Original Article

A technological approach to "Reaching the Unreached" – Leveraging teleophthalmology services in Rural Gujarat

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Purpose: Early detection of sight-threatening disorders by technological applications like teleophthalmology and prompt treatment can help decrease visual impairment. This study evaluated the role of teleophthalmology in underserved rural areas along with cost-saving estimates for the end user. **Methods:** A prospective, observational, cross-sectional hospital-based study was conducted over 3 months. First 1000 teleconsultations were included. None of the patients denied providing informed consent. The patients were consulted at the eight vision centers and three satellite centers of the hospital in the nearby rural and tribal regions closer to their residential places. These vision and satellite centers were connected to the base hospital like a hub and spoke model with a teleophthalmology network. **Results:** Cataract (n = 301, 30.1%) and refractive error (n = 290, 29%) were the most common diagnosis. 42.1% of patients were referred to base hospital for further evaluation. Thus, a total of 57.9% of patients were not required to visit the base hospital for initial consultation, saving time and money. Furthermore, 15.1% of patients were provided medical treatment at the vision center and satellite center, which helped in making teleophthalmology cost-saving for the patients. An average of Rs. 621/- were saved per patient for the community in our study. **Conclusion:** Networked teleophthalmology model can be an affordable and feasible tool for providing eye care delivery services in rural and tribal regions of Gujarat and the whole country, especially for the end user. Thus, it may be a workable model in ophthalmology practice with substantial cost saving to the community.

Key words: Cataract, cost-saving, refractive error, tele-health, telemedicine, teleophthalmology, tribal region of Gujarat

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Telemedicine has evolved over the years and proves to be an effective way to provide healthcare services remotely. Ophthalmology is a specialty that has been taking advantage of this technology to a great extent. Advancements in hardware, software, Internet connectivity, and other communication technologies have helped ophthalmologists to diagnose and treat a variety of urgent and chronic eye conditions from a distance.[1] Tele-ophthalmology can increase the reach of ophthalmologists to rural and underserved areas and be able to provide eye care to prevent blindness. Furthermore, teleophthalmology has been particularly helpful during the recent COVID-19 pandemic in decreasing in-person consultation and maintaining social distancing.[2]

As per the International Agency for Prevention of Blindness (IAPB), India possesses a maximum number of people with total vision loss and blindness.[3] Moreover, it is estimated that 80-90% of this blindness could be prevented by proper medical attention and awareness.[4] Cataracts and uncorrected refractive errors top the causes of preventable blindness in India.[4,5] Furthermore, according to National Blindness and Visual Impairment Survey, India (2015-2019), rural areas are more affected as compared to urban areas in addition to a proportionately higher rural population in the difficult-to-reach areas.[5] In rural and tribal areas of India, the lack of ophthalmologists or proper infrastructure has led to delays in diagnosing of preventable causes of blindness.[6,7]

Teleophthalmology can provide a solution to this problem and help attenuate preventable blindness cases in underserved, rural, and tribal regions.[8] Teleophthalmology could be beneficial for various purposes, such as screening, consulting, counseling, prioritizing the patients, optimizing the medications, supervising, follow-ups, educating as well as in emergency situations.[2,9] It can be particularly useful in rural areas where specialists are not available for screening and evaluation. Teleconsultation can evaluate the patient similarly to face-to-face consultation through videoconferencing and help identify the ones who are truly

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in need of an expert ophthalmologist's care. Thus, this can maximize the utility of limited resources available in rural areas.[10] Furthermore, this mode also allows the patients to avail eye care near their homes and avoid the significant burden of travel and loss of daily wages. Thus, it can prove to save time, cost, and effort for both patients and experts.[2] It should also be noted that this modality depends on a good referral network equipped to handle the load coming through and provide services.

Thus, the aim of the present study was to explore the role of teleophthalmology as a cost-saving model for detecting eye disorders in rural and tribal communities of Gujarat, having limited access to ophthalmic care.

Methods

Study design and period: The present study was a prospective, observational, cross-sectional study conducted at a tertiary care base hospital in Surat, Gujarat. The study was conducted from May 2021 to July 2021

Study population: It included eight vision centers and three satellite centers of the hospital in the nearby rural and tribal regions. These regions were 11 remote villages in South Gujarat at an average distance of 53 km (range: 25-90 km) from the base hospital, namely, Khapar, Uchchhal, Sagbara, Dediapada, Umarpada, Kim, Kosamba, Bardoli, Netrang, Jhankhvav, and Vyara. These remote centers were linked to the base hospital via teleophthalmological means. These centers were not having any full-time ophthalmologists, and the patients in these regions will have to travel to the base hospital for consultancy.

Ethics approval: The study was approved by the Institutional Ethics Committee and was registered with Clinical Trial Registry, India. All the principles and guidelines of the Declaration of Helsinki were adhered.

Study Plan: All the patients who underwent teleconsultation at the 11 remote villages in South Gujarat at an average distance of 53 km (range: 25-90 km) from the base hospital during the study period were included in the study. Written informed consent from all the participants was obtained before recruiting in the study; however, it was not audio recorded. The patients who refused to provide consent were excluded. All the patients had an undilated fundus examination. Preliminary information of the patient (name, age, sex, address, and chief complaint) was recorded upon the visit, followed by clinical examination. The clinical examination was carried out by trained vision technicians present at each center. The visual assessment was conducted by the standard Snellen's visual acuity chart.

Furthermore, patients were subjected to refraction studies via an auto-refractor and subjective refraction and measurement of intraocular pressure with iCare (rebound) tonometer (ICARE Finland model TA01I). The intraocular pressure measurement along with optic disc photographs was used to suspect the presence of glaucoma in the patients, who were then referred to visit the base hospital for further investigations. The slit lamp (Aurolab – Hawk I B 2 model) examination and anterior and posterior segment imaging was also conducted without dilating the pupils as we were using a nonmydriatic fundus camera (Forus Trinetra model). The live feed of the examination was transmitted to the base hospital using the Internet along with the patient details. The ophthalmologist at the base hospital interacted with the patient and the technician via real-time videoconferencing [Fig. 1].

Figure 1: (a) Trained vision technician examining the patient on telemedicine. (b) Photograph depicting patient consulting with ophthalmologist using teleophthalmology services

The ophthalmologists evaluated the clinical data and provided the diagnosis in real time. The trained vision technician carried out any further examinations needed when advised by the ophthalmologist. The patients who were diagnosed with different disorders were then provided the medical treatment. The patients needing surgery were referred to the base hospital. A flowchart depicting the workflow is provided in Fig. 2.

Following are the case definitions for the different ocular pathologies being identified via teleconsultation: Refractive error: uncorrected visual acuity of less than 6/9 and improving to 6/6 with glasses; cataract: best-corrected visual acuity of less than 6/9 and anterior segment photo showing grade 2 or more of nuclear sclerosis; conjunctivitis: symptoms of redness, watering, itching along with signs of sticky yellowish discharge, conjunctival congestion ± lid edema; chalazion: slowly growing painless lump in the eyelid; stye: red, painful lump near the edge of eyelid; glaucoma suspect: IOP >21 mm Hg with cup: disc ratio >0.5 or asymmetry of >0.2; corneal ulcer: a defect in corneal epithelium stained with fluorescein, associated with photophobia, blurring of vision, pain, and redness ± history of ocular trauma; diabetic retinopathy: fundus photo s/o hemorrhage/hard exudates/new vessels ± maculopathy; age-related macular degeneration (ARMD): Drusen/choroidal neo-vascular membranes (CNVM).

Cost estimates: The approximate costs were estimated mostly from the end user's perspective.

The patient-related costs were calculated, which included wages lost by the patient, cost of meals, average travel expenses from their location to the base hospital, and some incidental expenditures. The incidental cost includes travel cost for the accompanying person, the cost of one meal for the escort, and loss of wages for the escort. As per the hospital guidelines, consultation charge at the base hospital was Rs. 100/-, whereas, at the vision center, it was Rs. 50/-. All expenses were calculated using 2021 as the base year in Indian Rupees. The wage loss information and travel expenses were obtained from the patients when they visited for follow-up and were generalized to the minimum value. All the costs were rounded to the next whole integer.

Data analysis: The data were presented as either number of patients or calculated as percentages.

Results

A total of the first 1000 teleconsultations conducted during the three months of the study period (May to July 2021) at the vision center and satellite centers of our base hospital were included in the study. None of the patients denied providing informed consent. Out of 1000 eye examinations conducted, 510 (51%) were female and 490 (49%) were male, suggesting equality in gender distribution undergoing teleconsultation. Combining all the examinations from the 11 centers, 652 (65.2%) patients were from the tribal community, whereas 348 (34.8%) patients were nontribals. The age range of the patients was from 1 year to 85 years, with a majority of patients between the age group of 41-70 years (n = 663) [Table 1].

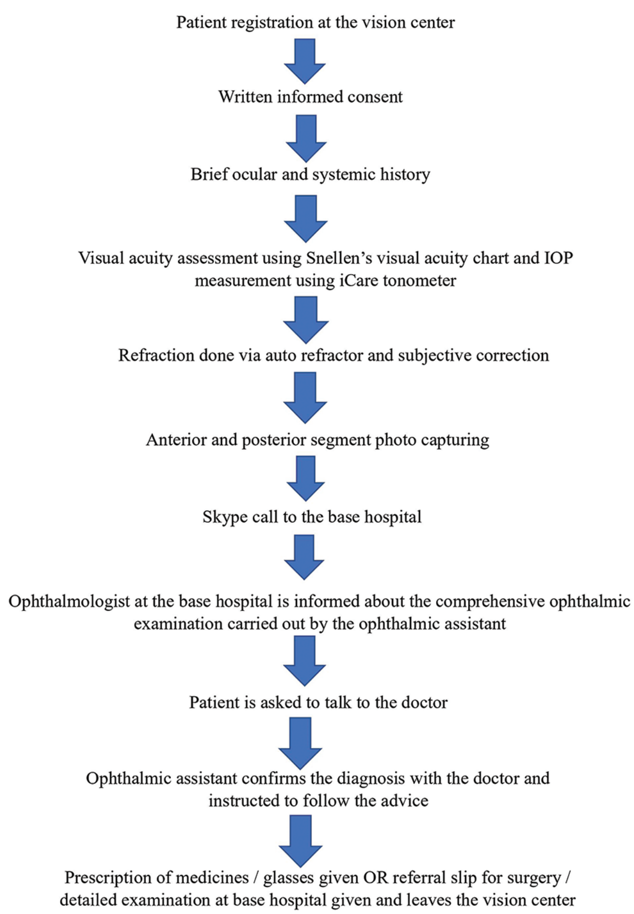

Figure 2: Flowchart depicting the workflow of patients using teleophthalmology services

The distribution of patients among the 11 centers was found to be Khapar (n = 149), Uchchhal (n = 94), Sagbara (n = 11), Dediapada (n = 75), Umarpada (55), Kim (n = 159), Kosamba (n = 179), Bardoli (n = 74), Netrang (n = 81), Zankhvav (n = 99), and Vyara (n = 24). Khapar was the most distant from the base hospital (90 km), whereas Zankhvav was nearest (25 km).

The ocular conditions of the patients examined via clinical examination and videoconferencing are depicted in Table 2. Majority of the patients were diagnosed with cataract (n = 301, 30.1%) followed by refractive error (n = 290, 29%). Furthermore, 9.7% of the patients were called for follow-up that included cases of cataract and pterygium surgeries. Other diseases found in the patients were corneal disease (5.2%), retinal pathology (1.9%), and suspected glaucoma (1.7%). Of the 52 corneal disease patients, 23 (44.23%) cases comprised of corneal foreign body, 5 (9.6%) had corneal opacity, 12 (23.07%) were of corneal ulcer, 3 (5.7%) had corneal tear, 2 (3.84%) had chemical injury, and 6 (11.53%) patients had dry eyes. Furthermore, one patient (1.9%) was an operated case of therapeutic penetrating keratoplasty who had come for follow-up. Of the 19 patients with retinal pathology, two (10.5%) were ARMD patients and five (26.3%) patients had diabetic retinopathy, whereas remaining patients had other retinal diseases.

The patients diagnosed with cataract were referred to the base hospital for cataract surgery. 42.1% of patients were referred to the base hospital for further evaluation, which included patients with cataract and pterygium requiring surgery, patients with corneal and retinal pathologies, patients with suspected glaucoma and suspected other diseases like amblyopia, cranial nerve palsy, ptosis, and dermoid cyst. A total of 15.1% of patients were provided medical treatment at the center, which included 9.7% conjunctivitis patients and 5.4% of patients with lid and adnexal diseases that included stye, chalazion, and blepharitis. All the 290 patients detected with refractive error (i.e., 29% of total patients enrolled) were provided with glasses at the vision center, which saved their visit to the base hospital. Ophthalmic examination of 4.1% of patients was within normal limits. 9.7% of patients were called for follow-up at the vision center.

Table 3 depicts the various costs incurred to the patients and their savings. It shows Rs. 6,21,080/- as the grand saving of the community considering 1000 consultations in the current study.

Discussion

The present study provides insights into the use of teleophthalmology in rural and tribal regions of Gujarat for providing eye care services. This model is found to be affordable and feasible in our study and agrees with

Table 1: Age and gender-wise distribution of the patients visiting the vision and satellite centers

	0-15	16-40	41-50	51-60	61-70	71-80	81+	Total
Male	17	112	97	116	117	30	1	490
Female	14	147	104	119	110	13	3	510
Total	31	259	201	235	227	43	4	1000

Table 2: Gender-wise diagnosis of ocular conditions identified via clinical examination and videoconferencing

Diagnosis/Gender	Male	Female	Grand Total
Cataract	138	163	301
Conjunctivitis	39	58	97
Cornea	29	23	52
Glaucoma	12	5	17
Surgery Follow-up	50	47	97
Lid/Adnexa disease	29	25	54
Pterygium	7	18	25
Refractive Error	147	143	290
Retina	12	7	19
Others	25	16	41
WNL	2	5	7
Total	490	510	1000

WNL: Within Normal Limits

Prathiba and Rema (2011) to apply teleophthalmology as an effective model of eye care in rural and underserved areas in India.[8] Furthermore, the pandemic (COVID-19) situation limited the in-person examination to maintain social distancing. Teleophthalmology allows ophthalmologists to continue caring for patients while keeping the experts and patients safe. Thus, the adoption of teleophthalmology as a high-quality, efficient care mechanism has been accelerated due to the pandemic, although challenges still exist.

Our data indicate that a maximum number of patients who came for teleconsultation for visual impairment were having either cataract or uncorrected refractive errors. Similar results were found in another teleophthalmology study conducted by Sankara Netralaya in rural regions of South India.[6] Timely assessment of the cataract and respective referrals to the base hospital for surgery can lead to a significant reduction in preventable blindness in such underserved regions. Moreover, most of the cataract patients are geriatric and have comorbidities. In the present time, when the risk of exposure to coronavirus has accelerated, many postoperative patients may be noncompliant for follow-up.[2] Thus, teleophthalmology can be a very effective tool for cataract assessment.

It has been reported that India and China account for nearly 50% of blindness and global visual impairment attributable to uncorrected refractive errors.[11] Moreover, most cases of preventable vision loss are due to cataract followed by refractive error.[12] In the current study, glasses were provided to all 290 patients with uncorrected refractive errors suggesting an important step toward correction of error and thereby prevention of visual impairment. Additionally, several patients were detected with treatable medical conditions such as conjunctivitis, stye, chalazion, and blepharitis. These patients were counseled and provided with medical treatment in the form of oral drugs and topical eye drops like antibiotics, anti-inflammatory, and anti-allergic drugs. Thus, this helped in saving time and money for the patients since they did not have to travel to base hospital. Moreover, the time of the expert ophthalmologist was also saved, along with the delivery of proper medical care to prevent blindness. Furthermore, a recent study suggested the requirement of scaling cost-effective strategies that will encourage people to seek corrective eye care services.[13] This could play a major role in reducing the preventable blindness burden. Our study provides evidence that setting up vision centers could be feasible for such rural population to seek corrective eye care services timely.

Our data indicate 1.7% of patients were suspected of glaucoma. Documented evidence from Kenya suggests a moderate agreement between the ability to diagnose glaucoma using telemedicine and slit lamp examination in the traditional way.[14] Another meta-analysis suggested that a greater number of cases of glaucoma were detected using teleophthalmology than in-person examination. Additionally, the teleophthalmology was found to be accurately discriminating between the screen test results suggesting it to be an effective tool with multiple benefits like early diagnosis, increase in referral rates, time-saving, and cost-effectiveness.[15]

Furthermore, a majority of retinal cases (1.9%) were of diabetic retinopathy followed by dry ARMD. This depicts that in rural areas where ophthalmologists are not available, early diagnosis of posterior segment disease is possible. Several models of teleophthalmology for diabetic retinopathy screening have been employed in different countries.[16-18] A very recent meta-analysis also suggests that tele-retinal screening showed high accuracy in terms of sensitivity and specificity in comparison with traditional face-to-face clinical examination.[18] Similarly, a meta-analysis suggested that teleophthalmology for ARMD is equally effective when compared to in-person examination and also increases the participation of patients in the screening.[19] Such tele-screening methods have been proven to be cost-effective, and reliable with high sensitivity and specificity.[20,21]

In this study, 5.4% had diseases of eyelids and adnexa. More than 60% of the subjects diagnosed with diseases of lid and adnexa were medically treatable and suitable treatment was given to them. In a study conducted in 16 districts of four southern states involving 5,604 patients, teleconsultation was advised in 6.9% of patients. Among them, 59.6% were referred to a higher level of care and 40.4% of patients were treated at the primary vision center. The authors suggested that teleconsultation played an important role in the management of disorders involving the anterior segment.[22]

Additionally, this study also evaluated the feasibility and affordability of the teleophthalmology model for eye care in the rural and tribal regions of Gujarat. This model was found to be feasible as there was good broadband connectivity in the rural regions of Gujarat, which could make real-time videoconferencing possible. The trained vision technician was a local person belonging to the region and thus could interact and counsel the tribal patients easily. Furthermore, a total of 1000 teleconsultations within a short span of 3 months without any denial for informed consent depict the success of teleconsultation in rural and tribal patients. The trained vision technicians were effective in explaining the problems and treatments to the rural and tribal patients.

Finally, the model was also found to be useful in cost-saving. Expert ophthalmologists were not required full-time at all the centers, while local trained vision technicians could conduct the activities required at the center. The ophthalmologist at the base hospital could provide the consultation and diagnosis to all 11 centers. The potential limitation of the study was the major

Table 3: Cost estimates and cost savings for patients from different regions

	Khapar	Sagbara	Dediapada	Uchchhal	Kosamba	Kim	Netrang	Bardoli	Umarpada	Vyara	Jhankhvav
Distance from base hospital (km)	90	75	70	65	55	50	50	35	35	35	25
(A) Two-way travel cost for two persons @ Rs. 1/- per km in state transport bus (Rs.)	360	300	280	260	220	200	200	140	140	140	100
(B) Cost of one meal for two persons (Rs.)	100	100	100	100	100	100	100	100	100	100	100
(C) Loss of wages for one person and the accompanying escort (Rs.)	300	300	300	300	300	300	300	300	300	300	300
(A+B + C) Total incidental expenditure for one patient to come to Mandvi (Rs.)	760	700	680	660	620	600	600	540	540	540	500
Total number of patients from the center examined on telemedicine	149	11	75	94	179	159	81	74	55	24	99
Total cost saved (Rs.)	1,13,240/-	7,700/-	51,000/-	62,040/-	1,10,980/-	95,400/-	48,600/-	39,960/-	29,700/-	12,960/-	49,500/-
Grand total of savings for the community (Rs.)						6,21,080/-					

expenditure in this model. It included the fundus cameras, slit lamps, laptops, and broadband connectivity. The setting up of the vision center is high in capital investment from the providers' perspective. However, it was able to save the cost for the patient. The various expenditures by the patient, such as two-way travel cost to base hospital, cost of meals on the day of visit to the base hospital as well as loss of their wages for a day were saved, making the model more effective for the patients. Such a model, involving indirect cost saving, in the long run, is helping to identify and nudge persons with visual impairment into corrective eye care and thus leading to a reduction in the overall burden of preventable blindness. Hence, it may be the most economical technique on a broader scale. This observation is supported by a recent cost-effectiveness study that presented vision centers with teleophthalmology services to be the most economical strategy for case finding related to cataract and refractive errors.[13]

Conclusions

The teleophthalmology proves to be an affordable and feasible tool for providing eye care in rural and tribal regions of Gujarat as well as the whole country where access to an expert ophthalmologist is not possible. Additionally, local trained vision technicians, hailing from the same communities, can easily communicate with patients and provide basic medical treatment and glasses. The model also is beneficial for society as it saves both time and money spent on visiting distant eye care facilities as well as unnecessary visits and saves a lot of indirect costs as well as direct costs. Although the modality of establishing this model is relatively high in capital investment, the recurrent costs for the provider, lesser number of false positives in the system, and high cost savings of both indirect and direct non-healthcare costs are very high for end users. As a result, teleophthalmology will play an integral role in providing high-quality, efficient care in the near future.

Ethics approval

The study was approved by the Institutional Ethics Committee of Divyajyoti Trust, Tejas Eye Hospital (Approval no: DJT/EC/001/15/02/2021).

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Conflicts of interest

There are no conflicts of interest.

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