

THE ROLE OF TELEMEDICINE IN POPULATION-BASED GLAUCOMA VISION SCREENING



Exploring telemedicine's potential to alter the delivery of care to millions of people.

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The number of people with visual impairment or blindness in the United States is projected to double to more than 8 million by 2050, with the youngest baby boomers turning 65 in 2029.¹ This aging population brings a concomitant rise in ocular diseases such as glaucoma, age-related macular degeneration (AMD), diabetic retinopathy (DR), and cataract. The resultant increase in demand for ophthalmic care will contribute to the growing prevalence of unmet health needs as the number of ophthalmologists remains stable.² Despite recommendations for routine screenings, many at-risk patients do not obtain regular eye examinations due to barriers to access such as travel burdens, limited economic resources, diminished provider availability, lack of patient education, and perceived lack of patient need.³

The Hoffberger Program, a community-based vision screening initiative, showed that even when barriers to vision screenings and eye care are reduced, inducing ocular disease suspects to schedule and attend an eye examination is challenging. Of the 1,331 people assessed in the Hoffberger Program, only 41% scheduled an appointment and underwent an examination. The primary reasons for failure to comply with follow-up recommendations were: no appointment given (26%), forgot to follow up (20%), lack of

transportation (9%), and lack of insurance coverage (6%), despite the fact that transportation and examination were offered at no cost. Of the patients who accepted a second appointment date after failing to attend the first one, only 25% attended an examination.⁴

While the supply of eye care providers remains stable, the demand for additional screening and evaluation generated by certain patient populations continues to rise. Various ethnic groups in the United States have been shown to have increased risk for and prevalence of glaucoma, DR, and other eye pathologies. The Baltimore Eye Survey examined racial variations in the prevalence of primary open-angle glaucoma (OAG) and

found that age-adjusted prevalence was four to five times higher in black individuals than in white individuals. Rates of OAG among black patients ranged from 1.23% in those aged 40 to 49 years to 11.26% in those aged 80 years and older.⁵

In a survey of a US-based Haitian Afro-Caribbean population ($n = 750$), glaucoma suspect status was high across all age groups, suggesting that glaucoma monitoring in people younger than 40 years may be indicated.⁶ A total of 25.5% of the participants were identified as glaucoma suspects, with determinants of increased cup-to-disc ratio including increasing age, lack of insurance, and higher IOP. Additionally, the Los Angeles Latino Eye Study

AT A GLANCE

- ▶ As the number of ophthalmologists remains stable, the increasing demand for ophthalmic care will contribute to the growing prevalence of unmet health needs.
- ▶ Telemedicine can help provide timely and accessible care to populations in need in a variety of settings, such as emergency departments and rural clinics.
- ▶ Cost, reimbursement, and licensure limitations are barriers to the adoption of telemedicine that have been partially circumvented during the COVID-19 pandemic.

highlighted the prevalence of OAG in Latino individuals (as high as 21.76% in those aged 80 years and older) and showed that 75% of Latino patients with OAG or ocular hypertension were previously undiagnosed.⁷

One solution to improve access to screening and care is telemedicine, which is defined as the exchange of medical information with patients via services such as two-way video calls, emails, smartphone communications, remote digital fundus imaging and other telecommunication technologies.² The application of telemedicine is rapidly growing in many medical fields, and its use has the potential to alter the delivery of health care to millions of people.⁸ Ophthalmology lends itself readily to telemedicine because the interpretation of images is a routine part of diagnosing and treating ocular diseases. Recent advances in portable cameras and smartphone-based ocular imaging systems have created a surge in the variety of portable ocular photography platforms available and in the use of these technologies for telemedicine.^{3,9} Among these innovations are nonmydriatic fundus cameras and AI-based algorithms.

USES OF TELEOPHTHALMOLOGY IN SCREENING POPULATIONS

Teleophthalmology applications have been implemented in the United Kingdom, Canada, India, and the United States to reach at-risk populations with limited access to eye care.¹⁰

The **Technology-Based Eye Care Services (TECS)** program at the Atlanta Veterans Affairs (VA) hospital uses a trained ophthalmic technician stationed at a primary care clinic away from the main hospital. This technician collects information about a patient's ocular status, including near and distance BCVA, refractive status, IOP, and corneal thickness, and captures mydriatic, non-stereoscopic, 45° fundus photographs.¹¹ At the same time TECS began, the Atlanta VA Eye Clinic also launched the New Comprehensive Clinic (NCC), a center dedicated to seeing new patients for routine eye care through standard

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face-to-face visits. In the first 13 months, TECS rendered care to 2,690 patients, with greater than 90% agreement between the TECS interpretation and the in-person findings of the physician. Patients spent 25% less time and physicians spent 50% less time with TECS visits than with NCC visits. A total of 98% of TECS patients were able to schedule a desired clinic appointment within 14 days, compared with 58% of NCC patients. This early experience with TECS has prompted discussions about expanding the application of teleophthalmology to serve patient populations with limited or no access to eye care and adapting the TECS model for emergency room triaging.¹¹

Teleglaucoma is an effective screening tool for glaucoma, as evidenced by systematic reviews and meta-analyses examining the effectiveness of teleglaucoma compared with inpatient examination, especially in remote and underserved communities. Thomas et al¹² found that teleglaucoma was more sensitive and less specific than in-person examinations, with benefits in detecting more true positive cases of glaucoma but with a higher false positive rate. These investigators also found that teleglaucoma could be used to recognize glaucoma cases otherwise not detected during in-person examinations. Using teleglaucoma as a tool for early detection allows more effective disease management, as glaucoma commonly progresses asymptotically and is often identified upon a patient incurring vision loss at an advanced stage.¹²

Teleophthalmology can also increase diagnostic efficiency by screening for additional pathologies such as DR and AMD. The implementation of teleretinal

screening within the Los Angeles County health system has resulted in a 16.3% increase in annual rates of screening for DR and an 89.2% decrease in screening wait times.¹³

TECHNOLOGICAL ADVANCES IN TELEOPHTHALMOLOGY

Nonmydriatic fundus photography has emerged as a promising alternative to direct ophthalmoscopy.¹⁴ In settings where training in ophthalmoscopy is limited, such as the emergency department, the value of posterior and anterior segment examination may be understated with poor imaging, further decreasing the diagnostic and prognostic value of the examination.

In one study, nonmydriatic ocular fundus photography was found to be highly sensitive in screening patients who presented to the emergency department with headache, focal neurologic deficits, visual loss, or diastolic blood pressure higher than 120 mm Hg. Of 350 patients, 44 had relevant ocular findings such as disc edema, disc pallor, and retinopathy that were not detected by emergency department health care professionals using direct ophthalmoscopy. Of those 44 patients, 27 (61%) had findings that were detected only by fundus photography.¹⁴

Limitations of traditional fundus and anterior segment cameras include their bulkiness, complex assembly, high cost, and the sophisticated training required for operation. As technology and scientific innovation advance, more affordable and portable alternatives to traditional ophthalmic devices will become available. The development of portable, easy-to-operate fundus and anterior segment cameras, such as the Volk Pictor

Plus (Volk Optical) and the Horus DEC 200 (MiiS), has revolutionized vision screening programs. Ophthalmologists at the Bascom Palmer Eye Institute have successfully implemented the Horus device, a Bluetooth-enabled nonmydriatic fundus camera that sends images to a HIPAA-compliant electronic health record system, into their community and international vision screening events.¹⁵

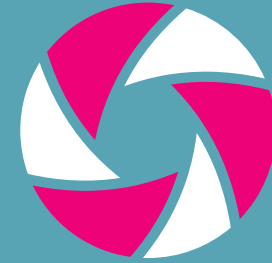
To combat issues with portability and cost, investigators at the Massachusetts Eye and Ear Infirmary and Illinois Eye and Ear Infirmary created a portable, inexpensive nonmydriatic fundus camera that measures 133 mm x 91 mm x 45 mm, weighs 386 g, and costs \$185.20.¹⁶ Welch Allyn also developed the iExaminer smartphone attachment to transform its PanOptic Ophthalmoscope into a mobile digital imaging device. Although many new fundus and anterior segment camera systems must still be validated in clinical studies, the possibility of using them to expand eye care to reach more patients is encouraging.⁹ As new technologies continue to emerge, the size and price of these devices should decrease.

AI encompasses natural language processing, machine learning, and deep learning algorithms that process and adapt based on data from digital patient charts or ophthalmic images. Numerous studies are under way to investigate the potential applications of AI across ophthalmology, including for glaucoma, DR, AMD, macular edema, and retinopathy of prematurity.¹⁷ Several machine and deep learning models integrating OCT, visual fields, and fundus photography data display high accuracy, sensitivity, and specificity for distinguishing glaucomatous eyes from healthy eyes.^{17,18} Fully data-driven, AI-based grading algorithms have also been shown to be sensitive and specific in screening fundus photographs obtained from diabetic patients, and in 2018 the FDA approved marketing of the IDx-DR (IDx) AI-based diagnostic system for autonomous detection of DR.^{18,19}

The **MVP FDT** is a low-cost, portable, smartphone-based frequency doubling technology (FDT) device used for visual

PORTABLE ALTERNATIVES TO TRADITIONAL OPHTHALMIC DEVICES

- Volk Pictor Plus Fundus Camera (Volk Optical)
- Horus DEC 200 Fundus Camera (MiiS)
- Massachusetts Eye and Ear Infirmary/ Illinois Eye and Ear Infirmary Pocket-Sized Retinal Camera
- iExaminer Mobile Adapter (Welch Allyn)
- MVP FDT Smartphone-Based Visual Field Testing Device



field testing that, in our experience, produces comparable results to the Humphrey FDT (Zeiss). The MVP FDT device can be assembled for less than \$130, and its portability enables its use in a variety of settings, especially for community and international glaucoma screenings.²⁰

OCT has shown utility in glaucoma screenings as well, with the diagnostic capabilities of various OCT machines increasing with disease progression.²¹ The ability to use OCT to distinguish glaucomatous from normal eyes lends itself to screening, although there are currently no clear diagnostic signs of glaucoma identifiable using OCT interpretation, and OCT images must still be used in conjunction with other clinical data.^{21,22} Population-based glaucoma screening using OCT may prove cost-effective and beneficial when applied to targeted high-risk populations and once machine learning methods to distinguish glaucomatous nerve fiber layer damage from normal scans are effectively integrated.^{17,23} The future role of OCT as a component in the glaucoma screening toolkit is also contingent upon the development of OCT machines with greater portability and lower cost.

ADDITIONAL BENEFITS

Medical mission trips and international ophthalmology stand to benefit from teleophthalmology.

Our previously described Sustainable Healthcare And Regional Education Through International Medical Excursions (SHARETIME) model will be enhanced by teleophthalmology in multiple ways. These services will assist in the patient screening process carried out by SHARETIME eye care staff in the host country, allow volunteer ophthalmologists to study patients' cases and prepare for surgery ahead of time, enable superior follow-up care, and improve information flow to strengthen the collaboration of the involved stakeholders.²⁴

Cost savings are expected to result from strategic implementation of teleophthalmology. Preliminary analyses of TECS suggest that the program costs less per patient than traditional clinic visits and that teleophthalmology may improve operational efficiency, reduce cost, and significantly improve access to care.^{10,11} A systematic review of economic analyses by Sharafeldin et al²⁵ confirmed the cost-effectiveness of teleophthalmology for glaucoma and DR screening. Despite accounting for additional costs—including training, equipment and maintenance, transmission or software, and referral for traditional examination when indicated—cost savings were observed with teleophthalmology versus traditional examinations. These findings suggest that the selection of targeted populations with high patient volumes and

high disease prevalence will increase the cost-effectiveness of screening initiatives.²⁵

BARRIERS TO ACCEPTANCE

Barriers affecting the development of teleophthalmology include the cost of equipment, restrictions in reimbursement, and limitations due to licensure. Because some ophthalmic imaging equipment can be costly, it is important to determine whether investment in these devices will improve care and resource utilization or if the equipment will be ill-suited for the population being served. In addition, Medicare tends only to reimburse for services that meet strict criteria. Although all 50 US states and the District of Columbia have some form of Medicaid reimbursement for telehealth in their public programs, coverage for telemedicine services varies depending on insurance provider, and the current procedural terminology billing codes must frequently be adapted to keep pace with new applications of telemedicine.^{25,26}

Entering 2020, diverse restrictions and guidelines had been instituted by state Medicaid programs for telemedicine. Nine state boards issued licenses related to telehealth, allowing out-of-state licensed providers to render services via telehealth; however, patients had to be physically present in a health care facility during telehealth interactions, and some reimbursable telehealth services were restricted to rural or underserved areas.^{26,28} Several of these barriers were significantly eased in March of 2020, when CMS implemented emergency declaration blanket waivers to expand reimbursement for telehealth in response to the COVID-19 pandemic. In addition to adding new billing codes, CMS temporarily waived requirements that out-of-state practitioners be licensed in the state where they are providing services and began considering virtual visits equivalent to and reimbursable as face-to-face encounters.^{28,29} In effect, these waivers of the Social

Security Act produced a testing ground for the expanded implementation of telemedicine.

CONCLUSION

Teleophthalmology is redefining eye care delivery. From emergency departments to rural clinics, telemedicine technologies will help provide timely and accessible care to populations in need. Using teleophthalmology to screen for ocular disease benefits both patients and health care systems by enabling earlier disease detection, decreasing morbidity, increasing cost savings, and reducing patient travel and wait times. As imaging technology advances, it will be imperative to examine the cost-effectiveness of screening devices to ensure that they truly enable more efficient care and resource utilization.

Cost, reimbursement, and licensure limitations are barriers to adoption of telemedicine that have been partially circumvented during the COVID-19 pandemic and should be further considered moving forward. It is unclear whether CMS requirements will remain relaxed or return to previous levels after the current emergency has resolved. However, the observed success of telemedicine during this period of loosened restrictions will likely result in wider acceptance among patients, providers, and insurers, leaving all parties more comfortable with the expanded implementation of teleophthalmology. ■

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