RESEARCH PAPER

Acceptability and Affordability of Tele-Ophthalmology Services in Bihar

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ABSTRACT

***Background*:** Access to specialized eye care remains limited in rural regions of India, particularly in states such as Bihar, where healthcare infrastructure and specialist availability are constrained. Tele-ophthalmology has emerged as a viable solution to address these gaps by enabling remote consultations through vision centres. However, its effectiveness depends not only on clinical outcomes but also on patient acceptance and financial feasibility.

***Aim*:** To evaluate the acceptability and affordability of tele-ophthalmology services delivered through vision centres in Bihar.

***Methods*:** A descriptive cross-sectional study was conducted among 352 patients attending tele-ophthalmology consultations at four vision centres (Bidupur, Saraiya, Lalganj, and Chhapra) under Akhand Jyoti Eye Hospital, Bihar. Data were collected using a validated interviewer-administered questionnaire assessing socio-demographic characteristics, acceptability (Likert scale), affordability (out-of-pocket expenditure), and patient experience. Statistical analysis included descriptive statistics, one-sample t-test, Kruskal–Wallis test, Mann–Whitney U test, and Spearman's correlation.

***Results*:** The study population was predominantly older (77.0% aged ≥46 years), female (55.7%), and from low-income households (49.1% earning ≤ INR 10,000/month). The mean composite acceptability score was 73.66 ± 10.53, which was significantly higher than the predefined acceptable threshold of 70 ($t = 6.52$, $p < 0.001$). Overall, 76.9% of participants reported being satisfied or very satisfied, while 100% indicated willingness to recommend the service and 98.9% expressed preference for future use. Acceptability varied significantly across age groups ($H = 15.78$, $p = 0.0004$), with younger participants reporting higher satisfaction, whereas no significant difference was observed based on gender ($p = 0.777$). The median out-of-pocket expenditure per visit was INR 250 (mean INR 377; range 20–2,010). Catastrophic health expenditure was observed in 10.8% of participants overall and increased to 19.6% among the lowest income group. A moderate positive correlation was identified between distance travelled and total expenditure ($r = 0.353$, $p < 0.001$).

***Conclusion*:** Tele-ophthalmology services in Bihar demonstrate high levels of patient acceptability and satisfaction, highlighting their potential as an effective model for delivering eye care in underserved regions. However, affordability remains a concern for economically disadvantaged populations. Strategic interventions, including financial support mechanisms and integration with public health insurance schemes, are essential to ensure equitable access.

Keywords: Tele-ophthalmology, Acceptability, Affordability, Out-of-pocket expenditure, Catastrophic health expenditure, Vision centres, Bihar
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INTRODUCTION

Visual impairment remains a significant global public health concern, with a disproportionately higher burden in low- and middle-income countries. The World Health Organization (WHO) estimates that a substantial proportion of visual impairment is either preventable or treatable, yet access to timely eye care remains limited in many regions(1). In India, the burden of visual impairment continues to be substantial, driven by factors such as population ageing, socioeconomic disparities, and inadequate distribution of healthcare services(2,3).

Bihar, one of India's most populous and economically disadvantaged states, exemplifies these challenges, particularly in the context of eye care. The state faces a severe shortage and uneven distribution of ophthalmic professionals. While the national average for ophthalmologists is approximately 1 per 65,000 people,

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Bihar's ratio is considerably worse, with some estimates suggesting as high as 1 ophthalmologist per 100,000 people in certain regions, and significant regional disparities across the state(2,4). This scarcity is further exacerbated by a pronounced urban-rural imbalance; nationally, the ophthalmologist-to-population ratio is 1:25,000 in urban areas but drops to 1:219,000 in rural areas(5). Given that nearly 90% of Bihar's population resides in rural areas, this disparity places an immense burden on the existing eye care infrastructure(6). The state also has the lowest density of qualified health workers in India, with only 1.5 per 10,000 population, starkly contrasting with states like Kerala (31.6 per 10,000)(7). Furthermore, rural health statistics indicate a critical shortfall of 87.3% specialists, including those relevant to eye care, in rural Bihar(8).

These systemic gaps in healthcare infrastructure and human resources lead to significant rural healthcare challenges. A large proportion of Bihar's population resides in rural and semi-urban areas where access to specialized ophthalmic care is severely limited. Patients often need to travel long distances to reach tertiary care centers, resulting in delays in treatment and increased out-of-pocket expenditure. These costs include not only medical expenses but also transportation, accommodation, and loss of daily wages, which contribute to financial hardship and reduced healthcare utilization(9,10). For instance, out-of-pocket expenditure accounts for 64.2% of health spending in Bihar, often leading to catastrophic health expenditures for vulnerable families(11). The prevalence of visual impairment is also notable, with Bihar recording one of the highest rates of near vision loss (36.24%) among older adults in India(3).

To address these formidable barriers, the vision center model has been introduced as an effective strategy for delivering primary eye care services closer to the community. Vision centers are designed to provide basic eye examinations, refractive services, and referral support, thereby reducing the need for patients to travel to higher-level facilities(12). The integration of tele-ophthalmology into this model has further enhanced its reach and efficiency, offering a crucial solution to Bihar's

unique challenges. Tele-ophthalmology utilizes information and communication technologies to facilitate remote diagnosis and management of ocular conditions. Through digital imaging and real-time data transmission, patients at peripheral vision centers can receive expert consultation from ophthalmologists located at base hospitals(13). This approach directly mitigates the impact of geographical barriers and specialist shortages, making expert eye care accessible and more affordable for rural populations.

In Bihar, Akhand Jyoti Eye Hospital (AJEH) has successfully implemented this model by establishing a network of tele-ophthalmology-enabled vision centers, including Bidupur, Saraiya, Lalganj, and Chhapra, connected to a central tertiary care facility. While the clinical effectiveness of tele-ophthalmology has been well established, its long-term success depends significantly on patient-related factors such as acceptability and affordability. Acceptability refers to how patients perceive the quality, convenience, and overall experience of the service, whereas affordability relates to the financial burden imposed by healthcare utilization(14,15). In low-income settings, even relatively small healthcare expenditures can result in catastrophic health expenditure, particularly among vulnerable populations(1). Therefore, assessing both acceptability and affordability is essential for evaluating the real-world impact and sustainability of tele-ophthalmology services. Despite the increasing adoption of tele-ophthalmology in India, there is a paucity of context-specific data from Bihar that examines these critical aspects from the patient's perspective. Existing studies have primarily focused on clinical outcomes or cost-effectiveness from a provider's viewpoint, with limited emphasis on patient experience in resource-constrained settings(16,17) .

Therefore, the present study was undertaken to evaluate the acceptability and affordability of tele-ophthalmology services delivered through selected vision centers under Akhand Jyoti Eye Hospital, Bihar, with the aim of generating evidence to support improved service delivery and policy planning

METHODOLOGY

Rationale for the Study

This research was born from a fundamental question: Can technology truly bridge the gap between world-class eye care and the rural poor? In Bihar, the greatest barrier to sight is often not a lack of medicine, but the "distance of poverty"—the physical miles to a hospital and the financial burden of reaching it. While tele-ophthalmology offers a digital solution, its success depends on human factors: whether patients trust a remote consultation (acceptability) and whether it prevents them from falling into debt (affordability). By investigating these pillars, this study aims to move beyond clinical metrics to understand the lived experience of the patient, ensuring that innovation serves as a bridge to equity rather than a luxury for the few.

Study Design and Setting

This investigation was conducted as a descriptive, cross-sectional observational study within the tele-ophthalmology network of Akhand Jyoti Eye Hospital (AJEH). Located in Mastichak, Saran district, Bihar, AJEH operates a specialized hub-and-spoke model designed to bring tertiary-level expertise to underserved populations. For this study, four strategic vision centers Bidupur, Saraiya, Lalganj, and Chhapra were selected based on their high patient volumes and accessibility. All four peripheral centers are situated within a 50 km radius of the central hub, facilitating a robust referral and consultation network.

Participants and Sampling
The study focused on adult patients (aged 18 years and above) who utilized tele-ophthalmology services at the selected centers during the study period. To ensure the safety and reliability of the data, patients presenting with acute ocular emergencies, those unable to communicate effectively, or those unwilling to provide informed consent were excluded. While the initial sample size was calculated at 384 participants (based on a 50% prevalence assumption, 95% confidence interval, and 5% margin of error), a total of 352 complete and valid responses were gathered and analyzed through a consecutive sampling approach.

Data Collection and Instrumentation
Data were gathered through structured, interviewer-administered questionnaires conducted in the local language to ensure cultural sensitivity and clarity. The questionnaire was divided into four key domains:

1. Socio-demographic Profiles: Capturing the baseline characteristics of the participants.
2. Acceptability: Measured via Likert-scale items to gauge patient trust, satisfaction, and perceived quality of remote care.
3. Affordability: Assessed by calculating total out-of-pocket expenditure (OOPE), including both medical costs and non-medical expenses like travel and lost wages.
4. Patient Experience: A qualitative assessment of the overall journey through the vision center.

The research instrument was rigorously validated, demonstrating a Content Validity Index (CVI) range of 0.8–1.0 and the questionnaire demonstrated acceptable internal consistency reliability (Cronbach's $\alpha = 0.709$).

For standardized assessment, acceptability scores were converted to a 0–100 scale, with a score of 70 or higher defined as satisfactory. Affordability was further scrutinized by identifying Catastrophic Health Expenditure, defined as any healthcare spending exceeding 10% of the household's monthly income.

Statistical Analysis
Quantitative data were managed in Microsoft Excel and processed using SPSS (version 26.0) alongside Python-based statistical libraries for advanced computation. Descriptive statistics (means, frequencies, and percentages) were used to summarize the patient profiles. Inferential analysis was conducted to identify significant trends and correlations using the one-sample t-test, Mann–Whitney U test, and Kruskal–Wallis test. Relationships between variables were explored through Spearman's correlation. In all analyses, a p-value of less than 0.05 was maintained as the threshold for statistical significance.

Ethical Approval Letter
The original Ethical Approval Letter from the Akhand Jyoti Eye Hospital Institutional Ethics Committee (Ref No: IEC-AJEH/02nd/03, dated 10/12/2025, IEC Registration Number: EC/NEW/INST/2025/4990)

Results: A total of 352 patients were included in the final analysis. The study population was predominantly older, with 77.0% (n=271) of participants aged 46 years and above, followed by 17.3% (n=61) in the 36–45 years age group and 5.7% (n=20) between 18–35 years. Females constituted 55.7% (n=196) of the sample, while males accounted for 44.3% (n=156). A substantial proportion of participants had no formal education (65.3%, n=230), with only a small percentage attaining secondary or higher education. In terms of occupation, the majority were homemakers (63.9%, n=225), followed by farmers (14.5%, n=51) and self-employed individuals (8.0%, n=28). Regarding income distribution (n=342 valid responses), 49.1% (n=168) belonged to the lowest income group (≤ INR 10,000/month), 34.2% (n=117) to the middle-income group (INR 10,001–20,000), and 16.7% (n=57) reported income above INR 20,000. Slightly more than half of the participants were follow-up cases (55.7%, n=196), while 44.3% (n=156) were new patients. The overall acceptability of tele-ophthalmology services was high, with a mean composite score of 73.66 ± 10.53 (on a 0–100 scale), which was significantly higher than the predefined acceptable threshold of 70 (one-sample t-test: $t = 6.52$, $p < 0.001$). Analysis of individual acceptability items revealed consistently high mean scores across positive domains, including ease of communication (mean = 4.24 ± 0.58), understanding of the consultation process (4.14 ± 0.59), clarity of doctor's advice (4.19 ± 0.57), convenience of service timing (4.14 ± 0.58), perception of proper clinical assessment (4.16 ± 0.56), and confidence in improvement of eye condition (4.24 ± 0.57). Among the negatively worded items, the reverse-scored mean for perceived effort required was relatively lower (2.98 ± 1.25), indicating that a proportion of patients experienced some difficulty during the process, whereas the impact on daily activities showed a moderate reverse score (3.49 ± 1.34). (Table: 1.1,Figure:1.1)

Table 1.1: Demographic Characteristics of Study Participants (n=352)

Characteristic	Category	Count	Percentage (%)
Age Group	18-35 years	20	5.7%
36-45 years	61	17.3%	
46+ years	271	77.0%	
Gender	Female	196	55.7%
Male	156	44.3%	
Education Level	No formal education	230	65.3%

Primary	34	9.7%	
Middle	20	5.7%	
Secondary	14	4.0%	
Higher secondary	39	11.1%	
Graduate	12	3.4%	
Graduate+	3	0.9%	
Occupation	Homemaker	225	63.9%
Farmer	51	14.5%	
Self-employed	28	8.0%	
Retired	13	3.7%	
Daily wage labor	11	3.1%	
Other*	24	6.8%	
Monthly Income (INR)	≤ 10,000	168	49.1%
*(n=342)	10,001 – 20,000	117	34.2%
> 20,000	57	16.7%	
Missing/Zero	10	2.8%	
Visit Type	New	156	44.3%
Review	196	55.7%	

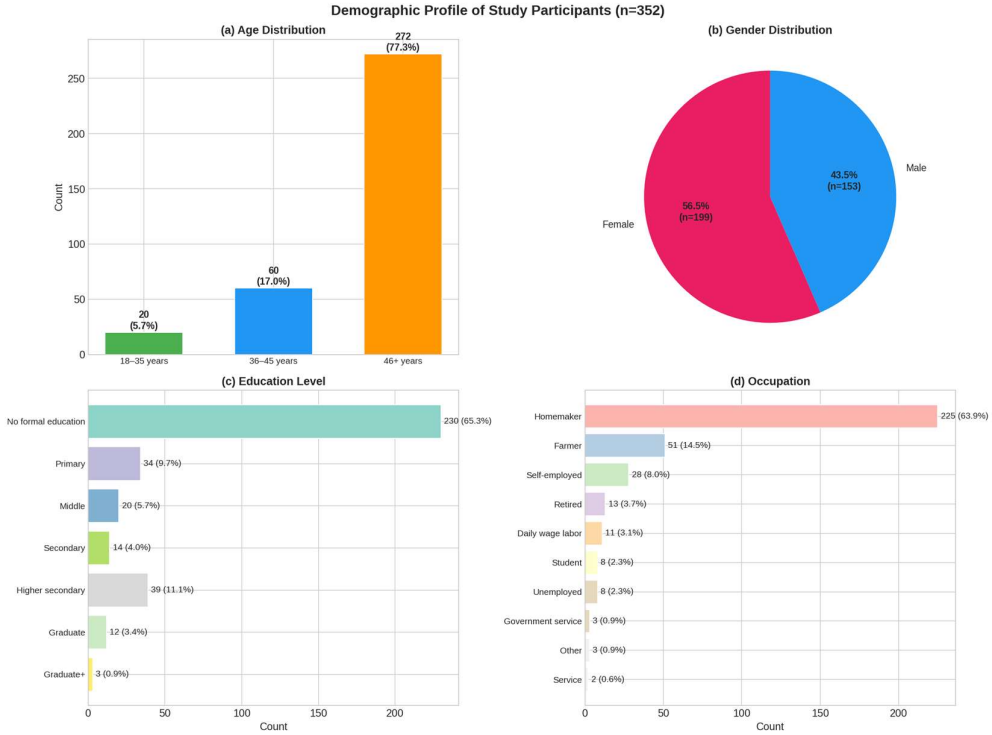

Figure 1.1: Demographic distribution of study participants.

In terms of overall satisfaction (Figure 1.2), 76.9% (n=271) of participants reported being either satisfied or very satisfied, while 21.0% (n=74) expressed neutral responses and only 2.0% (n=7) reported dissatisfaction. Additionally (Figure1.3), 100% of participants indicated willingness to recommend the service to others, and 98.9% expressed preference for using tele-ophthalmology services in the future.

A majority of patients also reported perceived time savings compared to traditional hospital visits. Comparative analysis demonstrated that **acceptability** scores varied significantly across age groups (Kruskal–Wallis H = 15.78, p = 0.0004), with younger participants reporting relatively higher acceptability scores. However, no statistically significant difference was observed between males and females (Mann–Whitney U test, p = 0.777) (Figure 1.4, 1.5). Regarding **affordability**, the median total out-of-pocket (OOP) expenditure per visit was INR 250, with a mean of INR 377 and a wide range from INR 20 to INR 2,010 (Table 1.2). The major contributors to total expenditure were investigation and medication costs, accounting for approximately 63.1% of the total OOP expenses, followed by transportation and other incidental costs. When assessed relative to household income, catastrophic health expenditure (CHE),

defined as spending exceeding 10% of monthly income, was observed in 10.8% of participants overall. This proportion increased markedly to 19.6% among patients in the lowest income group, indicating a disproportionate financial burden on economically disadvantaged individuals (Figure 1.6, 1.7).

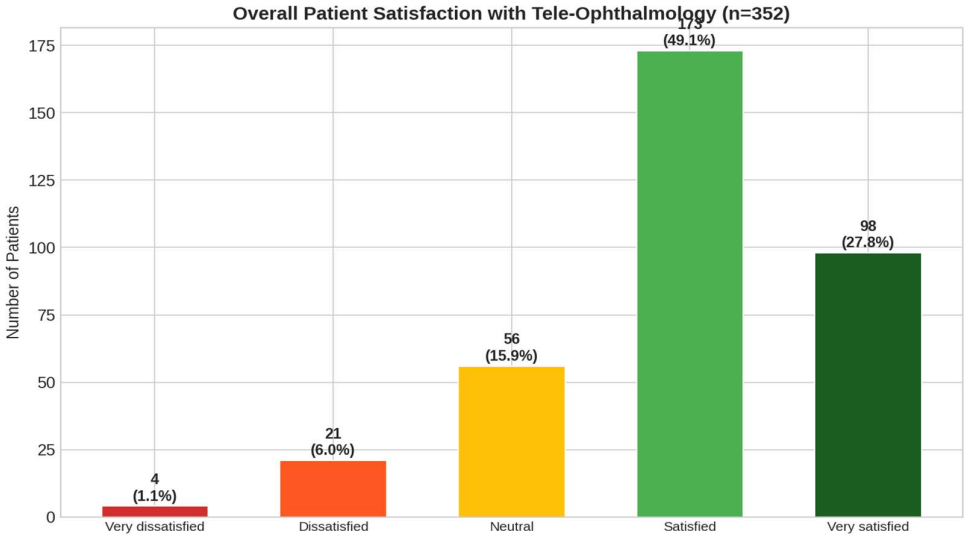

Figure 1.2: Distribution of overall patient satisfaction.

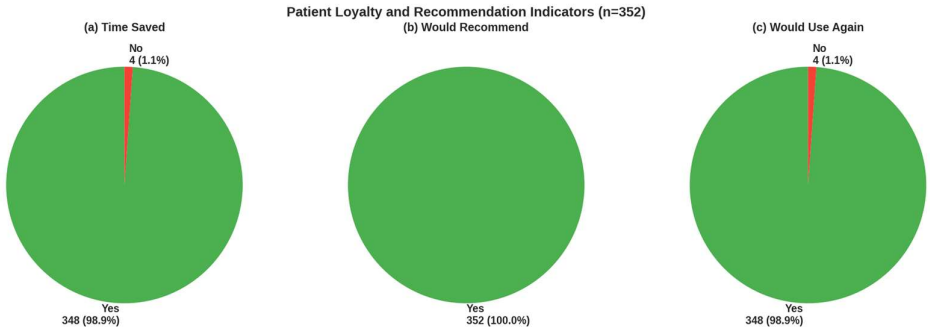

Figure 1.3: Patient responses regarding time savings, recommendation, and future preference.

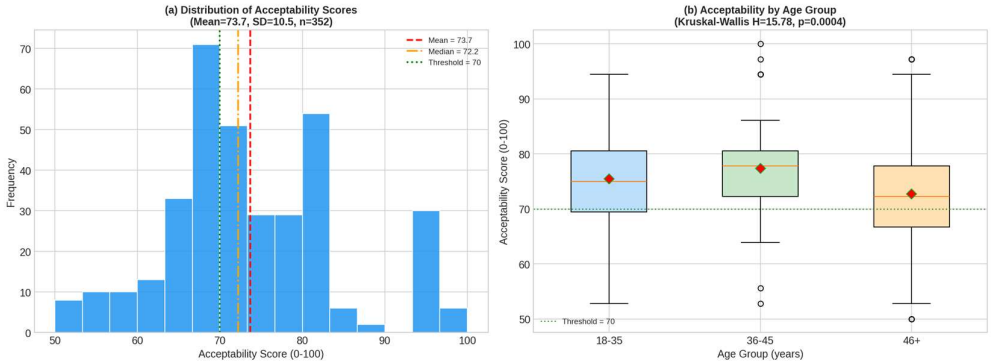

Figure 1.4: Distribution of the composite Acceptability Score

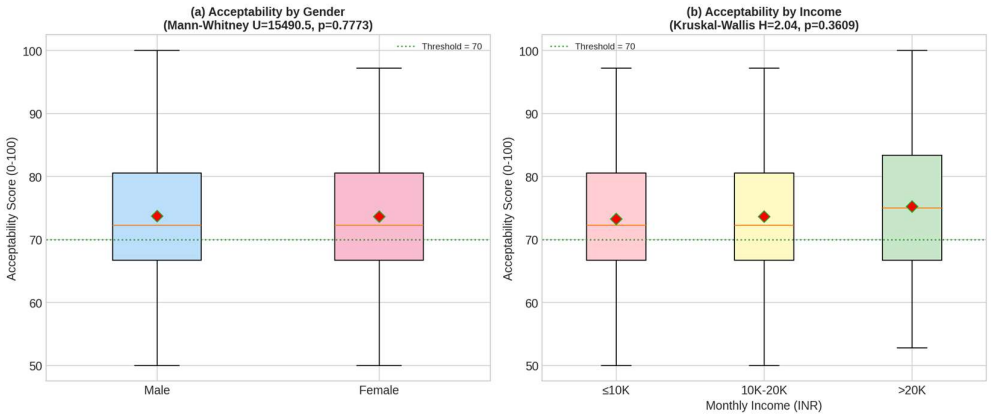

Figure 1.5: Acceptability scores across Age, Gender, and Income groups.

Correlation analysis revealed a statistically significant moderate positive relationship between the distance travelled to the vision centre and total OOP expenditure (Spearman's rho = 0.353, $p < 0.001$), suggesting that patients travelling longer distances incurred higher costs. Qualitative feedback from participants highlighted convenience, reduced travel, and shorter waiting times as major advantages of tele-ophthalmology services, while suggestions for improvement included reducing costs of investigations and improving ease of the consultation process.

Table 1.2: Breakdown of Out-of-Pocket Expenditure per Visit (n=352)

Cost Component	Mean (INR)	Median (INR)	Std. Dev (INR)	% of Total OOP
Investigation + Medicines	238.1	100.0	293.4	63.1%
Transport (Patient)	65.5	40.0	73.4	17.4%
Transport (Attendant)	70.6	40.0	114.3	18.7%
Food & Lodging	2.4	0.0	10.9	0.6%
Total OOP Expenditure	377.0	250.0	360.6	100.0%

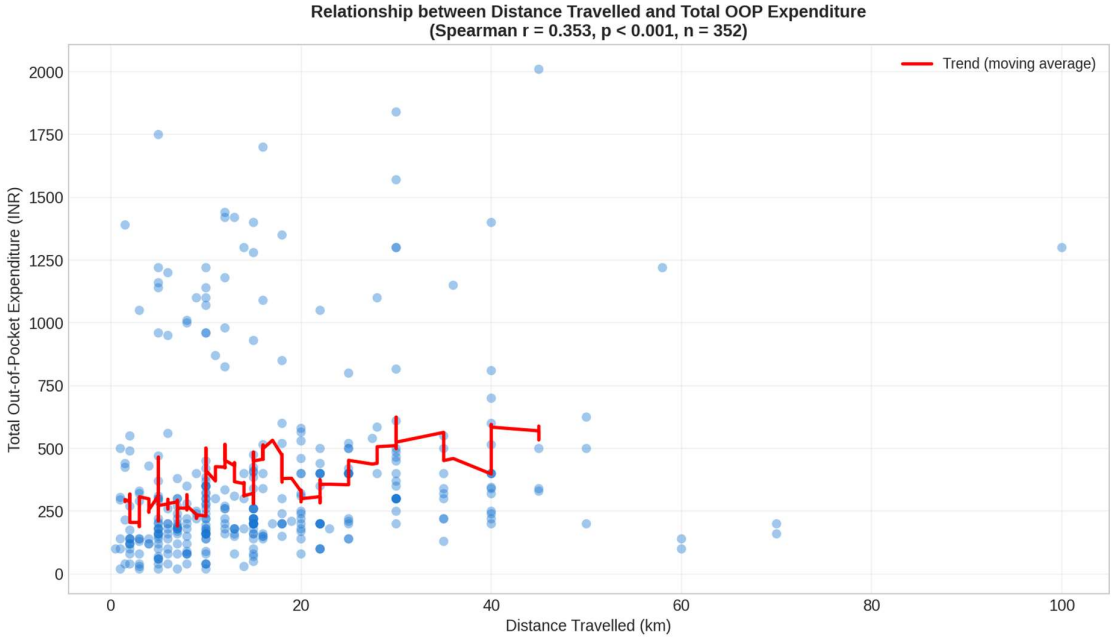

Figure 1.6: Relationship between Distance Traveled and Total OOP Expenditure

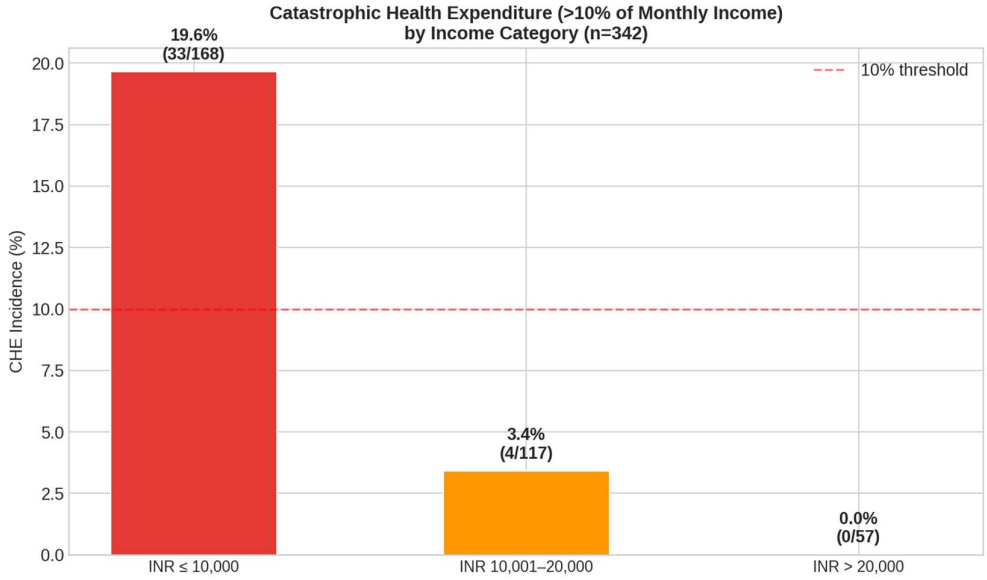

Figure 1.7: Incidence of Catastrophic Health Expenditure by Income Group.

DISCUSSION

This study ventured into the heart of Bihar, a region where access to quality eye care is often a distant dream, to evaluate how tele-ophthalmology is being received by the very people it aims to serve. Our findings paint a compelling picture: while the digital bridge of tele-ophthalmology is largely embraced by patients, the financial journey across that bridge remains a significant hurdle for many. This duality underscores the practical relevance of such innovations in resource-constrained settings, highlighting both their promise and the persistent challenges of healthcare equity.

Acceptability of Tele-Ophthalmology: A Digital Embrace

The high level of patient acceptability observed in our study is a testament to the power of bringing care closer to home. With a mean composite acceptability score of 73.66 ± 10.53, significantly exceeding the predefined threshold of 70 ($t = 6.52$, $p < 0.001$), it is clear that patients are finding substantial value in this model. A remarkable 76.9% of participants reported being satisfied or very satisfied, and nearly all (100%) expressed a willingness to recommend the service, with 98.9% preferring it for future use. These figures resonate strongly with previous research indicating high patient satisfaction in tele-ophthalmology due to the sheer convenience and reduction in arduous travel(15,18). Patients in our study consistently lauded the clarity of communication, the quality of advice received, and the overall consultation experience, suggesting that tele-ophthalmology can indeed deliver care comparable to traditional face-to-face interactions(8).

However, the embrace of technology is not uniform. We observed a significant association between age and acceptability ($H = 15.78$, $p = 0.0004$), with younger individuals demonstrating higher levels of acceptance. This trend is not surprising, reflecting a broader familiarity with digital technologies among younger demographics(1). Encouragingly, the absence of a significant difference based on gender ($p = 0.777$) suggests that tele-ophthalmology services possess an inherent inclusivity, capable of transcending traditional gender-based barriers to healthcare access in diverse populations. Yet, the journey is not without its bumps. A subset of patients found the process demanding, hinting at underlying challenges such as unfamiliarity with technology, potential workflow inefficiencies, or limited digital literacy. These are not unique to Bihar; similar barriers have been identified in other rural settings where digital healthcare systems are still nascent(19). To truly unlock the full potential of tele-ophthalmology, these friction points must be addressed through targeted patient education, intuitive user interface design, and streamlined service delivery.

Affordability: The Persistent Economic Hurdle

From an economic vantage point, our findings reveal a persistent vulnerability. While tele-ophthalmology undeniably eases the burden of indirect costs—such as the time lost from work and the expense of travel—it does not entirely eradicate the financial strain of seeking care. The median out-of-pocket expenditure (OOPE) per visit was INR 250 (mean INR 377; range 20–2,010), which, while seemingly modest, contributed to catastrophic health expenditure (CHE) in 10.8% of all participants. This figure alarmingly climbed to 19.6% among the lowest income group, underscoring the precarious economic tightrope many families walk. This aligns with broader trends in India, where high OOPE often pushes vulnerable households into financial distress(9). The substantial contribution of investigation and medication costs to the total expenditure suggests that while tele-ophthalmology has democratized physical access, financial accessibility remains a partially unmet promise. Previous studies have similarly noted that telemedicine models are more

effective at reducing non-medical costs, while direct medical expenses continue to weigh heavily on affordability(13).

The intrinsic link between geography and finance was further illuminated by a moderate positive correlation between distance traveled and total expenditure ($r = 0.353$, $p < 0.001$). Patients residing further from the vision centers invariably incurred higher costs, reinforcing the critical role of decentralized, community-based vision centers in mitigating financial burdens(12). This study thus underscores a vital message: tele-ophthalmology is a powerful tool, but it must be integrated into a broader public health strategy. To achieve truly equitable eye care delivery, it must be complemented by measures such as financial subsidies, inclusion in government health insurance schemes, and a robust strengthening of primary care infrastructure.

Limitations and Future Directions

While our cross-sectional design offers a valuable snapshot of patient perceptions, it does not capture longitudinal outcomes, which could provide deeper insights into sustained acceptability and long-term financial impacts. Furthermore, the study's focus on a specific geographic setting may limit its generalizability to other regions with different socio-economic or healthcare landscapes. The reliance on self-reported expenditure data also introduces a potential for recall bias. Nevertheless, the rigorous use of a validated questionnaire and a substantial sample size bolster the reliability and relevance of these findings, offering crucial insights for policy and practice in regions striving for universal eye health.

5. CONCLUSION

The findings of this study indicate that tele-ophthalmology services delivered through vision centres in Bihar are highly acceptable among patients, with the majority reporting satisfaction with the consultation process, effective communication, and overall convenience. The model successfully addresses key barriers related to geographical access by enabling patients in rural and semi-urban areas to receive specialist eye care without the need for extensive travel, thereby improving service utilization and patient experience. However, despite the relatively low median cost of services, affordability remains a significant concern, particularly among low-income groups. A proportion of patients experienced financial burden in the form of out-of-pocket expenditure, with some meeting the criteria for catastrophic health expenditure. This highlights that while tele-ophthalmology reduces indirect costs such as travel and time loss, direct medical expenses continue to influence overall financial accessibility. In conclusion, tele-ophthalmology represents an effective and scalable approach for strengthening eye care delivery in resource-limited settings. To maximize its impact and ensure equitable access, it is essential to complement this model with targeted financial support strategies, improved cost regulation, and integration into public health insurance schemes.

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