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# The Current State of Teleophthalmology in the United States

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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. *Ophthalmology 2017;■:1–6 © 2017 by the American Academy of Ophthalmology*

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 front-line 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


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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.