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Scaling Up Teleophthalmology for Diabetic Eye Screening: Opportunities for Widespread Implementation in the USA

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Abstract

Purpose of Review—We discuss opportunities to address key barriers to widespread implementation of teleophthalmology programs for diabetic eye screening in the United States (U.S.).

Recent Findings—Teleophthalmology is an evidence-based form of diabetic eye screening. This technology has been proven to substantially increase diabetic eye screening rates and decrease blindness. However, teleophthalmology implementation remains limited among U.S. health systems. Major barriers include financial concerns as well as limited utilization by providers, clinical staff, and patients. Possible interventions include increasingly affordable camera technology, demonstration of financially sustainable billing models, and engaging key stakeholders.

Summary—Significant opportunities exist to overcome barriers to scale up and promote widespread implementation of teleophthalmology in the USA. Further development of methods to sustain effective increases in diabetic eye screening rates using this technology is needed. In addition, the demonstration of cost-effectiveness in a variety of billing models should be investigated to facilitate widespread implementation of teleophthalmology in U.S. health systems.

Keywords

Diabetic eye screening; Diabetic retinopathy; Teleophthalmology; Telemedicine; Implementation; Barriers

Introduction

Diabetic eye disease is the leading cause of blindness in working age U.S. adults [1]. Early detection and treatment reduce the risk of blindness by 95% [2]. Yet, fewer than 60% of patients with diabetes obtain yearly recommended eye screening, with even lower screening rates among underserved populations [3, 4]. Teleophthalmology provides an evidence-based

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method of diabetic eye screening as an alternative to traditional in-person dilated eye exams [5–11]. This technology, endorsed by the American Diabetes Association, increases much-needed access to eye care and has guidelines published by the American Telemedicine Association and English National Health Service [12–16]. Patients obtain retinal photos at a convenient location, such as their primary care provider's clinic, and the images are transmitted to a distant site for grading. The subset of patients found to have significant eye pathology can then be referred in a timely fashion for in-person evaluation by eye care specialists. Using this technology, the English National Health Service has achieved screening rates over 80% and, for the first time in 50 years, the leading cause of certifiable blindness among English working-age adults is no longer diabetic retinopathy [6, 17••].

Adoption of teleophthalmology in the USA has been much slower than that in England. Successful U.S. teleophthalmology programs are largely limited to settings such as the Veterans Affairs (VA) Health System, the Indian Health Service, and large county health systems [18–21, 22•]. These health systems have contributed key evidence validating the effectiveness of teleophthalmology. However, they also have unique features that are neither representative of nor feasible for the vast majority of U.S. health systems with regard to their financial structure and robust electronic health record (EHR) documentation of diabetic eye screening [23]. In addition, teleophthalmology programs that rely on research support for their operations often have difficulty achieving financial sustainability following the end of the grant funding period [23].

Teleophthalmology has tremendous potential to prevent avoidable blindness and increase access to eye care for our growing U.S. population of patients with diabetes. Allowing patients to obtain diabetic eye screening more conveniently in their local communities overcomes significant barriers to care, especially among rural populations [11, 24]. In order to fully reap its benefits, greater adoption of teleophthalmology is needed across U.S. health systems [25]. This review examines the barriers to scale up and widespread implementation of teleophthalmology in the USA (Table 1).

Camera Technology

Advancements in retinal camera technology that do not require pharmacologic pupil dilation (i.e., non-mydriatic fundus cameras) have provided the foundation for the development of teleophthalmology programs. Newer camera technology and changes in imaging protocols have helped address major barriers such as high rates of ungradable images and cost. However, substantial opportunities remain to address remaining barriers related to affordability, space, and portability.

A major barrier to teleophthalmology adoption is a high rate of images ungradable for diabetic eye disease evaluation. Ungradable images can be due to a variety of causes such as small pupil size, eye pathology (e.g., cataract, vitreous hemorrhage), and imager inexperience [5]. Ungradable images require referral for further eye care due to a high prevalence of pathology in these cases [26]. As a result, high ungradable rates can overwhelm downstream eye care services and reduce the cost-effectiveness of teleophthalmology programs. Poor image quality also reduces confidence among imaging staff, which can lead to lower utilization of teleophthalmology. Early teleophthalmology programs reported ungradable image rates of up to 35% despite using professional eye photographers [27–29]. Fortunately, newer cameras have several features that substantially reduce ungradable rates to < 5%. Cameras commonly used in teleophthalmology programs include the Topcon NW400 (Topcon Medical Systems Inc., Oakland, NJ, USA) and the CenterVue DRS (CenterVue Inc., Fremont, CA, USA), which provide more user-friendly imager interfaces, auto-focus, and auto-capture capabilities [16]. These features allow high-resolution retinal images to be reliably obtained even by clinic staff with no eye care experience and minimal training (< 4 h) [30••]. In addition, the use of validated single- or two-field imaging protocols and selective use of dilating eye drops have demonstrated ungradable rates of < 5% [30••, 31, 32••]. Finally, cameras with ultra-wide-field retinal imaging capabilities (e.g., Optos Inc., Marlborough, MA, USA) achieve ungradable rates of < 5% without the use of dilating eye drops, but these cameras have significantly higher costs than non-mydriatic fundus cameras [33•].

More recent advances in camera technology include the development of portable handheld and smartphone-based cameras to overcome barriers related to cost, limited clinic space, and portability [34, 35]. A health care system's initial investment typically ranges from $5,000 to $100,000 per camera, although leasing options may also be available [16]. There may be additional installation, hardware, and service fees [23]. To reduce costs, a single camera can be shared by several clinics that are located in close proximity to one another. Smartphone-based cameras offer an alternative option for providing portable imaging at low cost and may facilitate scale up of teleophthalmology programs due to their widespread availability. However, there are mixed reports regarding the sensitivity of various smartphone-based cameras for diabetic retinopathy detection, and most studies were performed with pharmacologic pupil dilation [36–38]. In addition, current handheld and smartphone-based cameras have higher ungradable rates compared with tabletop non-mydriatic cameras when imaging is performed without pharmacologic pupil dilation [39]. Further investigation is needed to develop more affordable handheld and smartphone-based cameras with improved image quality to increase their sensitivity in diabetic retinopathy detection without pharmacologic pupil dilation. While newer camera technology and imaging protocols have improved image gradability, remaining barriers to widespread implementation of teleophthalmology include affordability, space, and portability.

Cost-effectiveness

Cost-effectiveness is an important consideration for health systems when deciding whether to invest resources into establishing a teleophthalmology program. From the perspective of a health system, the cost-effectiveness of a teleophthalmology program relates to the ability of a program to improve care while decreasing cost and workload burdens [40]. Many published studies have demonstrated that teleophthalmology is cost-effective, but most of these studies were performed in programs that rely on federal appropriations or research grant funding, which are not applicable to the vast majority of U.S. health systems [23]. In addition, concerns regarding unclear billing and reimbursement models, as well as limited guidance in calculating return on investment for individual health systems, are significant barriers to teleophthalmology adoption by U.S. health systems.

Most studies analyzing teleophthalmology's cost-effectiveness have been favorable, but have drawn data from settings not representative of most U.S. health systems [23, 41, 42, 43••, 44]. The cost-effectiveness of teleophthalmology in the USA has been studied in the context of unique populations such as prisoners and federal agencies such as the Veteran's Health Administration [45, 46]. Three models commonly used to analyze cost-effectiveness are incremental cost-effectiveness ratio (ICER), cost savings per patient, and return on investment. Using these models, studies have shown teleophthalmology to cost $16,514 per 18.73 quality-adjusted life years (QALYs) gained compared with a cost of $17,590 per 18.58 QALYs gained using non-teleophthalmology screening methods [45]. Cost-savings and return on investment estimates have varied considerably depending on costs from establishing and implementing the teleophthalmology program. Cost-savings varied between $36 to $154 per patient and an average of US$2.97 million per federal agency for using teleophthalmology in place of traditional in-person dilated eye exams for diabetic eye screening [43••]. A larger patient population and the use of automated grading have also been shown to increase cost-savings [46, 47]. Return on investment has been estimated at $15 for every $1 spent, while another study found a return on investment of 53% [48, 49]. Data on cost-effectiveness have been supportive of teleophthalmology, but estimates vary considerably and are limited by the fact that most data came from settings not representative of the majority of U.S. health systems [23, 25].

Another challenge for U.S. health systems seeking to adopt teleophthalmology programs is the lack of clarity surrounding billing and financial models [23, 50, 51]. There is currently no consensus on which retinal imaging codes should be used to bill for teleophthalmology services (e.g., CPT 92250, CPT 92227, or 92228), and a detailed discussion can be found in a review by Zimmer-Galler et al. [15, 23, 52]. As with other telemedicine services, there can be limited or no reimbursement from payers [23]. Rural health clinics and federally qualified health centers have substantial regulatory limitations for telemedicine reimbursement, despite the fact that they serve populations with the greatest potential to benefit from teleophthalmology [53]. In addition, there are large differences between local coverage determinations and reimbursement for teleophthalmology billing codes among Medicare Administrative Contractors (MACs). State-by-state restrictions and guidelines for administering telemedicine further increase variability, fragmentation of coverage, and uncertainty regarding billing and reimbursement across different regions of the USA [54]. This uncertainty limits teleophthalmology adoption by making it difficult for health system administrators to assess return on investment for providing preventive health services such as teleophthalmology [55]. The financial sustainability of U.S. teleophthalmology programs remains a challenge in the current billing and reimbursement environment [23].

Several factors can influence the cost-effectiveness of teleophthalmology for a given health system. Cost-effectiveness varies depending on the size of the diabetes patient population, baseline diabetic eye screening rates, billing and staffing models, and the proportion of patients enrolled in health insurance plans that offer quality incentives (i.e., payfor-performance) [50]. Diabetic eye screening is a well-established, evidence-based quality measure used in HEDIS and the Centers for Medicare and Medicaid Services (CMS) quality rating programs, in which participating health systems may receive significant financial incentives for achieving certain benchmarks [56, 57]. A high prevalence of diabetes can increase cost-effectiveness [43••]. Other factors include patient age, screening frequency, and utilization. Many U.S. health systems benefit from providing higher quality care at lower cost (e.g., those with large capitated patient populations and/or participating in accountable care organizations). Modjtahedi et al. reported that over 100,000 patients received teleophthalmology diabetic eye screening at Kaiser Permanente Southern California, an integrated health care network of primary care providers and specialists, including eye care providers [58]. Daskivich et al. found that the Los Angeles County safety net's primary care-based teleophthalmology program eliminated 14,000 eye specialty care visits, increased diabetic eye screening rates by 16.3%, and reduced wait times for screening by 89.2% [19]. These types of health systems are more likely to benefit from teleophthalmology programs where start-up costs are recouped by reducing the costs of treating more advanced diabetic eye disease. On the other hand, health systems that rely on billing for services separately (e.g., fee-for-service) may benefit more by providing a higher quantity of higher acuity care (rather than preventive services) since cost-savings to payers are not necessarily shared with the health system [43••]. Health systems must consider these many factors when evaluating the costs, benefits, and methods for implementing a teleophthalmology program. Further development of tools to provide tailored projections regarding return on investment to individual health systems is needed to help guide administrators in making these decisions [59].

Although many studies have shown significant cost-savings from using teleophthalmology compared with traditional eye examinations, they often use data from settings not representative of most U.S. health systems. Additional cost-effectiveness research examining a variety of billing models in community health systems is needed [23]. This data would not only increase adoption of teleophthalmology but would also strengthen the evidence for expanding payer reimbursement for teleophthalmology.

Organizational/Systems

There are multiple organizational and system-level resources needed for successful teleophthalmology implementation. Standardized processes, tailored implementation to the local health system, and communication regarding diabetic eye screening between primary care and eye care providers are critical components. Successful teleophthalmology programs, such as the VA, have benefited from the use of standardized protocols [60]. These protocols include standardization of image capture, grading, and reporting, as well as secure data transmission, storage, and retrieval. The American Telemedicine Association and the American Academy of Ophthalmology have published guidelines and practice recommendations for teleophthalmology programs [15, 61]. However, there is no single, standardized implementation that works for every health system. Each health system must adapt these recommendations to fit their unique needs and resources. Yet, there is limited guidance on how to tailor the implementation of teleophthalmology programs to a local health system. As a reflection of the complexity of teleophthalmology implementation, several commercial entities offer services to facilitate the establishment of teleophthalmology programs for individual health systems [62–64].

Communication of diabetic eye screening is another essential component of most teleophthalmology programs, but can be highly challenging due to the lack of shared or interoperable EHRs [23]. Primary care providers rely on receiving diabetic eye screening reports from eye care providers to determine when a patient is due for screening. Unfortunately, this documentation is often incomplete because many patients obtain eye care from clinics outside their primary care provider's health system, which have non-interoperable EHRs [65]. In addition, eye care providers, unlike other medical specialists, often do not rely on patient referrals from primary care providers. Primary care clinic staff typically have limited time to invest in requesting diabetic eye screening records from outside eye care providers [66]. Therefore, they often rely on patients to self-report diabetic eye screening, which has limited accuracy [67, 68]. In addition, the lack of accurate diabetic eye screening documentation makes it extremely difficult for health systems to assess and improve their performance on this quality measure. Opportunities to improve communication regarding diabetic eye screening include developing standardized workflows and reporting forms, as well as increasing EHR interoperability. Another possibility is the use of regulatory mandates (rather than guidelines) requiring eye care providers to report diabetic eye screening or the establishment of a centralized reporting registry similar to those used for immunizations or prescribing opioids [69, 70].

While guidelines exist for establishing teleophthalmology programs, they are often highly complex to implement. Health systems would benefit from step-by-step guidance to adapt teleophthalmology programs to their unique resources and needs. Improved communication regarding diabetic eye screening represents a major opportunity to improve documentation of screening rates for health systems and increase the likelihood of successful teleophthalmology implementation.

Clinical Personnel

Health systems face multiple barriers for staffing teleophthalmology programs and for achieving the provider and staff buy-in needed to sustain their effectiveness [73, 75]. A health care system must design a workflow that allows imagers to incorporate new tasks into their schedule without being overburdened [61, 71, 75]. Many teleophthalmology programs are situated in primary care settings where 90% of patients with diabetes regularly obtain care [72••]. Understaffing and high staff turnover in these and other settings can decrease image quality, reduce patient and staff satisfaction, threaten the viability of teleophthalmology programs, and may even lead to their abandonment [73]. Various health care systems have designated medical assistants, radiologists, or lab technicians to serve as teleophthalmology imagers by training existing staff [61]. Maximizing the use of existing personnel, rather than hiring new staff to perform imaging, is a practical approach in many primary care clinics since patients with diabetes typically account for a small proportion of overall patient clinic visits each day [72••, 75]. Thus, the relatively low daily volume of teleophthalmology imaging, especially in smaller clinics, may make it difficult to cover the cost of hiring new staff solely to perform teleophthalmology imaging.

While teleophthalmology implementation addresses the current shortage of eye care providers, the shortage of eye care providers available to interpret or grade these images can also be a limiting factor. Health systems can have retinal images graded by their own eye care providers or by partnering with eye care providers in their community. There are also commercial reading centers available that provide image grading services. In addition, recent FDA approval of an autonomous artificial intelligence (AI) software algorithm for grading teleophthalmology images may facilitate widespread adoption of teleophthalmology by reducing the need for human graders [30••, 74]. However, there may be additional barriers with regard to cost and real-world implementation of these AI systems, including health system administrators', providers', and patients' acceptance of this new technology.

An additional personnel issue is that primary care clinic providers and staff may need to perform new tasks to identify and educate eligible patients for teleophthalmology [75]. Typically, there is initial enthusiasm for teleophthalmology that bolsters utilization and drives substantial increases in diabetic eye screening. However, this enthusiasm can wane over time as providers and staff are engaged in other health care quality initiatives. In addition, teleophthalmology can create a perceived barrier of increased workload that further strains the time primary care providers and staff may have to address more acute patient health concerns [32••]. As a result, there can be poor utilization of teleophthalmology after significant investments have been made in staff training, equipment purchases, and program development. A recent randomized controlled trial comparing teleophthalmology to traditional in-person dilated eye exams found that teleophthalmology initially increased diabetic eye screening rates, but screening rates declined below 55% within 18 months [8]. A restructuring of work processes is often needed to accommodate new tasks and responsibilities among primary care providers and clinic staff, which can otherwise become too burdensome and difficult to sustain.

Since the decision to adopt teleophthalmology is often made by health system administrators, front-line providers and staff may have limited investment in the success of the program and are often unfamiliar with teleophthalmology [32••]. Opportunities to strengthen primary care provider and clinic staff buy-in include engaging them in integrating teleophthalmology into existing clinic workflows, as well as having providers and staff undergo teleophthalmology imaging to better describe the experience and convey the benefits to patients [32••]. Additional interventions include providing financial incentives for providers to increase diabetic eye screening rates and providing audit and feedback on diabetic eye screening performance and reminders to discuss diabetic eye screening with patients (e.g., best-practice alerts embedded in the EHR) [32••].

Identifying and training clinical personnel for imaging and grading are now more feasible due to improvements in camera technology, the availability of reading centers, and the promise of AI software. Workflow burdens added to primary care providers and clinic staff are often underrecognized barriers to successful teleophthalmology utilization. Partnering with front-line primary care providers and staff to tailor implementation and integrate teleophthalmology into existing workflows represents an important opportunity to obtain buy-in and minimize staff barriers to adoption [32••]. Ensuring that providers and staff understand the goals and rationale for the teleophthalmology program, have the tools needed to identify patients due for screening, and are able to convey to patients the importance of screening are key to ensuring successful teleophthalmology implementation.

Patients

Despite teleophthalmology's ability to improve access to care and high patient satisfaction, patient adherence with diabetic eye exams may continue to be limited even when teleophthalmology is readily available [8]. Patient barriers include being unfamiliar with teleophthalmology, gaps in knowledge regarding diabetic eye screening, and language and cultural barriers, as well as logistical challenges [32••, 78]. Opportunities to overcome these patient barriers include a strong recommendation to use teleophthalmology from their primary care provider, improve education regarding diabetic eye screening, minimize patient costs, maximize patient convenience to reduce time and travel barriers, and provide patients with reminders when they are due for diabetic eye screening [32••, 78].

Many patients have not heard of teleophthalmology and have limited knowledge regarding diabetic eye screening [32••, 79]. Primary care providers serve a critical role in educating and motivating patients to obtain screening. A primary care provider's recommendation for teleophthalmology has been found to be the strongest facilitator for patients to use this technology [32••]. Furthermore, 90% of patients with diabetes regularly see their primary care provider [72••, 81]. Offering teleophthalmology services within primary care clinics and leveraging a strong recommendation from a patient's primary care provider have significant potential to overcome patient barriers to teleophthalmology use [32••, 72••]. In addition, several studies have demonstrated a need for greater patient education regarding diabetic eye screening in general [76, 80, 82]. This lack of knowledge can be addressed by providing patient education during primary care clinic appointments and diabetes education programs, as well as publicizing teleophthalmology programs among the general public [66, 80, 83]. Such education is most likely to be reinforced when supplied by someone a patient trusts, such as their provider, clinic staff member, diabetes educator, or a peer from a diabetes support group [84]. Patient barriers likely vary among different populations, and further research is needed to better understand which strategies are most effective for different groups. Health systems may benefit from soliciting patient feedback from patient advisory boards and focus groups to tailor the information to their patient population.

Lastly, patient logistical barriers are also important factors to consider in the design of sustainable teleophthalmology programs. These barriers include the out-of-pocket cost for teleophthalmology, as well as time and costs related to travel, time off work, and time spent at the clinic. Due to limited payer coverage of this technology, the out-of-pocket cost of telemedicine remains a barrier for patients [32••]. The overall burden of managing diabetes, along with other medical problems, is another barrier for patients in managing their eye health [32••]. When juggling many medical problems, eye health may not be a high priority prior to the onset of vision symptoms. Maximizing patient convenience in terms of teleophthalmology location (e.g., primary care clinics, pharmacies, or employer-based screening), flexible schedules, and hours (e.g., providing after workhours, weekend, and walk-in availability for imaging) and providing the service at low cost and outreach to patients with reminders when they are due for screening are all opportunities to overcome patient barriers to teleophthalmology use [32••].

While teleophthalmology itself is fundamentally a patient-oriented service, there are many knowledge-related and logistical barriers to patient utilization. Adoption of teleophthalmology by health systems nationwide requires leveraging opportunities to educate patients and maximize their utilization of this technology to improve patient outcomes and prevent vision loss.

Conclusion

Teleophthalmology adoption will be critical to meet the growing need for eye care among the increasing U.S. population with diabetes, particularly in underserved communities. Significant opportunities exist to overcome barriers to scale up and promote widespread implementation of teleophthalmology in the USA. Further development of methods to sustain effective increases in diabetic eye screening rates using this technology is needed. In addition, the demonstration of cost-effectiveness in a variety of billing models should be investigated to facilitate widespread implementation of teleophthalmology in U.S. health systems.

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Table 1

Possible interventions to promote widespread implementation of teleophthalmology for diabetic eye screening in the USA

Category	Barriers	Possible interventions
Camera technology	• High proportion of ungradable images • Cost • Space/portability	• Single- or two-field fundus photography imaging protocols • Selective use of dilating eye drops to obtain gradable images as needed • Use of confocal and wide-field imaging cameras • Each camera serves patients from multiple clinic sites • Less expensive camera technology • Handheld, smartphone-based, and compact tabletop cameras
Cost-effectiveness	• Unclear billing and reimbursement models • Unclear return on investment	• Demonstration of a variety of financially sustainable billing models • Improved insurance reimbursement for telemedicine services • Tailored tools for calculating return on investment for individual health systems
Organizational/ systems	• Need to tailor implementation to individual health system • Incomplete documentation of diabetic eye screening • Limited communication regarding diabetic eye screening	• Toolkit guiding tailored implementation of teleophthalmology to an individual health systems' needs and resources • Improved methods for primary care providers and clinic staff to access and update diabetic eye screening records • Improved methods for communicating diabetic eye screening reports to primary care providers (e.g., standardized workflows and reporting forms, electronic health record interoperability, national or state-wide registries, regulatory mandates)
Clinical personnel	• Imager and grader training/capacity • Obtain provider and staff buy-in and sustain engagement	• Training existing staff or hiring additional staff if needed for imaging • Partnering with local eye doctors and reading centers and/or use of artificial intelligence software for grading images • Engage providers and clinic staff to integrate teleophthalmology and streamline clinic workflow • Provide financial incentives, audit and feedback reporting, and reminders to discuss diabetic eye screening with patients (e.g., best-practice alerts)
Patients	• Lack of knowledge • Time and financial constraints	• Recommendation of teleophthalmology by primary care providers • Patient education materials and publicizing teleophthalmology • Providing teleophthalmology in primary care, pharmacy, or employer screening • Offer convenient, same-day imaging • Low-cost pricing and lower patient co-pays through improved insurance coverage • Outreach to patients with reminders when due for diabetic eye screening (e.g., phone, text, mail)