Telemedicine Use in Ophthalmology During & After COVID-19

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Abstract: ***COVID-19 pandemic, which first appeared in Wuhan, China, had a catastrophic effect on people's health and healthcare systems, which was overloaded by the quick spread, which resulted in a shortage of medical personnel, hospital beds and other supplies. Travel and quarantine limitations brought on by the COVID-19 epidemic have increased the demand for telemedicine. Telemedicine has played a key role in Ophthalmology. Ophthalmologists diagnose and treat a wide range of acute and chronic eye problems thanks to the development and accessibility of strong hardware, sophisticated software, and quick communication technologies. Telemedicine has the potential to enhance the patient experience in the high-volume speciality of ophthalmology, especially in primary care settings where access to specialists is challenging. It may also be a more affordable option than in-person expert consultations. The present study is a systematic review study which was performed from the year 2020 to 2025 in accordance with Preferred Reporting Items for Systematic Reviews & Meta Analyses (PRISMA) 2020 through online electronic database Pubmed, Google Scholar, Scopus using the following search strings: "telemedicine", "telehealth", "ophthalmology" and "Covid19". Initially, 305 records were found, including research with a COVID-19 focus. A total of 104 records were determined to be eligible after irrelevant, non-English, and duplicate studies were eliminated. The final qualitative analysis had 32 records. Numerous teleophthalmological systems and equipment are being used and studied, and the results have been encouraging. Studies demonstrating AI's contribution to teleophthalmological techniques suggest that this may be the future for practice of ophthalmology. Age-related macular degeneration, glaucoma, and retinopathies are being highlighted by research in teleophthalmology.***

Keywords: Age-Related Macular Degeneration, Covid-19, Diabetic Retinopathy, Glaucoma, Teleophthalmology, Telemedicine, Telehealth.

1. Introduction

The SARS-CoV-2, which caused the COVID-19 pandemic, first appeared in Wuhan, China, in December 2019 and quickly spread throughout the world. The World Health Organisation (WHO) proclaimed it a worldwide pandemic on March 11, 2020 (WHO, 2020). The respiratory system is the main organ affected by the virus, which spreads through respiratory droplets and causes mild to severe disease and occasionally even death. Millions of infections and fatalities were caused by COVID-19, which had a catastrophic effect on world health. From a low-grade fever and cough to pneumonia and multi-organ failure, the virus caused a serious respiratory illness. Healthcare systems were overloaded by the quick spread, which resulted in a shortage of medical personnel, hospital beds and other supplies. [1, 6]

In addition to its effects on health, the pandemic had a significant impact on social and economic structures. To stop the virus from spreading, governments implemented social separation, travel bans, and lockdowns. Economic downturns, job losses, educational interruptions, and a rise in mental health problems were the results of this. Travel and quarantine limitations brought on by the COVID-19 epidemic have increased the demand for telemedicine. [1, 3]

During the pandemic, telemedicine, which uses digital platforms to deliver healthcare remotely became widely used. Telemedicine, which is the practice of providing medical care remotely by sharing information and using digital tools, assisted in bridging the distance between patients and healthcare practitioners in the face of social distancing policies, lockdowns, and overcrowded medical facilities. Remote consultations, chronic disease management, mental health support, and COVID-19 screening and monitoring were among the main uses of telemedicine during the pandemic. [6, 14]

Telemedicine has played a key role in Ophthalmology. Ophthalmologists diagnose and treat a wide range of acute and chronic eye problems thanks to the development and accessibility of strong hardware, sophisticated software, and quick communication technologies. The majority of teleophthalmology services rely on digital photos taken by primary care doctors or skilled technicians using a variety of in-clinic equipment for fundus and anterior segment photography. An ophthalmologist receives the digitally transmitted images for evaluation in real time or at a later period. Telemedicine has the potential to enhance the patient experience in the high-volume speciality of ophthalmology, especially in primary care settings where access to specialists is challenging. It may also be a more affordable option than in-person expert consultations. During a patient's typical primary care visit, a quick and easy teleconsultation can identify individuals who require additional in-person subspeciality care. In rural areas and underdeveloped nations and regions, where the specialists needed for screening and evaluations are frequently unavailable or inaccessible, this idea may be crucial. [2, 3, 9]

2. Method

This systematic review was performed from the year 2020 to 2025 in accordance with Preferred Reporting Items for Systematic Reviews & Meta Analyses (PRISMA) 2020 through online electronic database Pubmed, Google Scholar, Scopus using the following search strings: "telemedicine", "telehealth", "ophthalmology" and "Covid19". Non-relevant articles were excluded from the present study by investigating their abstracts and titles, taking this as the eligibility criteria for verifying the articles. Research articles which were not in English languages and did not have English translation were excluded from the study. Editorials, letters, and commentary were not included. Initially 505 articles were screened which included studies focussed on Covid19. After non-English, non-relevant and duplicate studies were excluded, a total of 32 studies were taken into consideration.

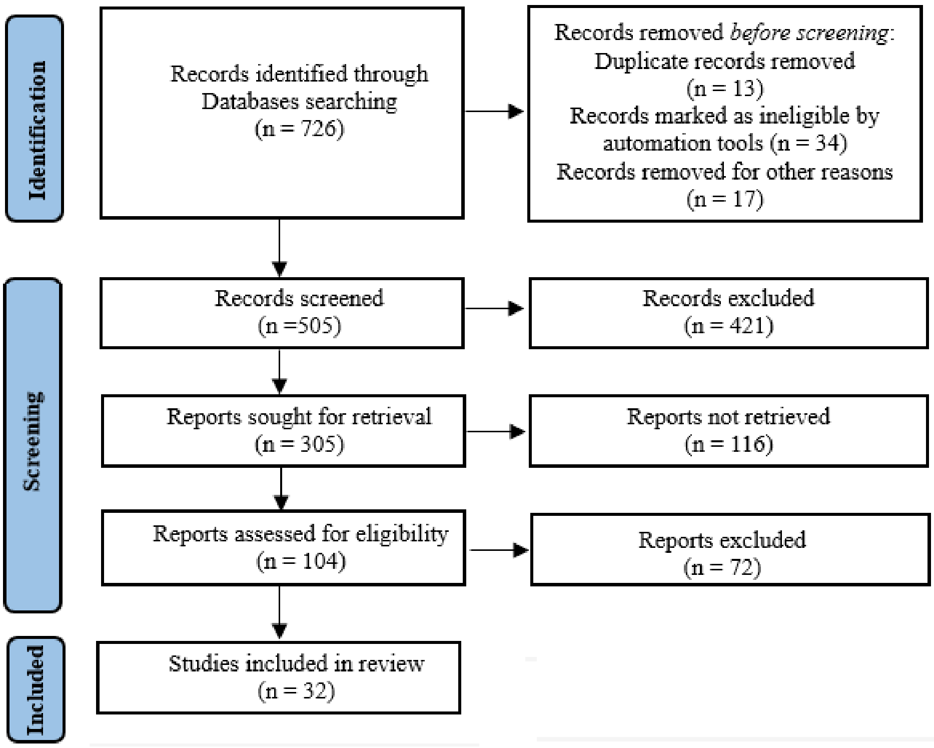

Figure 1: Inclusion flowchart of identified records

3. Different Ophthalmological Conditions

3.1 Diabetic Retinopathy

As the most prevalent condition for disease-specific remote care in ophthalmology, DR screening has made extensive use of telemedicine. Remote screening is becoming more important than ever when millions of people are placed under quarantine. Tele-screening AI-enabled DR screening can benefit low-and middle-income people and address the global health burden. COVID-19 has been detected in over 200 countries globally. [5]

Teleophthalmology services have been successfully implemented in various nations, despite geographical differences. Research of 978 diabetic patients in Riyadh, Saudi Arabia, found that distant non-mydriatic funduscopic screening photography can detect diabetic retinopathy (DR) early. (19). A large cross-sectional investigation in Chile yielded similar findings [20]. Virtual retina clinics in the UK provide a cost-effective and safe alternative to in-person professional follow-up, including urgent referrals. In a cross-sectional investigation with 2788 patients, Afshar et al. also suggested a novel imaging technique for DR screening. The study proposed a combination of multiple fixed-location cameras and a mobile ultra-widefield camera installed in a van for high-volume clinics [1, 5]. The examples above demonstrate how teleophthalmology can be used to alleviate clinic overcrowding, decrease administrative contacts, and remotely triage and select individuals who need a face-to-face examination. Retinal telemedicine applications, primarily in DR and retinopathy of prematurity (ROP), are dependable and economical, according to Chee et al., and must be incorporated into the current clinical systems. However, they recommend telemedicine which is ought to be used in conjunction with in-person office visits, especially for high-risk patients, rather than as a replacement for them. Improving patient adherence to therapy and follow-up requires an understanding of how patients view telemedicine. One disadvantage of tele-screening that should be mentioned is that it is not specific to teleophthalmology; it has been observed in in-person consultations as well as for other medical specialities. Both teleophthalmology applications and retinal illnesses heavily rely on image-based studies. [1, 16, 18]

Therefore, teleophthalmology has most likely benefitted the retinal field for both screening and follow-up. DR in adults and retinopathy of the retina in children. In their evaluation of extensive DR telemedicine screening programs worldwide, Tozel et al. showed that a high degree of clinical accuracy and simpler patient access are achieved [17]. Recent studies have shown documented cost savings and a reduction in unnecessary referrals for both urban and rural populations using teleophthalmology services [16, 18]. For DR patients who are least likely to attend a screening test, the UK's statewide teleophthalmological screening program has been hailed as an excellent option [1]. Similarly, teleophthalmology initiatives in Canada have helped geographically dispersed populations in both urban and rural areas. Additionally, teleophthalmological screening in the Zimbabwe Retinopathy Telemedicine Project (ZRTP) allowed patients with restricted access to learn about and manage DR [18, 19, 21].

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Retinopathy of Prematurity:

Numerous research has suggested that telemedicine is an efficient way to check for ROP, determined in a review of a ten-year regional telemedicine study where the ROP screening program examined 1181 infants' widefield digital imagery. This study suggested tele-screening as a useful technique to solve the personnel gap in ROP screening and demonstrated that it could be a successful modality in diagnosing and controlling ROP. The widefield digital imaging of 1181 infants was examined in a retrospective analysis of a regional telemedicine ROP screening program that lasted 10 years. This study shown that telescreening can be a useful tool for controlling and diagnosing ROP and suggested it as a useful instrument to deal with the lack of personnel in ROP screening. Tele-screening for ROP in preterm newborns was determined to be a practical and effective method for accessible screening in a retrospective review, while it was unable to fully replace due to technical challenges in imaging the peripheral retina. The core of teleophthalmological developments and applications is in retinopathy of prematurity (ROP). According to recent research, teleophthalmology can be a sensitive and accurate method for DR screening, and it has promise as a universal newborn screening method. [1, 2, 16]

Age Related Macular Degeneration:

Majority of COVID-19 cases occur in middle-aged adults, especially the elderly, and the likelihood of developing serious illness is higher in these patients. It was stated that using telemedicine to treat AMD necessitates the use of more sophisticated imaging modalities than those typically employed for DR and that it is not advised to expand the use of current DR tele-screening techniques to screen for AMD. According to a prospective study on 298 elderly individuals with cognitive issues, such as dementia, teleophthalmology can be effectively used for several screenings for eye disorders. A nonrandomized study involving 159 patients demonstrated how non-dilated OCT and digital fundus photography for remote diagnosis were able to obtain higher diagnostic accuracy in determining cases of AMD that can be referred when contrasted with a retinal specialist's in-person dilated eye examination.76.7% of these patients preferred remote care over in-person standard examinations, which is noteworthy for the future of telemedicine in ophthalmology [1]. Additionally, telemedicine was found to be effective in the long-term care of patients treated with intravitreal antiVEGF injections for exudative AMD, with a mean follow-up period of 2.4 ± 0.81 years. Like DR, teleservices can be used to identify patients who require an in-person assessment remotely, lessen administrative purpose contacts, and relieve clinic crowding. [1, 10]

Glaucoma:

A telescreening strategy was implemented for Glaucoma in seven primary care clinics and four qualifying practices, according to the Philadelphia Telemedicine Glaucoma Detection and Follow-up Study. High detection rates of suspect optic nerves and ocular hypertension were attained by their diagnostic setup and model, which made use of telemedicine imagery in addition to demographic and clinical data (IOP measures, visual acuity, and family history of glaucoma) [4]. To manage glaucoma remotely, Gan et al. offer a variety of telemedicine techniques, including IOP measurements, fundus photography, anterior segment imaging, central corneal thickness pachymetry, and retinal nerve fibre layer imaging [29]. Each patient's information can be gathered and sent to a remote healthcare provider for interpretation, waiting additional guidance. They established three tiers of tele-programs, ranging from the most basic, which just included glaucoma screening, to the most complete, long-term treatment monitoring, which included diagnostic consultation. [1]

Telemedicine was shown to be as beneficial in a recent trial involving 200 adult glaucoma patients at 2346 Graefes Arch Clin Exp Ophthalmol (2020) 258: 2341–2352. detecting the progression of glaucomatous disease, in contrast to in-clinic visits, and was endorsed as playing a part in the long-term care of glaucoma patients when paired with routine in-person examination, even in the face of unique situations like patients living in remote rural areas or the ongoing COVID-19 pandemic. Patients were given remote management and therapy recommendations in addition to remote diagnostic [30]. In a prospective trial of 107 participants, the accuracy and consistency of telemedicine approaches in contrast to the conventional clinical exam were also validated among those who received automated tonometry, refractive state measurements, keratometry readings, a nonmydriatic retinal scan, and an OCT, which yielded a wealth of data, including measurements of the thickness of the central cornea, angle anatomy, cup/disc ratio, distribution of the retinal nerve fibre layer, and posterior pole ganglion cell complex information. More than 80% of 92 lead consultant ophthalmologists in the UK who participated in a big survey said that glaucoma virtual clinics were acceptable for their patients, and that efficiency and patient safety were at least on par with in-person care. [30, 31]

Based on time cost analysis, Arora and colleagues and Rathi and colleagues came to the conclusion that teleglaucoma required less time than in-person visits. After 30 years, teleglaucoma was able to stop 24% more incidences of blindness from glaucoma. The overall benefit for patients who tested positive for teleglaucoma was 15.7 QALYs, which was 1.1 less than the benefits of receiving therapy in person. When a patient with teleglaucoma is seen, their time can be better used and they can receive more prompt treatment. Most glaucoma telescreening involves taking pictures of the optic nerve with portable or handheld cameras. In both developed and poor nations, teleglaucoma could enhance glaucoma diagnosis and treatment. According to Staffieri and colleagues, telemedicine improves the likelihood of identifying those who have undiagnosed or high-risk glaucoma. It can also be used to lower the demand for glaucoma appointments and lower the likelihood that patients will receive unnecessary treatment or follow-up [31, 32]. First, the information given during the teleconsultation was somewhat inconsistent, according to the ophthalmologist. This issue is less significant in a traditional in-person appointment because the glaucoma specialist can get the information, they need by asking the patients questions or doing an examination. Additionally, technical variables such as the bandwidth and storage of telecommunication devices may limit the development of teleglaucoma. Because of this, treating teleglaucoma in developing nations is exceedingly challenging. The high price of additional gear and ophthalmic

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imaging equipment is an additional constraint because retinal cameras can cost more than $10, 000 USD. [1, 4]

When adopting telemedicine, distance is no longer an obstacle for glaucoma screening, diagnostic consultation, and long-term therapy monitoring. With the goal of providing high-quality, reasonably priced treatment while striking the right balance between clinical, financial, and humanistic goals, telemedicine is required because of inadequate medication or intervention techniques, as described by Delgrado et al. [4]. AI can serve as a type of teleophthalmological treatment for glaucoma by gathering information from home-use equipment such intraocular pressure tonometry self-monitoring, smartphone-based head-mounted perimeter for VF defect detection, smartphone applications for ophthalmology, and data processing to produce a diagnostic or progression risk percentage [7, 8, 9].

Anterior segment:

Hu and Lorch evaluated the use of teleophthalmology in treating disorders of the anterior segment. Aspects such as the clinical context (diagnosing and screening), encounter settings (home, mobile health units, general practitioner (GP) office), feasibility (cost-effectiveness, diagnostic accuracy), and implementation barriers (medico-legal aspects, reimbursement, disparities in care, and patient and provider attitudes) were among the topics they covered. They concluded that teleophthalmology could provide low-access patients with both acute and chronic diagnostic and therapeutic medical care remotely. [1]

The most common diagnosis (42.7%) in a one-year retrospective audit of a teleophthalmology consultation program of 709 patients in western Australia was cataract, which was followed by glaucoma (11%), AMD (4.4%), and DR (3.8%). Urgent disorders such external eye trauma, periorbital cellulitis, narrow-angle glaucoma, retinal/vitreous detachment, and retinal artery/vein occlusion could also be found among the diagnosis made at the end of the teleophthalmology consultation. Patients reported a same level of satisfaction with telemedicine-assisted informed consent sessions before laser vision correction and refractive lens exchange surgeries as those who met with their surgeon in person [1, 11, 12].

Telemedicine can provide a sensitive and targeted monitoring tool for tracking the growth of iris and choroidal nevi in an ocular oncology setting, according to a validation study of 99 patients. Interestingly, Nankivil et al. unveiled a robotic, remote-controlled stereo slit lamp system that enables 3D patient examination viewing and recording using a satellite, internet, and local network. This device could perform a "distant face-to-face" slit lamp examination of the anterior segment of the eye, even though only healthy participants were tested with it. Teleophthalmology has been shown to be a promising tool for the diagnosis and treatment of anterior segment diseases as well as lid and adnexal pathologies in rural India, according to the EyeSmart study-I. [1, 8, 13, 14]

Pediatric Ophthalmology:

Several difficulties had been observed when implementing telemedicine in case of pediatric ophthalmology. While providers were using telemedicine, the protocol was always being improved. A "live" document was made available through a link to guarantee that administrators and providers alike were informed about the most recent workflows. Additionally, efforts were made to find suitable video platforms as well as security concerns, patient and provider ease of use, video quality, and cost. VA was assessed using the GoCheckKids phone app, and the findings indicated a moderate correlation between VA and a standard clinic routine, suggesting the possibility of future VA screening at home [2]. Sabri et al. suggested using video-recorded screening to evaluate kids. When there is no direct access for consultation, a research on paediatric amblyopia and eye disease can be conducted by qualified non-eye care providers who can record sufficient footage for a remote ophthalmologist to review. Regarding postoperative care, teleophthalmology can also help with paediatric patients' virtual visits, which can make their wait times shorter while maintaining high-quality care for the kids [2, 19, 28].

4. Challenges/ Limitations

Teleophthalmology and its applications include drawbacks, just like any other new technological advancement. Although there are many potential benefits and opportunities in teleophthalmology, there are also obstacles that the scientific community must overcome. According to Liu et al., teleophthalmology is unfamiliar to both patients and medical professionals, which emphasises the need for comprehensive training and consistent referral guidelines [31, 24]. In addition, several other issues, including patient informed consent, payment for the consultation, medical-legal liability for the treating physician, and prescription of medication, require further consideration and policy formation. On patients' perspectives on teleophthalmology survey, including willingness to pay (WTP), the cost was cited as a concern for which education is required, particularly in underserved and low-resourced populations [20, 26]. Any clinical examination must include visual acuity testing, and while there are numerous apps that promise to accurately measure visual acuity at home. Lack of standardisation is seen in the use of nonstandard optotypes, data presented in unconventional notations, and the inability to calibrate the device and guarantee appropriate testing distance. There are benefits to telemedicine as well. It facilitates access to subspeciality care and lessens the strain of travel. Whereas virtual consultations require a minimum of technical knowledge and resources for image sharing, but even video calls and photographs do not provide as much information as can be obtained through slit-lamp examination and crucial tests, like intraocular pressure measurement, are not possible. Additionally, teleophthalmology may raise the workload for medical staff, leading to a phenomenon or workarounds that increase the number of ophthalmologists' jobs and patient volume. As a result, teleophthalmology must be used with extreme caution in routine clinical practice. [15, 22].

5. Future Perspectives

The outlook for teleophthalmology is wide-ranging and intricate. The COVID-19 epidemic has expedited the use of telemedical instruments, particularly in ophthalmology, and the use of telemedicine in healthcare is growing. The new technology is already being adopted by ophthalmologists,

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while noticing its advantages throughout the pandemic. Careful and thorough research is necessary to address obstacles related to cost-effectiveness and ethical issues for the collected data to implement programs and deploy devices successfully [1, 5].

6. Conclusion

Numerous teleophthalmological systems and equipment are being used and studied, and the results have been encouraging. Studies demonstrating AI's contribution to teleophthalmological techniques suggest that this may be the future for practice of ophthalmology. The primary problems for the use of teleophthalmological equipment are economic viability, safe data collection, and performance validation, even though the advantages are gradually becoming apparent. Age-related macular degeneration, glaucoma, and retinopathies are being highlighted by research in teleophthalmology to avoid visual impairment. The transfer of ophthalmological care from the doctor's office to the patients must be considered by eye care delivery systems that provide high-quality patient care. More research must be planned and financed to reduce avoidable vision impairment of any kind and provide the finest ophthalmological treatment feasible.

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