

Adoption, Challenges, and Future Prospects of Tele-optometry: A Comprehensive Review

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ABSTRACT

The ongoing problem of blindness and low vision affects India because rural areas lack sufficient access to eye care facilities. Tele-optometry involves the provision of eye care through communication media. People in remote regions with no access to eye care services show increasing demand for immediate medical attention which drives the growing acceptance of this solution. This review studies existing research on tele-optometry and tele-ophthalmology while examining three main topics which include adoption models, implementation frameworks, and patient perceptions. The systematic search which followed PRISMA guidelines identified 24 open-access studies that Google Scholar, PubMed, and Research Gate published between 2014 and 2024. The operating capacity of tele-optometry depends on three essential requirements which include reliable digital infrastructure, secure data management and user acceptance by both clinicians and patients which enables early detection of eye conditions in while decreasing the number of preventable blindness and vision impairment cases.

Keywords: Telemedicine, Teleoptometry, Teleophthalmology.

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INTRODUCTION

The increase in elderly people together with the rising diabetes rates and the existing knowledge gap about eye complications has created a situation which requires eye care services but remains unsolved in rural areas of India. The main reasons for blindness in the country are cataract, glaucoma, and diabetic retinopathy. The worldwide blind population in 2020 included 596 million people who had distance vision problems with 43 million of them classified as blind.¹ However, with today's accessible treatment options, the majority of these conditions, more than 90%, can be prevented or treated.¹ The number of people with vision impairment keeps rising despite national

programs and efforts to address these problems. This situation demonstrates the urgent need for better methods that require more financial resources to support ophthalmology work which will prevent and treat blindness in India.

People in rural areas of India face difficulties in accessing high-quality eye care services. Tele-optometry which belongs to the field of telemedicine enables remote eye check-ups and consultations to provide eye care services.² Telemedicine specialists use tele-optometry to deliver eye care services to poor people in remote areas.² Particularly in places with restricted access and resources, telehealth is a cutting-edge and well-liked method of bringing patients and healthcare professionals together. Its adoption is growing rapidly across various medical specialties. Globally, the use of telehealth has surged by 257% to 700% in countries such as Canada, Australia, the United States, and the United Kingdom.³

Despite the fact that telehealth and telemedicine are frequently used synonymously, an examination of peer-reviewed definitions reveals that telemedicine is a

subset of telehealth.⁴ According to NEJM Catalyst, Telehealth is defined as “The delivery and facilitation of health and health-related services including medical care, patient education, health information services and selfcare via telecommunications and digital communication technologies”.⁵ On the contrary, ‘Telemedicine practice guidelines’ defined telemedicine as “The delivery of health-care services, where distance is a critical factor, by all health-care professionals using information and communications technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and the continuing education of health-care workers, with the aim of advancing the health of individuals and communities”.⁶

Telehealth runs in two primary forms: synchronous and asynchronous. Synchronous telehealth encompasses live consultations, such as video calls, where actions like prescribing medications, providing reassurance, or determining the need for an in-person appointment occur in real-time.⁷ In contrast, asynchronous telehealth involves transmitting health data through a store-and-forward method, eliminating the need for immediate interaction.⁸ This approach is frequently used for activities like screening for disorders like retinopathy of prematurity and diabetic retinopathy.¹

Telehealth has become the standard practice for multiple healthcare fields, while teleophthalmology has achieved high acceptance rates from both doctors and patients. The COVID-19 pandemic created an essential need for tele-optometry because it allowed doctors to treat chronic eye diseases through remote patient care and virtual contact lens checkup appointments. The healthcare industry has begun to fully adopt remote optometry services which enable patients to receive eye care without needing to visit a medical facility. The transition to tele-optometry services received support from improvements in software development, internet access, and advanced eye examination tools.⁷

This study will investigate how tele-optometry services have been adopted by healthcare providers while identifying the obstacles that prevent its widespread use and examining potential future developments which will fill current research gaps.

METHODS

Three major databases, Google Scholar, PubMed, and ResearchGate, were searched systematically for relevant literature on the use of tele optometry and teleophthalmology. The review papers were critically synthesized using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) technique (Figure 1). The search involved terms which included “Teleoptometry adoption” and “Teleophthalmology adoption” and “Teleophthalmology AND tele optometry in India” and “Frameworks AND Teleoptometry” and “Barriers AND Teleoptometry” and “Knowledge AND Teleoptometry” and “Patient perception AND Teleoptometry OR Teleophthalmology.” The search was restricted to open access publications from 2014 to 2024 because of the fast technological advancements in this field. The researchers evaluated articles for relevance and duplicate removal. The selection process for 24 publications followed rigorous inclusion and exclusion criteria which resulted in publications that enhanced the understanding of tele-optometry and teleophthalmology through their exploration of techniques and frameworks and barriers and knowledge gaps and patient perceptions.

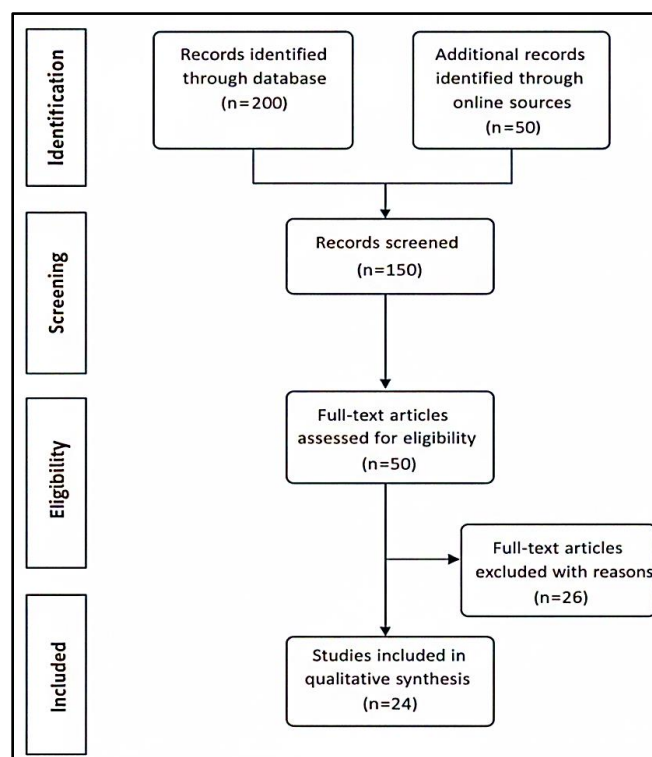


Figure 1: PRISMA Flow Diagram for Literature Review.

The Ministry of Health and Family Welfare (MoHFW), in cooperation with NITI Aayog, the Board of Governors (BoG), and the Medical Council of India (MCI), released Telemedicine Practice Guidelines during the COVID-19 lockdown in March 2020.⁶ The medical standards aimed to simplify telemedicine operations for doctors while maintaining safety for both patients and their health care providers.

Indian Space Research Organisation (ISRO) has developed its advanced satellite communication system to deliver specialized medical services to remote and rural areas of India and to underprivileged communities throughout the country by combining satellite technology with medical research and information technology. The program uses digital health technology to enhance patient outcomes and enable better communication between optometrists and other healthcare professionals while overcoming geographical barriers.⁹

The current data shows that complete global tele-optometry adoption rates have not been recorded in one standard documentation method. The rates at which people adopt new technologies show significant regional differences because different regions possess different abilities to implement technological systems and their governing authorities and healthcare systems use different regulatory methods.

The leading Indian eye care facilities have used teleophthalmology to provide high-quality eye care services to people who live in remote and rural areas for about three decades. Apollo Telehealth, which serves as a major telemedicine pioneer, has changed healthcare operations through its skilled personnel and advanced digital technology.⁹ The program has distributed free eyeglasses to two million recipients. The Madras Diabetic Research Foundation (MDRF) and World Diabetes Foundation (WDF) collaborate on the MDRF/WDF Rural India Diabetes Prevention Project, which stands as one of the major telemedicine initiatives currently underway.¹⁰ Forty-two villages in the Kancheepuram District of Tamil Nadu, near Chunampet, are served by this community outreach initiative. The project uses a mobile telemedicine van which connects to satellites to find diabetes along with its diabetic eye disease complications. The van's digital retinal camera operates through local eye technicians who have received professional training. The technicians have captured retinal color photos from 2,000 diabetic patients because they took eye images of all four quadrants. The images are

transmitted to the Chennai base hospital through satellite links which enable ophthalmologists to conduct video conferencing with rural patients.¹⁰ The Sankara Nethralaya Medical Research Foundation in Chennai operates a teleophthalmology project that connects to ISRO satellites and uses a mobile van designed for eye examination purposes. The van which carries an optometrist together with a social worker conducts eye disease screening at village camps. The medical team begins digital fundus picture taking after they finish pupil dilation and they transmit the images through a video conferencing system to enable real-time dialogue between the patient and the ophthalmologist. The 6,300 camps have provided information which has benefited 620,930 people until now.

The Aravind Teleophthalmology Network operates a mobile eye-screening van which connects to satellites to screen diabetic patients at multiple clinics and hospitals and camps.¹⁰ The network had screened 20,080 patients through 74 camps by July 2006. The Aravind Comprehensive Eye Survey Research Group studied diabetic retinopathy which affected 10.5% of the population in rural South India and found that only 6.7% of those affected received medical evaluation.

The tele-ophthalmic care models include four distinct services which include remote monitoring and screening and triage and consultative services. Most of these services are designed to handle emergency situations and triage processes and standard eye care procedures. The disease-specific care models primarily handle diabetic retinopathy and glaucoma as their most frequent medical conditions. The local clinicians typically obtain medical images which they forward to an ophthalmologist who conducts the assessment.¹¹

Telemedicine evaluation frameworks serve as essential methods for evaluating numerous aspects of telehealth services, assuring thorough examination of issues, and promoting successful implementation. Several prominent models and frameworks are presented in Table 1

The Comprehensive Model for Evaluating Telemedicine balances cost, quality, and access across clinical, educational, and administrative roles while evaluating effects at the individual, community, and society levels using a three-dimensional approach (level, focus, and activity).¹³

Several organized frameworks that look at the efficacy, preparedness, and sustainability of

Table 1: Overview of the main frameworks and thematic domains used in telemedicine research.¹²

Model	Conceptual basis	Methodological Approach	Validation Status	Structural Characteristics	Key Thematic Focus
Barriers to telemedicine diffusion	Grounded in principles of diffusion of innovation	Longitudinal examination of three telehealth initiative	Formal validation not reported	Identification of four broad categories influencing adoption	Technological, organizational, behavioral, economic barriers
eHealth readiness assessment tools	Derived from e-readiness and organizational change theories	Adaptation of existing e-readiness scales with expert input	Expert interviews and statistical reliability testing	Multi-item questionnaire with 51 statements linked to Likert scale	Technology, learning, society, economic, policy
UTAUT applied to telehealth	Unified Theory of Acceptance and Use of Technology	Application of the UTAUT survey framework in telehealth settings	Supported by prior studies and expert validation	Structured set of Likert-scale items	Perceived usefulness, perceived ease of use, behavioral intention, demographic moderators
Seven Core Principles for the Successful Development of Telemedicine Systems	No particular theory	Evidence synthesis combined with practical experience from Australian telehealth implementations	No formal validation described	Practice-oriented guidelines organized into seven principles	System ownership, grassroots engagement, technology usability, training, evidence dissemination
Lessons in telemedicine service innovation	Conceptual rather than theory-based	Evidence synthesis combined with practical experience from Australian telehealth implementations	Formal validation not reported	Practice-oriented guidelines organized into seven principles	Policy, evidence, perceived benefit, commitment, professional roles, border crossing
Framework for assessing health system challenges in scaling mHealth	ICT-for-health perspectives in low- and middle-income settings	Qualitative synthesis of literature, stakeholder interviews, site visits, and document analysis	Validation procedures not specified	Four overarching dimensions encompassing capacity requirements	Government, organization, technology, finances
Comprehensive model for telemedicine evaluation (Hicks & Boles, 2004)	Informed by transactional economics theory	Design and integration of three evaluation dimensions	No formal validation reported	Three-dimensional framework: each dimension has several categories	Individual, community, society, cost, quality, access
The Layered Telemedicine Implementation Model	Knowledge-based barriers influencing telemedicine diffusion	Systematic review of 45 articles on the implementation of telemedicine services	No formal validation	Life-cycle-oriented model comprising five implementation phases	Technology, acceptance, organization, policy, and legislation
Khoja–Durrani–Scott (KDS) evaluation framework	Broad concepts related to eHealth evaluation and system life-cycle models	Systematic review and expert opinions	Validation reported separately by authors	Outcome-focused framework mapped across life-cycle stages and thematic areas	Evidence, technology, economic, behavioral, and socio-technical, ethical, change management, policy

e-medicine can be used to understand its evaluation and implementation.

Like system development cycles, lifecycle frameworks provide individual phase guidance to

ensure that planning, testing, and deployment processes are in line with the expected outcomes. The Layered Telemedicine Implementation Model, emphasizes factors at phases.

- Prototype phase: Focuses on technology usability and user acceptance.
- Pilot phase: Include financial and organizational structure.
- Operational phase: Emphasizes policy, legislation, and security.¹⁴

The Khoja–Durrani–Scott (KDS) Framework provides a comprehensive evaluation of telehealth by addressing development, implementation, integration, and ongoing operation across key themes such as healthcare impact, technology readiness, economic value, ethics, and policy support. The reviewed studies lacked any explanation about why researchers chose theoretical frameworks for their research. Telehealth implementation research could benefit from exploring theories that exist in related fields.¹⁵

Outlined by the Board of Governors in 2020, the framework for telemedicine practice in India encompasses five scenarios.⁶

1. Patient to Registered Medical Practitioner (RMP) as in Figure 2.
2. Caregiver to Registered Medical Practitioner (RMP).
3. Health Worker to RMP.
4. RMP to RMP.
5. Emergency Situations.

Essential Principles

1. Professional Judgment: Determine whether an in-person visit is required or if a telemedicine consultation is appropriate, the RMP must exercise professional judgment. Care quality should be the top priority.
2. Communication Mode: Text, audio, and video consultations have the same rules, but patient care and management can differ according to the communication mode.
3. Selection of Communication Mode: The clinician should choose the most suitable communication mode based on the patient's health condition. If proper examination is required, the clinician should specifically request video consultation.
4. Discretion to End: The clinician has the right to terminate the consultation at any point and, if necessary, suggest the patient to have an in-person session.
5. Patient Rights: Tele-consultation can be

terminated by the patients at their discretion, and they can do so at any point in time.

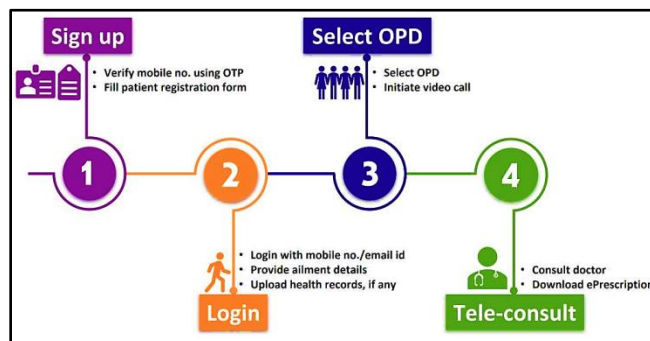


Figure 2: Steps of Patient to RMP teleconsultation.

With technological advancements, tele-optometry can significantly enhance the availability of eye care services across diverse populations. The potential in the field of optometry is immense due to the increased availability of eye care professionals to serve rural and remote areas.^{2,5,7,16} Some key benefits include:

1. Telemedicine helps people living in remote locations who lack access to eye care services. The system enables instant virtual eye testing which produces fast visual assessment results that improve both visual outcomes and life satisfaction.
2. The community screening programs identify four types of eye conditions which include cataracts and glaucoma and diabetic retinopathy and refractive errors. The program enables timely treatment which helps to prevent vision loss.
3. The online training programs and virtual events of telemedicine enable optometrists and eye care professionals to develop new skills while they learn about current medical practices.
4. Tele-optometry provides remote assessment and counselling together with assistive technology training to enhance the daily life of people who lack access to specialized medical services.
5. Telemedicine works together with government agencies and nonprofit organizations and community initiatives to provide health services which reach underserved populations for the purpose of preventing blindness and advancing eye health knowledge.
6. Telemedicine uses digital imaging systems and artificial intelligence to assess remote eyecare effectiveness and cost efficiency which leads to

better evidence-based practices in optometry research.

The health system of India can provide treatment for limited patients with blindness because of infrastructure problems and workforce deficiencies and lack of public awareness. The surveyed optometrists showed limited understanding of tele-optometry because structured training programs and knowledge-sharing platforms and tele-optometry service promotion remained undeveloped. The healthcare workers in Libya, Pakistan, Saudi Arabia, and India show knowledge gaps which need complete educational programs and training to solve.¹⁷⁻²⁰ Previous research established that tele-optometry systems face a significant obstacle caused by difficulties in data accuracy management.²¹⁻²³

The adoption of tele-optometry and its public recognition will improve when optometry schools include tele-optometry training in their curriculums. The field of tele-optometry exists in its initial development stage and needs both public awareness initiatives and the establishment of service delivery standards and training protocols. The American healthcare system has widespread knowledge about teleophthalmology methods yet more than 90 percent of ophthalmologists in the United States have never applied these techniques according to research findings.²¹ The study participants showed reluctance because they doubted tele-ophthalmology results could be trusted, and they did not believe in the effectiveness of remote patient assessment methods. The successful operation of telehealth systems needs both technical expertise and the healthcare provider's perception of telehealth technology.²⁴ Karthikeyan et al, reported that during the early COVID-19 phase, 50.94% of Indian optometrists used tele-optometry, with 85.19% offering services free of charge.²⁵ The rising worldwide demand together with upcoming health crises necessitate the establishment of organized training and incentive programs. Tele-optometry enables eye care facilities to provide standard services while making treatment accessible to patients from rural and distant areas.

Tele-optometry enhances remote area eye care because it provides better access to services while decreasing travel expenses and allowing for quick medical evaluations and treatment procedures. The system establishes a unified healthcare model that connects eye doctors with basic medical facilities while it develops public health services through its

ability to conduct remote tests and identify diseases at their initial stages especially in areas that lack essential medical resources. The combination of artificial intelligence and high-resolution imaging and portable medical equipment and secure data storage systems improve diagnostic performance and patient privacy protection and healthcare team efficiency especially when used together with electronic health record systems.

CONCLUSION

Teleophthalmology programs have been successful in their mission to provide high-quality eye care services to remote and rural areas in India yet tele-optometry remains underused in both implementation and adoption. Telehealth platforms for delivering optometry services face major problems because of existing global policies and practices which have become less effective. The existing research about tele-optometric care requires more investigation because researchers need to focus on safety analysis research.

The research process requires extensive work to develop systems which deliver optometry services through telehealth in a safe and efficient manner. Optometry practitioners and all other stakeholders must improve their tele-optometry training programs to meet the needs of increasing demand for eye care in low-income areas. The framework developed through this method can be used to deliver eye care services during pandemics and in their subsequent recovery periods.

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Conflict of Interest: Authors declared no conflict of interest.

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