemedicine services within Pakistan's healthcare system. Understanding the economic implications of telemedicine adoption is critical for ensuring sustainable resource allocation and maximizing health outcomes for stroke patients in resource-limited settings.

2. LITERATURE REVIEW

Telemedicine, has emerged as a transformative approach to improving access to stroke care, especially in regions with limited specialist availability. The central question guiding contemporary research is whether telemedicine provides a cost-effective alternative to traditional in-person consultations in acute and post-acute stroke management. A strong consensus in the literature supports telemedicine as either cost-saving or at least cost-neutral, with comparable clinical outcomes and enhanced system efficiency (Bashshur et al., 2016; Demaerschalk et al., 2024; Handschu et al., 2014).

Studies established the feasibility and diagnostic accuracy of telestroke systems, showing equivalence in thrombolysis eligibility and decision-making compared to bedside evaluations (Lucas et al., 2024; Evan et al., 2022). Subsequent studies confirmed that patient outcomes—including mortality, functional recovery, and safety—are not significantly different between telemedicine and in-person stroke assessments (Sharififar et al., 2023; Demaerschalk et al., 2024). In many cases, telemedicine even improved clinical workflow by enabling real-time access to specialists and more consistent stroke evaluation across facilities (Ho et al., 2023).

From an economic standpoint, multiple evaluations have found telemedicine to be cost-effective or cost-saving across diverse healthcare systems. In Germany, video-based teleconsultation was shown to be more cost-effective than telephone advice when accounting for reduced patient transfers and improved outcomes, with incremental cost per QALY gained ranging from €115 to €516 (Handschu et al., 2014). In Norway, Buvik et al. (2019) demonstrated that telemedicine becomes cost-saving when consultation volumes exceed 150 visits annually, highlighting economies of scale as a major determinant of long-term sustainability. Similarly, Conners et al. (2012) reported that telemedicine in acute ischemic stroke remains cost-effective as long as at least 30 patients are evaluated per hospital per year, underscoring the importance of maintaining adequate service volume.

Beyond direct cost comparisons, several studies have examined system-level and patient-level savings. Appireddy et al. (2019) observed that telemedicine reduced average patient expenses by CAN$52.83 per visit by avoiding travel, accommodation, and food costs. Likewise, Knepley et al. (2020) and Sarfo et al. (2018) found that telerehabilitation following stroke was less costly and equally effective as in-person rehabilitation, suggesting the broader economic potential of remote care beyond acute management. These findings are echoed by Demaerschalk et al. (2022), study in which it was emphasized that telemedicine interventions in primary and emergency care yield substantial savings by minimizing unnecessary transfers, reducing hospital stays, and preventing long-term disability.

While some evidence indicates that door-to-needle times can be slightly longer in telemedicine settings, this difference does not translate into poorer outcomes or higher costs (Bladin et al., 2020; Loggini et al., 2024). On the contrary, process improvements through standardized telemedicine protocols have been shown to eliminate “weekend or off-hour effects” in acute stroke care (Cossey et al., 2019). Moreover, patient satisfaction and perceived quality of care remain high, with studies highlighting that empathy and rapport can be effectively conveyed via video consultations (Cheshire et al., 2020).

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Overall, the literature demonstrates strong and consistent evidence that telemedicine for stroke care is cost-effective, clinically equivalent, and operationally efficient, especially in rural and underserved settings. The cumulative data suggest that initial implementation costs are offset by long-term system-level savings and QALY gains. However, future research should address long-term cost-utility outcomes, indirect costs such as caregiver burden, and context-specific implementation strategies to optimize scalability in low- and middle-income healthcare systems.

3. METHODOLOGY

3.1 Study Design

This study employed a cross-sectional survey-based design to evaluate the perceived cost-effectiveness and clinical feasibility of telemedicine consultations compared to traditional in-person consultations for stroke patients in primary healthcare settings in Pakistan.

3.2 Study Setting

The study was conducted across healthcare facilities in two distinct cities of Pakistan: Islamabad and Gujrat. In Islamabad the setting was Al Nafees Medical College and Hospital and in Gujrat the facility was Ikram Hospital.

3.3 Sample Size

A sample size was calculated using an epi calculator. According to a study tilted as “Stroke care in Pakistan” the incidence of stroke was 250 per 100000 of the population make an incidence of 0.25%. Hence keeping the frequency of 0.25 and a level of significance of 95% the estimated sample size was n=13. To improve the methodological rigor while considering that data was collected from the two distinct cities a sample size was increased to n=30.

3.4 Inclusion and Exclusion Criteria

Patients aged eighteen years or above with confirmed stroke diagnosis within the past twelve months who were attending outpatient departments for follow-up consultations were included. Patients needed to be cognitively able to participate or have a caregiver available to respond on their behalf, and provide written informed consent. Patients were excluded if they had severe cognitive impairment without an available caregiver, were critically ill or medically unstable, refused participation, or had insurmountable communication barriers.

3.5 Data Collection

Data collection was conducted using a structured questionnaire specifically developed for this study and administered to stroke patients. The questionnaire was initially developed in English and translated into Urdu using forward-backward translation methodology involving two independent translators.

The questionnaire comprised six main sections. The first section collected demographic and socioeconomic information including age, gender, education, occupation, income, residence location, distance from healthcare facility, insurance status, and family composition. The second section gathered stroke history and healthcare utilization data including stroke type, time since occurrence, functional status using modified Rankin Scale, frequency of visits, current medications, and rehabilitation services. The third section documented actual costs

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incurred during recent in-person consultations across multiple categories. Direct medical costs included consultation fees. Direct non-medical costs captured transportation expenses for patients including mode of transport and distance traveled, accommodation costs if required, and food and miscellaneous expenses.

The fourth section assessed telemedicine awareness including prior knowledge and experience, and technology access including smartphone ownership, internet connectivity quality, mobile data availability, computer or tablet access, and familiarity with video calling applications. The fifth section presented a detailed hypothetical telemedicine scenario explaining how telemedicine work. Patients then estimated costs for telemedicine consultations including expected reduce consultation fees, no transportation charges, no additional waiting time in the hospital, no accommodation needed and no food and other miscellaneous charges. Patients were directly asked whether telemedicine would save them money compared to in-person visits and to estimate potential savings in both money and time.

3.6 Statistical Analyses

Data analysis was conducted using SPSS Statistics version 27.0 and R statistical software. Descriptive statistics were calculated for all variables, with means and standard deviations for continuous variables such as costs, age, and distance, and medians with interquartile ranges for skewed cost data. Frequencies and percentages were calculated for categorical variables including demographics and question related to the use of technologies for telemedicine. Mean total costs per patient for in-person consultations were calculated by summing across all cost categories, and similarly for estimated telemedicine costs. The cost difference between in-person and telemedicine consultations was computed for each patient, representing potential savings, and mean differences with percentage cost savings were calculated overall and by cost categories including direct medical costs, direct non-medical costs, and indirect costs. Comparative analyses were conducted using independent samples t-tests. A significance level of 0.05 was used for all hypothesis testing.

3.7 Ethical Consideration

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants in their preferred language, with caregiver consent for cognitively impaired patients. All questionnaires were identified by unique identification numbers only, with no personal identifiers recorded. Completed questionnaires were stored in locked cabinets and electronic data were password-protected. Results were presented only in aggregate form. Participants were informed that participation would not affect their medical care and no financial compensation was provided. Data were stored securely for five years following good clinical practice guidelines. Ethical approval was taken from Al Nafees Medical College and Hospital Islamabad and Ikram Hospital Gujrat. The study was conducted from March 2024 to November 2024.

4. RESULTS

4.1 Demographic Characteristics

A total of 30 stroke patients participated in the study, with 17 patients (56.7%) recruited from Al Nafees Medical College and Hospital in Islamabad and 13 patients (43.3%) from Ikram Hospital in Gujrat. The mean age of participants was 58.3 ± 12.4 years, ranging from 35 to 78 years. The majority of participants were male (n=18, 60.0%), while females constituted 40.0% (n=12) of the sample. Regarding education level, 6 patients (20.0%) had no

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formal education, 10 patients (33.3%) had completed primary education, 9 patients (30.0%) had secondary education, and 5 patients (16.7%) had higher education. In terms of residence, 16 patients (53.3%) resided in urban areas while 14 patients (46.7%) lived in rural locations. The mean distance from the healthcare facility was 24.6 ± 18.3 kilometers, with rural patients traveling significantly longer distances (mean 38.2 ± 15.7 km) compared to urban patients (mean 12.4 ± 8.9 km). Only 7 patients (23.3%) had health insurance coverage. The detailed demographic and socioeconomic characteristics of the study participants are presented in Table 1.

Table 1: Demographic and Socioeconomic Characteristics of Participants (N=30)

Characteristic	Category	n (%) / Mean ± SD
Study Site	Al Nafees Hospital, Islamabad	17 (56.7%)
	Ikram Hospital, Gujrat	13 (43.3%)
Age (years)		58.3 ± 12.4
Gender	Male	18 (60.0%)
	Female	12 (40.0%)
Education Level	No formal education	6 (20.0%)
	Primary education	10 (33.3%)
	Secondary education	9 (30.0%)
	Higher education	5 (16.7%)
Occupation	Unemployed/Retired	11 (36.7%)
	Daily wage laborer	8 (26.7%)
	Salaried employee	7 (23.3%)
	Self-employed	4 (13.3%)
Monthly Income (PKR)	<20,000	12 (40.0%)
	20,000-50,000	13 (43.3%)
	>50,000	5 (16.7%)
Residence	Urban	16 (53.3%)
	Rural	14 (46.7%)
Distance from facility (km)		24.6 ± 18.3
Health Insurance	Yes	7 (23.3%)
	No	23 (76.7%)
Family Size		5.8 ± 2.1

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4.2 Clinical Characteristics and Healthcare Utilization

Regarding stroke type, 24 patients (80.0%) had ischemic stroke while 6 patients (20.0%) had hemorrhagic stroke. The mean time since stroke occurrence was 6.4 ± 3.2 months, with 8 patients (26.7%) within 3 months of stroke, 14 patients (46.7%) between 3-6 months, and 8 patients (26.7%) between 6-12 months post-stroke. Functional status assessment using the modified Rankin Scale showed that 5 patients (16.7%) had mRS score 0-1 indicating no significant disability, 12 patients (40.0%) had mRS score 2-3 indicating moderate disability, and 13 patients (43.3%) had mRS score 4-5 indicating moderately severe to severe disability. The frequency of outpatient follow-up visits varied, with 18 patients (60.0%) requiring monthly visits, 9 patients (30.0%) visiting every three months, and 3 patients (10.0%) visiting less frequently. All patients were on antithrombotic medications, with 20 patients (66.7%) also taking antihypertensives and 12 patients (40.0%) on lipid-lowering medications. Only 9 patients (30.0%) were receiving any form of rehabilitation services. The clinical characteristics and healthcare utilization patterns are summarized in Table 2.

Table 2: Clinical Characteristics and Healthcare Utilization (N=30)

Characteristic	Category	n (%) / Mean ± SD
Stroke Type	Ischemic	24 (80.0%)
	Hemorrhagic	6 (20.0%)
Time Since Stroke (months)		6.4 ± 3.2
	<3 months	8 (26.7%)
	3-6 months	14 (46.7%)
	6-12 months	8 (26.7%)
Modified Rankin Scale	0-1 (No significant disability)	5 (16.7%)
	2-3 (Moderate disability)	12 (40.0%)
	4-5 (Severe disability)	13 (43.3%)
Frequency of OPD Visits	Monthly	18 (60.0%)
	Every 3 months	9 (30.0%)
	Less frequent	3 (10.0%)
Current Medications	Antithrombotic	30 (100%)
	Antihypertensive	20 (66.7%)
	Lipid-lowering	12 (40.0%)
	Other medications	18 (60.0%)
Rehabilitation Services	Yes	9 (30.0%)
	No	21 (70.0%)

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4.3 Actual Costs of In-Person Consultations

The actual costs incurred by patients during their most recent in-person consultation visits were recorded across multiple cost categories. The mean direct medical cost, comprising only consultation fees, was PKR 2,500 ± 750 per visit. Direct non-medical costs averaged PKR 4,940 ± 2,180 per visit, including transportation expenses for patients (based on mode of transport and distance traveled), accommodation costs (when required), and food or miscellaneous expenditures. Specifically, patient transportation costs averaged PKR 2,800 ± 1,420, while accommodation costs, incurred by six patients (20%) traveling from distant locations, averaged PKR 1,800 ± 450. Food and miscellaneous costs averaged PKR 340 ± 180 per visit.

The total mean cost per in-person consultation visit was PKR 7,440 ± 2,680. Rural patients incurred significantly higher total costs (mean PKR 9,850 ± 3,240) compared to urban patients (mean PKR 6,120 ± 2,150, p = 0.002), primarily due to higher transportation and accommodation expenses.The mean total time spent per consultation visit was 6.8 ± 3.2 hours, including travel time (4.2 ± 2.6 hours), waiting time (1.8 ± 0.9 hours), and consultation time (0.8 ± 0.3 hours) table 3.

Table 3. Actual Costs of In-Person Consultations (N=30)

Cost Category	Mean ± SD (PKR)	Range
Direct Medical Costs		
Consultation fees	2,500 ± 750	1,000–4,000
Total Direct Medical	**2,500 ± 750**	**1,000–4,000**
Direct Non-Medical Costs		
Patient transportation	2,800 ± 1,420	500–6,000
Accommodation (n = 6)	1,800 ± 450	1,200–2,500
Food & miscellaneous	340 ± 180	100–800
Total Direct Non-Medical	**4,940 ± 2,180**	**1,800–9,300**
Total Cost Per Visit	**7,440 ± 2,680**	**3,200–13,500**
Time Spent (hours)	**6.8 ± 3.2**	**2.5–14.0**

4.4 Technology Access and Telemedicine Awareness

Assessment of technology access revealed that 21 patients (70.0%) owned smartphones, with 15 patients (50.0%) owning smartphones capable of video calls. Internet connectivity at home was available for 18 patients (60.0%), with 11 patients (36.7%) reporting good quality internet, 7 patients (23.3%) reporting fair quality, and 12 patients (40.0%) having no internet access at home. Mobile data packages were used by 19 patients (63.3%). Computer or tablet access was limited, with only 8 patients (26.7%) having such devices at home. Familiarity with video calling applications varied, with 16 patients (53.3%) having used WhatsApp video calls, 4 patients (13.3%) having used other applications like Skype or Zoom, and 10 patients (33.3%) having no experience with video calling. Regarding

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telemedicine awareness, only 9 patients (30.0%) had prior knowledge of telemedicine services, and only 2 patients (6.7%) had previous experience with any form of teleconsultation. Urban patients had significantly higher smartphone ownership (87.5% vs 50.0%, p=0.02) and better internet connectivity (75.0% vs 42.9%, p=0.04) compared to rural patients. The technology access and telemedicine awareness data are presented in Table 4.

Table 4. Technology Access and Telemedicine Awareness (N=30)

Characteristic	n (%)
Smartphone Ownership	21 (70.0%)
Video call capable smartphone	15 (50.0%)
Internet Connectivity at Home	18 (60.0%)
Good quality	11 (36.7%)
Fair quality	7 (23.3%)
Poor/No connectivity	12 (40.0%)
Mobile Data Package	19 (63.3%)
Computer/Tablet Access	8 (26.7%)
Video Calling Familiarity	
WhatsApp video calls	16 (53.3%)
Other applications (Skype/Zoom)	4 (13.3%)
No experience	10 (33.3%)
Prior Telemedicine Knowledge	9 (30.0%)
Prior Telemedicine Experience	2 (6.7%)
Technology Access by Location	
Urban smartphone ownership	14/16 (87.5%)
Rural smartphone ownership	7/14 (50.0%)
Urban internet connectivity	12/16 (75.0%)
Rural internet connectivity	6/14 (42.9%)

4.5 Perceived Costs of Telemedicine Consultations

The fifth section presented a hypothetical telemedicine scenario to illustrate how remote consultations would function. Patients estimated potential costs assuming reduced consultation fees and no expenses for transportation, accommodation, or food. The mean direct medical cost (consultation fee) was PKR 1,200 ± 480 per visit around 52% lower than in-person consultations. As no additional non-medical expenses were anticipated, the total estimated cost per teleconsultation was PKR 1,200 ± 480, with an average saving of PKR 6,240 ± 2,300 per visit. Participants

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also expected significant time savings, estimating 1.2 ± 0.6 hours per teleconsultation compared to 6.8 ± 3.2 hours for in-person visits. Overall, 93.3% of respondents believed telemedicine would save both time and money (Table 5).

Table 5. Estimated Costs of Telemedicine Consultations

Cost Category	Mean ± SD (PKR)
Direct Medical Costs	
Consultation fees	1,200 ± 480
Total Direct Medical	1,200 ± 480
Direct Non-Medical Costs	
Patient transportation	—
Accommodation	—
Food & miscellaneous	—
Total Direct Non-Medical	0
Total Estimated Cost Per Visit	1,200 ± 480
Estimated Time Spent (hours)	1.2 ± 0.6
Mean Estimated Savings (PKR)	6,240 ± 2,300

4.6 In-Person vs. Telemedicine Consultations

Comparison of actual in-person consultation costs with patients perceived costs for telemedicine revealed substantial potential economic and time savings. The mean total cost for an in-person visit was PKR 7,440 ± 2,680, compared to an estimated PKR 1,200 ± 480 for a telemedicine consultation, reflecting an average saving of PKR 6,240 ± 2,300 per visit ($p < 0.001$).

Similarly, the mean total time spent for in-person consultations was 6.8 ± 3.2 hours, which was reduced to 1.2 ± 0.6 hours under the telemedicine model, indicating an average time saving of 5.6 ± 2.9 hours ($p < 0.001$). Overall, almost all respondents (93.3%) perceived telemedicine as a cost-effective and time-efficient alternative to traditional in-person visits, particularly benefiting those from rural areas who faced higher transportation and accommodation expenses (Table 6).

Table 6. Comparison of Actual and Perceived Telemedicine Consultation Costs and Time

Parameter	In-Person Consultation (Mean ± SD)	Telemedicine (Perceived) (Mean ± SD)	Mean Saving (± SD)	p-value
Total Cost per Visit (PKR)	7,440 ± 2,680	1,200 ± 480	**6,240 ± 2,300**	**< 0.001**

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Time Spent per Visit (hours)	6.8 ± 3.2	1.2 ± 0.6	**5.6 ± 2.9**	**< 0.001**

6. DISCUSSION

The findings of this study demonstrate that telemedicine represents a highly cost-effective and time-efficient alternative to conventional in-person consultations for stroke patients in Pakistan's primary healthcare settings. The total mean cost for an in-person consultation was PKR 7,440 ± 2,680 compared to PKR 1,200 ± 480 for a teleconsultation, reflecting an average saving of PKR 6,240 ± 2,300 per visit ($p < .001$). Similarly, telemedicine was associated with significant time savings, reducing the average consultation duration from 6.8 ± 3.2 hours to 1.2 ± 0.6 hours ($p < .001$). These findings align with international literature showing that telemedicine can substantially reduce healthcare costs, improve access to care, and maintain comparable clinical outcomes.

Evidence from high-income settings supports the economic efficiency of telemedicine in stroke management. Afolabi et al. (2023) found that integrating a telemedicine service in the East of England stroke care pathway improved thrombolysis rates during out-of-hours care, resulting in National Health Service (NHS) savings of £482,000 within one year and £471,000 over five years, along with additional social care savings exceeding £1.7 million. Similarly, Gao et al. (2022) modeled the long-term impact of a national stroke telemedicine program in Australia, showing an average cost saving of AU$1,526 per patient from a societal perspective and an incremental gain of 0.45 quality-adjusted life years (QALYs). These findings suggest that telemedicine not only reduces acute care expenditures but also leads to sustained long-term benefits by minimizing post-stroke complications, rehospitalizations, and nursing home admissions.

The present study's observed savings primarily stem from reductions in direct non-medical costs, such as transportation, accommodation, and food-related expenses, which are particularly burdensome for rural patients. This pattern mirrors international data where telemedicine's cost-effectiveness is most pronounced in geographically dispersed or resource-limited settings (Gao et al., 2022; Afolabi et al., 2023). Bashshur et al. (2016) also highlighted that telemedicine enhances efficiency by reducing patient transfers, optimizing provider time, and preventing costly delays in diagnosis and intervention. In Pakistan, where healthcare infrastructure disparities and travel barriers remain significant, telemedicine offers a pragmatic solution to bridge rural–urban inequities in stroke care. From a broader health systems perspective, the cost-effectiveness of telemedicine extends beyond immediate consultation savings. By improving timely access to specialized care, it can reduce long-term disability, enhance functional recovery, and decrease social and economic dependence on caregivers. These benefits translate into QALY gains similar to those reported internationally (Gao et al., 2022). The consistency of evidence across diverse health systems underscores telemedicine's scalability and sustainability as part of integrated stroke management models. Overall, this study reinforces global evidence that telemedicine is a cost-effective, equitable, and patient-centered alternative to in-person stroke consultations. Implementation in Pakistan's primary healthcare context could alleviate financial and logistical burdens on families, reduce health disparities, and enhance care continuity. Future studies should explore the real-world cost-utility and outcome effectiveness of telemedicine through longitudinal designs to guide national health policy and digital health integration strategies.

7. CONCLUSION

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Telemedicine offers a practical, cost-effective solution to improve stroke care accessibility and efficiency in Pakistan's primary healthcare system. By reducing travel, waiting times, and out-of-pocket expenses, it eases the financial burden on patients especially in rural areas and enhances timely access to specialist care. Beyond economic benefits, telemedicine supports better continuity of care and outcomes through quicker follow-ups and reduced complications. Integrating telemedicine into national stroke care pathways can strengthen health equity, optimize resources, and promote sustainable healthcare delivery in resource-limited settings.

AUTHOR'S CONTRIBUTION AND DECLARATIONS

Conception or Design: Subhan Ali Gondal, Muhammad Adnan Yousaf

Data Collection and Processing: Shoukat Hayat, Hammad Ahmad

Analysis or Interpretation of Data: Suhail Karim, Sara Sabir

Manuscript Writing & Approval: Subhan Ali Gondal, Muhammad Adnan Yousaf, Shoukat Hayat, Hammad Ahmad, Suhail Karim, Sara Sabir, All Authors

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Furthermore, this research did not involve the use of animals, plants, or any biological specimens requiring ethical approval. Therefore, ethical clearance from an institutional review board, prior informed consent (PIC) from respondents, or animal/plant welfare approvals are not applicable to this study.

The author(s) affirm full compliance with international ethical standards for research and publication.

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