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The Current State of Teleophthalmology in the United States

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Abstract

Telemedicine services facilitate the evaluation, diagnosis, and management of the remote patient. Telemedicine has rapidly flourished in the United States and has improved access to care, outcomes, and patient satisfaction. However, the use of telemedicine in ophthalmology is currently in its infancy and has yet to gain wide acceptance. Current models of telemedicine in ophthalmology are largely performed via “store and forward” methods, but remote monitoring and interactive modalities exist. Although studies have examined the effects of telemedicine, few reports have characterized its current status. We perform a descriptive analysis of the current state of teleophthalmology in the United States. We describe the use of teleophthalmology in the hospital and outpatient settings. We also review the applications to retinopathy of prematurity, diabetic retinopathy, age-related macular degeneration, and glaucoma, as well as anticipated barriers and hurdles for the future adoption of teleophthalmology. With ongoing advances in teleophthalmology, these models may provide earlier detection and more reliable monitoring of vision-threatening diseases.

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By definition, telemedicine is "the use of electronic information and communications technologies to provide and support health care when distance separates the participants."[1] With the introduction of novel tools and technology to remotely diagnose and monitor diseases, the use of telemedicine has expanded across disciplines. Remote diagnosis has utility in ophthalmology, where there is often a need for diagnosis for emergency and inpatient consultations, as well as for screening (e.g., diabetic retinopathy, retinopathy of prematurity [ROP]) and monitoring of chronic disease (e.g., glaucoma). Studies have described models of telemedicine, including application in different clinical settings, rural and urban communities, and screening and monitoring of eye disease. We review the literature and describe the needs, opportunities, and current state of teleophthalmology in each of the clinical settings and disease areas in the United States.

Hospital-Based Evaluations

Emergency Teleophthalmology

Teleophthalmology in the emergency department (ED) setting has the opportunity to provide rapid specialty support to frontline providers. Emergency telemedicine services are unique compared with other areas of telemedicine because needs are typically immediate, requiring real-time teleophthalmology, and often have an interactive audio or video component.[2] This section reviews the opportunity for teleophthalmology in the emergency setting in the United States, summarizes tele-emergency models applicable to ophthalmology, and discusses barriers and potential policy implications.

Annually, approximately 2 million people seek ophthalmic care in the ED setting in the United States.[3] Approximately 33% of these patient encounters occur in nonmetropolitan settings.[3] More than 50% of EDs do not have available eye care professionals.[3] Furthermore, data indicate that house officers are uncomfortable dealing with eye emergencies despite increasing availability of equipment, possibly leading to further disparities in care.[3,4] This could be further aggravated when nonphysician providers evaluate patients in the urgent care setting without physician staffing. Specialty input at the front lines of patient care traditionally has been filled by onsite eye care professionals or by transporting patients to the eye care professional.

Mueller et al[2] describe 3 models of tele-emergency care deployment.

a) Model 1: A central ED physician providing consultative services to nonphysicians at distant sites.

b) Model 2: A central ED physician providing consultative services to multiple smaller EDs at distant sites.

c) Model 3: A specialist (cardiology, neurology, trauma, ophthalmology) providing consultative services to physicians at distant EDs.

A typical tele-emergency consultation has 4 components: diagnosis, treatment decisions, request for admission, and case disposition decisions.[2] The first model addresses all aspects of the tele-emergency consultation, and the second model is best suited for complex cases that may require transfer of care. A model well suited to ophthalmology would likely be a combination of the first and third models. In such a model, an ophthalmologist would be available for consultation to remote physician and nonphysician providers to aid in diagnostic support and treatment initiation. Furthermore, such services would ensure appropriate patient triage and transfer for in-person ophthalmic evaluation as necessary.

Tele-emergency services have proven effective in bringing expert consultation to frontline providers, "permit[ing] accurate and efficient diagnosis and treatment and reducing unnecessary transfers."[2] A survey of 292 administrators and clinicians across 71 hospitals involved with telemedicine found 95% of respondents agreed and 61% strongly agreed with the statement that "tele-emergency improves the quality of care at my facility."[2] Frontline providers believe live consultation improves patient care compared with traditional models and provides useful confirmation of diagnosis and treatment.[2] In addition, telemedicine serves to educate local providers and increase provider and patient confidence in the care provided.[2] Backup specialty input via telemedicine services has the potential to make an infrequent diagnosis for the distant clinician more routine.[2] Tele-emergency also increases provider-to-provider interaction and improves compliance and diffusion of evidence-based protocols.[2] Finally, tele-emergency services shorten time to care, especially in the rural setting where specialty providers are often called from home. It also allows patients to receive care closer to their home and family, avoiding the inconvenience and cost of travel. When transfers do occur, the receiving team is better informed and can organize care ahead of patient arrival, leading to improved coordination of care.[2]

In the United States, there are few applications of teleophthalmology in the emergency setting. The US Army used a teleophthalmology tool for consultations in military settings abroad. Live audio/video services were not available, and communication occurred over email, with 87% of consults accompanied by photographs. In a 5-year retrospective analysis, 53% of teleophthalmology consults were for diagnostic support, and an additional 37% of consults were for management recommendations. The average response time was less than 8 hours and more often quicker than 6 hours. In 23.5% of 285 consultations over the review period, requesters specifically asked for guidance to determine need for medical evacuation.[5] This reflects a need for support by frontline providers and how the ophthalmology patient can be daunting for the "uninitiated."

The only known emergency teleophthalmology program deployed in the United States to the best of our knowledge is at the University of Pittsburgh. Emergency department physicians were given an iPhone 4S (Apple, Cupertino, CA) and an ophthalmoscope adaptor to capture images. Remote ophthalmologists used the clinical history, basic examination findings, and images provided by emergency staff to triage patients. A review of 50 consecutive patients demonstrated that off-site ophthalmologists can make "accurate and safe triage decisions" with this solution.[6]

Teleophthalmology in the emergency setting has the potential to expand the care team, promote patient-centered care, and improve care coordination.[2]

Retinopathy of Prematurity

The goal of tele—ROP screening is to provide assessment for at-risk babies and reduce reliance on the limited number of ophthalmology specialists. A few key barriers that hinder direct examination by ophthalmoscopy are decentralization of neonatal intensive care units (NICUs), low reimbursement, and high ROP malpractice awards.[7,8] In 2015, the American Academy of Pediatrics and the American Academy of Ophthalmology released a joint systematic review of the tele-ROP literature. The 11 studies ultimately reviewed featured independent masked comparison of a cohort of subjects examined with both wide-angle digital retinal photography and reference standard ophthalmoscopic examination. The largest study in the review reported that digital photography for detection of referral-warranted ROP had sensitivity, specificity, and negative predictive values of 98.2%, 80.2%, and 99.6%, respectively.[9] The positive predictive value was 44.3% at a 13.8% treatment-requiring ROP rate.[9] The RetCam product line from Clarity Medicine Systems (Pleasanton, CA) was clinically validated as an adjunct to standard indirect biomicroscopy. However, given the limited view of the full peripheral retina,[9–11] the Academies recommended at least 1 in-person ROP examination before treatment or discharge from tele—ROP monitoring.[7]

An increasing number of pediatric ophthalmologists provide tele—ROP screening services to NICUs throughout the country. The Ophthalmic Mutual Insurance Company (http://www.omic.com/rop-safety-net/) published the “ROP Safety Net” guidelines to provide guidance for safe tele—ROP practice. Focus ROP (www.focusrop.com) has created an online educational platform and certification program for tele—ROP screening. There are several active tele-ROP programs in the United States. Examples include the tele-ROP collaboration between South Shore Hospital in South Weymouth, Massachusetts, and the Department of Ophthalmology at Boston Children’s Hospital, and Stanford University’s “SUNDROP” program that provides tele—ROP screening for 5 community NICUs. A retrospective analysis at the Stanford University program demonstrated sensitivity and specificity approaching 100%, without any adverse events in more than 1000 eyes.[12]

Outpatient Evaluation

The outpatient setting and primary care provider visits provide an opportunity for patients to receive eye care via telemedicine as part of their routine visit. Acquisition of retinal imaging at these ambulatory sites can improve the patient experience, increase the number of patients screened, decrease travel distance to specialists, and facilitate referral to eye care professionals. The most common blinding diseases, such as age-related macular degeneration (AMD), diabetic retinopathy, and glaucoma, share similar features in which routine imaging and screening can appropriately identify individuals who may require further care.

Diabetic Retinopathy

The American Academy of Ophthalmology recommends annual retinopathy screening for diabetic patients.[13] However, only one third of patients adhere to vision care guidelines.[14] The reasons for poor compliance are several, including lack of patient education, lack of access to care, and geographic limitations. Moreover, a study from the 2005–2008 National Health and Nutrition Examination Survey demonstrated that 73% of patients with diabetic retinopathy were unaware of their condition.[15] The goal of telemedicine in diabetic retinopathy screening is to increase the number of patients screened and monitor those at risk for progression.

Several US-based programs have demonstrated the cost-effectiveness and reliability of tele—diabetic retinopathy screening.[16,17] The Veterans Affairs program is the largest telemedicine diabetic retinopathy screening program in the United States. This program uses a "store and forward" technique to increase access to annual diabetic eye examinations.[16] A health care professional identifies those at risk for diabetic retinopathy or those overdue for screening. Nursing staff or technicians then use nonmydriatic digital imaging systems at select primary care clinics to obtain fundus photographs. These photographs are forwarded to a reading center, where an eye care professional evaluates and makes recommendations for follow-up and further evaluation.[18] The Veteran Affairs screening program has improved delivery of eye care to veterans by decreasing the distance traveled for screening eye examinations, screening patients at younger ages, and increasing the number of known diabetic retinopathy cases.[16]

The Indian Health Service-Joslin Vision Network has performed diabetic retinopathy screening for American Indians and Alaskan Natives since 2001.[19] This group has demonstrated the utility of teleophthalmology in screening at-risk and remote populations. Their most recent study demonstrated that nonmydriatic ultrawide-field imaging compared with nonmydriatic multifield fundus photography increased the detection of diabetic retinopathy by approximately 2-fold and reduced the percentage of ungradable images by 81%. Moreover, by using ultrawide-field imaging, peripheral lesions were identified in 10% of subjects that were suggestive of more severe diabetic retinopathy.[20]

In addition to reading centers, several commercial companies have developed automated diabetic retinopathy screening solutions. Commercial systems for diabetic retinopathy screening include the Intelligent Retinal Imaging System, which is an automated computer algorithm—based screening technology. A recent study by Walton et al,[21] using Intelligent Retinal Imaging System screening in 15 015 consecutive patients, demonstrated that the sensitivity and specificity of this system, compared with reading center interpretation, was only 66.4% and 72.8%, respectively. Although the findings are encouraging, further work remains to improve clinical validity.[22] Given the increasing prevalence of diabetic retinopathy, the emergence of automated screening serves as a promising tool to address this public health issue.

Age-Related Macular Degeneration

By 2020, approximately 9 million people in the United States will have vision loss from AMD. The American Academy of Ophthalmology recommends routine screening every 1 to 2 years for those aged 65 years or older.[13] However, similar limitations seen in other retinal diseases exist where patients are unable to access specialty care or are not educated about their disease.[15] Moreover, given that early AMD is generally asymptomatic, and a majority of patients with AMD are unaware of their diagnosis,[15] there is an opportunity for earlier diagnosis with teleophthalmology.

The aim of ongoing trials is to determine the accuracy and utility of digital imaging in AMD screening and for neovascular AMD detection. A recent prospective randomized clinical trial by Li et al[23] evaluated teleophthalmology screening versus retinal specialist—based screening to identify change from dry to neovascular AMD. The study found no differences in wait times between the 2 groups. This suggests telemedicine may be a useful screening tool for the initial detection of neovascular AMD. However, when screening for recurrence of wet AMD, longer wait times to treatment reinitiation were observed, but no adverse visual outcomes occurred. The trial by Li et al[23] was the first application of teleophthalmology for screening and monitoring of wet AMD. The utility of telemedicine in AMD screening is currently not as well validated as diabetic retinopathy screening, and to the best of our knowledge, no established telemedicine programs are in place in the United States for macular degeneration screening.

Although the utility of office-based optical coherence tomography (OCT) to monitor and diagnose AMD is commonplace, the role of OCT in teleophthalmology is less well defined. The ability to evaluate retinal layers and intraretinal and subretinal fluid is a key advantage over fundus photography. A small study with community spectral-domain OCT found that 34% of screened patients did not require "face-to-face" ophthalmology evaluation and demonstrated areas for potential cost savings.[24] However, given the cost of implementing a teleophthalmology system with OCT and limited clinical validation through remote monitoring, further study is indicated.

Home Amsler grids are a critical component of patient self-monitoring. New technology incorporating home monitoring with telemedicine may allow earlier identification of choroidal neovascularization compared with traditional methods. The AREDS2-HOME study[25] used the ForeseeHome device (Notal Vision Ltd., Tel Aviv, Israel), which uses macular visual field testing for home monitoring. A device monitoring center receives the results and reports changes to the clinical center, where the determination is made whether the patient warrants further evaluation. The study found choroidal neovascularization was detected earlier in high-risk patients using home monitoring.[25] Further studies are ongoing and will be essential to identify the role of telemedicine in AMD monitoring.[26]

Glaucoma

Glaucoma is estimated to affect more than 3 million Americans and is the second leading cause of blindness in the United States. Early detection and treatment initiation are essential to prevent asymptomatic vision loss from this "silent thief of vision."

The majority of prior approaches for screening have evaluated the utility of using digitally transmitted optic nerve photographs using portable or handheld cameras. These techniques typically capture stereoscopic optic nerve photos for remote evaluation.[27] One study comparing in-person versus teleophthalmology assessment of cup-to-disc ratio by glaucoma specialists demonstrated moderate agreement.[28] Teleophthalmology approach demonstrated positive and negative predictive values of 77.5% and 82.2%, respectively. Despite these promising findings, there is significant interobserver variability using disc photographs, as is seen in clinical practice.[29]

Adding other tools, such as intraocular pressure measurements, may add data points that facilitate more accurate diagnosis. Although older noncontact tonometers were limited by accuracy, newer technologies[30] and techniques using contact lenses[31] may allow for more accurate and on-demand intraocular pressure measurements. This is especially important for home monitoring, which would allow tracking of diurnal variation and facilitate adjustment of treatment regimens. However, the technology is evolving, and there is still significant variability between different devices.[32]

Advanced testing modalities generally require patients to visit a setting equipped with OCT technology, corneal pachymetry, and perimetry. Given the importance of having trained operators, a telemedicine model that uses an outpatient site as a testing center is promising. In Australia and Canada, glaucoma monitoring by optometrists and technicians under the direction of remote glaucoma specialists led to improved clinical decision making and reduced appointment frequency.[33,34] The Eye Care Quality and Accessibility Improvement in the Community study is ongoing and screens patients for glaucoma at 2 Wal-Mart Vision Centers.[35] In this study, clinical imaging and testing (standard automated perimetry, OCT, or optic nerve head stereoscopic photos) are transmitted and evaluated by a glaucoma specialist at a reading center. The results of this 1-year prospective study are pending; however, this may be a scalable solution given the widespread presence of large retailers with vision centers in the United States.

A recent meta-analysis of tele-glaucoma versus in-person screening demonstrated that tele-glaucoma screening has higher specificity and lower sensitivity for glaucoma detection compared with traditional in-person clinical examinations.[36] Techniques using teleophthalmology and imaging are less time-consuming and reduce overall visit length.[37] A recent report reviewing and modeling the use of teleophthalmology in glaucoma showed telemedicine is cost-effective, increased ophthalmology referral rates, and reduced patient travel time and length of clinic visit.[38]

Barriers to Teleophthalmology

Although telecommunication barriers such as bandwidth and storage limitations have largely been overcome in the United States, the cost of ophthalmic imaging equipment and other hardware can be prohibitive as retinal cameras can cost more than $10 000. Also, teleophthalmology in the outpatient setting relies on already overburdened primary care clinics to perform additional tasks and ensure patient compliance with recommendations from the telemedicine evaluation.

A unique barrier to deployment of telemedicine in ophthalmology is physician perspectives. Although emergency physicians use telemedicine services in other specialties and would likely support and adopt teleophthalmology services, 59% of ophthalmologists reported “low confidence” in their ability to make decisions based on images alone.[39] This contrasts to the University of Pittsburgh’s experience with emergency teleophthalmology, where all patients in their series who required urgent ophthalmic care were appropriately triaged for evaluation.[6] Medical liability also is quoted as a reason for pause; however, medical images are potentially protective because they allow objective documentation of examination findings, mitigating medical malpractice concerns.[39]

Reimbursement remains an additional barrier to widespread adoption. Coverage for telemedicine services among insurance providers varies, and the Current Procedural Terminology billing codes require clarification for applicability to telemedicine.[17] Individual state Medicaid programs have varying and individual restrictions and guidelines for telemedicine delivery.[40] Medicare only reimburses telemedicine services provided in rural areas and does not cover "store and forward" applications, except in Alaska and Hawaii.

Last, individual state licensure limits a practitioner's ability to provide care across state lines. Physicians must be licensed in the state where the patient resides. Widespread implementation is impeded by the often onerous credentialing and licensing process for each state. This is being actively addressed by the TELEmedicine for MEDicare Act of 2015,[41] which would enable providers to provide telehealth Medicare services in any state.[40]

Successful application of teleophthalmology in any of its forms requires development of image acquisition, transfer, and storage systems that adhere to patient confidentiality standards, identification and mitigation of professional liability risk, clear reimbursement/ payment streams, and consistent and continual training of involved personnel.

Conclusions

Telemedicine has transformed the patient experience in multiple medical specialties. Ophthalmic telemedicine in the United States is in its infancy but has the potential to improve access to care, decrease cost of care, and improve adherence to evidence-based protocols. Clinicians will have to reconsider and reevaluate traditional care delivery models as teleophthalmology and remote consultations become more readily available. Clinicians will be tasked with embracing innovation while ensuring protocols and implementation are evidence based and improve outcomes. Although significant barriers lay ahead for widespread adoption, ophthalmic telemedicine shows promise for our patients.

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Abbreviations and Acronyms

AMD	age-related macular degeneration
ED	emergency department
NICU	neonatal intensive care unit
OCT	optical coherence tomography
ROP	retinopathy of prematurity

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