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Early Experience with Technology-Based Eye Care Services (TECS)

A Novel Ophthalmologic Telemedicine Initiative

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Purpose: The aging population is at risk of common eye diseases, and routine eye examinations are recommended to prevent visual impairment. Unfortunately, patients are less likely to seek care as they age, which may be the result of significant travel and time burdens associated with going to an eye clinic in person. A new method of eye-care delivery that mitigates distance barriers and improves access was developed to improve screening for potentially blinding conditions. We present the quality data from the early experience (first 13 months) of Technology-Based Eye Care Services (TECS), a novel ophthalmologic telemedicine program.

Design: With TECS, a trained ophthalmology technician is stationed in a primary care clinic away from the main hospital. The ophthalmology technician follows a detailed protocol that collects information about the patient's eyes. The information then is interpreted remotely. Patients with possible abnormal findings are scheduled for a face-to-face examination in the eye clinic.

Participants: Any patient with no known ocular disease who desires a routine eye screening examination is eligible.

Methods: Technology-Based Eye Care Services was established in 5 primary care clinics in Georgia surrounding the Atlanta Veterans Affairs hospital.

Main Outcome Measures: Four program operation metrics (patient satisfaction, eyeglass remakes, disease detection, and visit length) and 2 access-to-care metrics (appointment wait time and no-show rate) were tracked.

Results: Care was rendered to 2690 patients over the first 13 months of TECS. The program has been met with high patient satisfaction (4.95 of 5). Eyeglass remake rate was 0.59%. Abnormal findings were noted in 36.8% of patients and there was >90% agreement between the TECS reading and the face-to-face findings of the physician. TECS saved both patient (25% less) and physician time (50% less), and access to care substantially improved with 99% of patients seen within 14 days of contacting the eye clinic, with a TECS no-show rate of 5.2%.

Conclusions: The early experience with TECS has been promising. Tele-ophthalmology has the potential to improve operational efficiency, reduce cost, and significantly improve access to care. Although further study is necessary, TECS shows potential to help prevent avoidable vision loss. *Ophthalmology 2016;■:1–8 Published by Elsevier on behalf of the American Academy of Ophthalmology*

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Vision is critically important. Patients are more fearful about losing their sight than any other disability.[1,2] Studies have identified diabetic retinopathy (DR), cataract, age-related macular degeneration (AMD), and glaucoma as the most common conditions causing visual impairment as people age.[3–6] Routine eye examinations are advised to detect these conditions, and the recommended frequency of these examinations increases over time.[7] Access to ophthalmic examinations can pose logistical challenges for many patients, particularly the elderly and socioeconomically disadvantaged persons, including distance to the clinic and need for transportation.[8–10] In the current economic climate, barriers to care and access disparities may increase as health care trends toward market consolidation. Delays in receiving care may occur if demand for services grows faster than existing clinical infrastructure. These factors combined may cause patients to be diagnosed at later stages of disease because they were unable to obtain eye examinations at the recommended interval.

In the Veterans Affairs (VA), specialty care such as ophthalmology may be located at a main facility that covers a large catchment area. Many veterans must travel a long distance to receive specialty care, which can be expensive and inconvenient. The travel barrier and rapid growth in demand for eye services (3.5% per year nationally and 12.2% in Atlanta[11]) far exceed existing clinical infrastructure and can result in delayed or lost access to eye care. The VA is in need of a better eye care delivery

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model that is more patient-centric, maximizes operational efficiency, and ultimately, is sustainable long term by either being cost-neutral or cost-saving to the system.

As a quality assurance−quality improvement (QA/QI) initiative, the Atlanta VA Eye Clinic launched a remote eye screening program called Technology-Based Eye Care Services (TECS).[12] The TECS protocol was developed from previously published literature[13−16] and was tested in the research setting[12,17] before being used in the clinical setting. The main goals of this program are 2-fold: (1) improve access by expanding the reach of specialty eye care, particularly to those living in rural communities and/or are socioeconomically disadvantaged; and (2) to develop a patient-centric eye care delivery model that improves operational efficiency. Information is reported according to Standards for Quality Improvement Reporting Excellence guidelines.[18]

Methods

This project was reviewed by the Atlanta VA Research and Development Department and judged to be a QA/QI study. Therefore, institutional review board approval was neither required nor obtained, participants did not sign informed consent, and clinical trial registration was not necessary. This project conformed to the tenets in the Declaration of Helsinki and complied with the Health Insurance Portability and Accountability Act. The VA Office of Rural Health supported the establishment of 3 rural TECS sites with clinical grants for fiscal years 2015 and 2016. Veterans' Integrated Service Network 7 supported the establishment of 2 urban TECS sites.

Technology-Based Eye Care Services Program

Technology-Based Eye Care Services is an ophthalmology−primary care partnership and is a form of ophthalmologic telemedicine, defined by the American Academy of Ophthalmology as "Care that uses telecommunication to facilitate ophthalmic care for remote evaluation of eye disease." An ophthalmology technician is based permanently in a primary care clinic and operates out of a single 120-square-foot room that does not contain typical eye lane equipment (i.e., no slit lamp or phoropter).[12,19,20] Screening data is collected including medical, ocular, family, and social history, best corrected distance and near visual acuity, refractive status (Marco ARK 1S), and intraocular pressure (iCare rebound tonometer), corneal pachymetry (Accutome PachPen), pupil check and mydriatic, non-stereoscopic, 45 degree fundus photographs of each eye.[19] The fundus photography protocol follows the standard, validated VA protocol utilized for the diabetic teleretinal screening program and includes images from the posterior pole, superotemporal, and nasal retinal fields along with an external photograph of each eye. Refractive status is measured by auto-refraction with some manifest adjustment. The auto-refractor used contains a built in Snellen eye chart capable of measuring distance and reading visual acuity with or without the auto-refraction in place, and there is the capability for manifest sphere adjustments in ±0.25D increments. Technicians also have trial lenses and will perform trial frame manifest refraction if there is a large difference between the current wearing and auto-refraction prescription, significant astigmatism (>2.00 D), or high myopia/hypermetropia (±5.00 D). All information is uploaded into the electronic health record (EHR). A physician reviews the information remotely, develops an assessment and plan, and prescribes eyeglasses. The readers follow a protocol that delineates when patients should be referred for a subjective refraction or in-person exam. A few example criteria include: best corrected distance vision 20/40 or worse, evidence of corneal irregularity or dryness, acute onset (2 weeks or less) of flashes/floaters. Those who require follow-up are seen face-to-face in the eye clinic.

The study population reported here (TECS cohort) encompasses all patients who received their eye care through the TECS program from March 2, 2015 (TECS inception date), through March 31, 2016. Patients with acute eye issues or known eye disease and those not desiring to receive eye care remotely were not screened in the TECS Clinic but rather scheduled for a face-to-face clinic examination. The Atlanta VA Eye Clinic also runs a New Comprehensive Clinic (NCC) that is dedicated to seeing new patients for routine eye care through a standard face-to-face visit. The NCC cohort in the same 13-month time frame was used as a comparison to the TECS cohort to assess impact of the TECS program.

Two main categories of assessment were tracked: program operation and access to care. Program operation was measured using 4 metrics: patient satisfaction, eyeglass remake rate, disease detection, and length of visit (also known as cycle time). Access to care was measured by appointment wait time and no-show rate.

Collection of Demographic, Rurality Data

Demographic information for patients seen in both the TECS and NCC Clinics during the 13-month time frame was extracted from the VA's Corporate Data Warehouse (CDW). The CDW is a standard database structure that incorporates information from multiple sources to facilitate reporting and data analysis at the enterprise level. Using this data repository, demographic data, diagnostic codes, and appointment and visit information were obtained for each patient using Microsoft SQL Server Management Studio (Microsoft Corp, Redmond, WA). Once obtained, data were analyzed using SAS software version 9.3 (SAS Institute, Cary, NC).

Race or ethnicity data were retrieved from the appropriate relational database tables and coded as non-Hispanic white, non-Hispanic black, Hispanic, other, or unknown. Non-Hispanic veterans of mixed race were classified as other, unless one of the races noted was black, in which case the patient was considered to be non-Hispanic black. Rurality, defined by Rural Urban Commuting Area (RUCA) codes, was based on resident zip code and classified veterans as living in urban, rural, or highly rural areas.[20] The number of years a patient had been using the VA Medical Center (VAMC) was calculated from the day the patient's enrollment became effective to the end of fiscal year 2015. The last eye examination in the VA was identified using stop code 407 or 408 indicating a visit to ophthalmology or optometry. Elixhauser comorbidities were recognized by the International Classification of Diseases, Ninth Revision, Clinical Modification, codes (using the enhanced International Classification of Diseases, Ninth Edition, Clinical Modification) and the International Classification of Diseases, Tenth Revision, codes in the patient's record from January 1, 2010, to the present.[21]

Program Operation Assessments

Patient Satisfaction. Patients were asked to complete the VA Telehealth Survey, which includes 6 questions based on a 5-point Likert scale (Supplemental Material, available at www.aaojournal.org). The anonymous survey was distributed to each patient by the technician at the completion of the TECS appointment. Patients were invited to leave the survey in an envelope at the end of the visit or mail it back to the VA at a later date. Scores were documented and then averaged per question. The total number of survey responses obtained was divided by the total number of patients seen to obtain the survey response rate.

Table 1. Characteristics and Quality Indicators of Patients Receiving Routine Eye Care Through Technology-Based Eye Care Services and the New Comprehensive Clinic*

Patient Characteristics	Technology-Based Eye Care Services	New Comprehensive Clinic	*P* Value
No. of patients	2690	4790	
Age (yrs), mean ± SD	62.8±12.1	58.0±12.7	< 0.001
Gender (%)			< 0.001
Male	90.8	84.6	
Female	9.2	15.5	
Race or ethnicity (%)			< 0.001
Non-Hispanic white	62.9	24.7	
Non-Hispanic black	29.3	68.1	
Hispanic	1.4	1.4	
Other	1.5	1.9	
Unknown	4.6	4.1	
RUCA category (%)			< 0.001
Urban	57.6	93.0	
Rural	38.4	6.9	
Highly rural	4.1	0.1	
Last known eye examination (%)			
More than 5 yrs ago†	20.6	18.6	0.183
More than 10 yrs ago‡	4.6	3.7	0.337
Selected Elixhauser comorbidities§			
Diabetes, uncomplicated	37.1	29.4	< 0.001
Diabetes, complicated	22.2	16.0	< 0.001
Obesity	40.9	35.9	< 0.001
Hypertension, uncomplicated	72.9	64.7	< 0.001
Cardiac arrhythmias	14.8	11.9	< 0.001
Peripheral vascular disorders	9.2	7.2	0.003
Chronic pulmonary disease	22.9	19.4	0.003
Hypertension, complicated	5.4	8.1	< 0.001
Alcohol use	15.6	24.3	< 0.001
Drug use	9.6	20.0	< 0.001
Psychoses	4.0	8.1	< 0.001
Depression	45.1	52.3	< 0.001
AIDS/human immunodeficiency virus	0.3	2.3	< 0.001
Rheumatoid arthritis/collagen vascular disease	1.6	2.4	0.024
Congestive heart failure	6.9	7.3	0.528
Results of examination (%)			
Glaucoma and glaucoma suspect	15.5	19.4	< 0.001
Macular degeneration	4.2	1.7	< 0.001
Diabetic retinopathy	4.6	2.2	< 0.001
Media opacity/cataract	28.0	59.4	< 0.001
Process measures (%)			
Eyeglass remake‖	0.64	0.94	0.322
No-shows	5.2	17.0	< 0.001
Cycle time (median minutes)	n = 262	n = 265	
Patient overall experience (check-in to photograph upload or eyeglass consult)	63	85	< 0.001
Patient care experience (technician workup to photograph upload or doctor sign-out)	38	48	< 0.001
Technician workup time (open Medflow to dilation time)	18	13	< 0.001
Doctor time (open Medflow to close Medflow)	5	10	< 0.001

RUCA = Rural Urban Commuting Area codes; SD = standard deviation.
*Comparison with New Comprehensive Clinic (i.e., routine eye care) at Atlanta main eye clinic.
†Includes veterans who had used the Veterans Administration Medical Center for 5 years or more (n = 3080).
‡Includes veterans who had used the Veterans Administration Medical Center for 10 years or more (n = 2268).
§For the full list of all 31 Elixhauser comorbidities, see Supplemental Table 1 (available at www.aaojournal.org).
‖Eyeglass remake rate: Technology-Based Eye Care Services, 7 of 1101; New Comprehensive Clinic, 84 of 8966.

Eyeglass Remakes. The main purpose for assessing eyeglass remakes in this setting was to determine if patients could successfully use prescription eyeglasses derived mostly from auto-refraction instead of the standard manifest refraction. All eyeglass returns and reasons for return are tracked on a database maintained by the Atlanta VA optical contractor. While eyeglasses may be remade for many reasons (e.g., change in base curve of lenses, intolerance to progressive bifocals, near add change because of working distance) only eyeglass remakes because of incorrect distance prescription were identified as a "Dr. Rx Change." The medical charts for each remake were reviewed to determine the reason for the incorrect distance prescription. Eyeglass remakes were

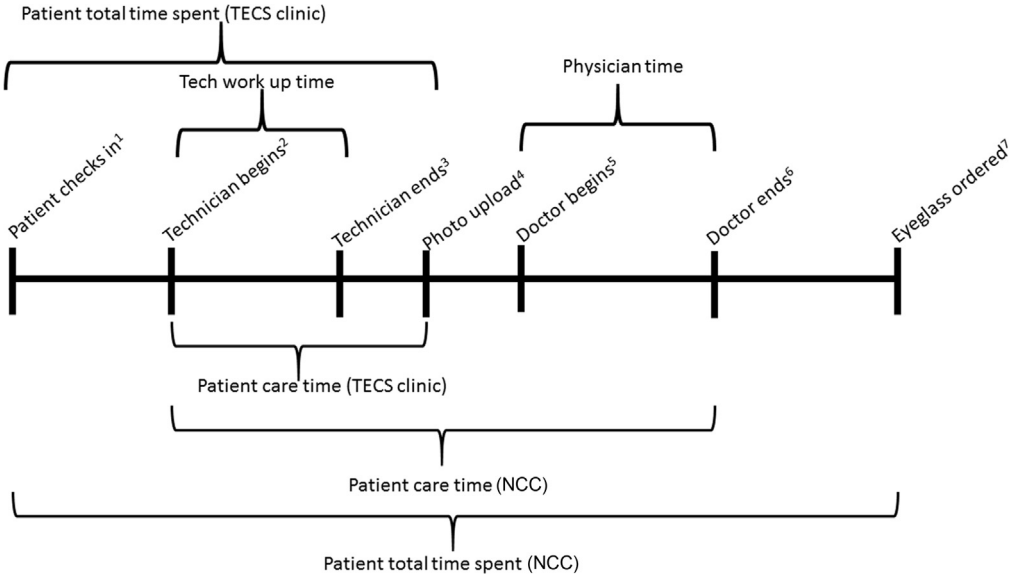

Figure 1. Flowchart showing cycle time intervals: 1 = documented in VistA for both Technology-Based Eye Care Services (TECS) and the New Comprehensive Clinic (NCC); 2 = time stamp when technician opens Medflow for both TECS and the NCC; 3 = time stamp when technician documents dilation in Medflow for both TECS and the NCC; 4 = time stamp when photographs are uploaded into VistA Imaging (TECS clinic only); 5 = time stamp when physician opens Medflow for both TECS and the NCC; 6 = time stamp when physician signs chart in Medflow for both TECS and the NCC; 7 = time stamp on the eyeglass consult order placed in the Veterans Affairs medical record (NCC only).

defined as a change in distance prescription (more than ±0.50 D sphere, ±0.25 D cylinder, or ±5° axis) from the initial prescription. The total number of "Dr. Rx Change" returns divided by the number of eyeglasses shipped yielded the eyeglass remake rate. The eyeglass remake rate was compared between TECS and the NCC.

Disease Detection. Eye diseases of interest were determined using International Classification of Diseases, Ninth Revision, and International Classification of Diseases, Tenth Revision, codes as outlined in Table 1. Cataracts, DR, AMD, glaucoma or glaucoma suspect, and select other eye diseases were chosen because they are the most common causes of visual impairment in the Veteran population. Disease was confirmed through both manual chart review and Corporate Data Warehouse queries of the patients who were referred and attended their face-to-face examination that occurred at the Atlanta VA Eye Clinic. The examining physician's diagnoses and plan were compared with the TECS referring diagnoses. Percent agreement and κ values were calculated. In all cases, the face-to-face visit was considered the gold standard. Fifty-six patients, identified through Corporate Data Warehouse queries, showed normal results on their TECS screening, but eventually had a face-to-face visit at the eye clinic after the TECS examination. These charts also were reviewed manually to determine whether the examining physician found disease that the TECS examination did not identify.

Length of Visit and Cycle Time. The Atlanta VA uses a variety of electronic health care record (EHR) systems. An eye care-specific EHR, Medflow, collects clinical information and sends a narrative note to the national VA Computerized Patient Record System (CPRS). Photographs are stored on an image management system, VistA Imaging. As data is entered during the patient encounter, Medflow places time stamps on clinical processes. Figure 1 illustrates the time stamps and intervals that were calculated during each patient's care process through TECS or NCC for a 6-week period. The NCC patients were chosen, whenever possible, to match the day of the week and the appointment time of the corresponding TECS patients. The median intervals for TECS and NCC were calculated and compared using the Wilcoxon test to determine whether the difference in the medians was statistically significant. Furthermore, to verify the validity of the time stamps collected from the Medflow, the care process was observed directly and timed physically with a watch in both TECS and the NCC.

Access to Care Assessments

Wait Time to Appointment. Wait time is defined in 2 ways. Typically, it is calculated as the difference between the date the patient requested their appointment and the actual date they were scheduled. For example, if a patient calls and requests an appointment (desired date) for Monday the 1st and he is scheduled for Friday the 5th, the wait time to appointment is 4 days. If no specific date request is documented (i.e., patient desires the first available appointment), then the wait time to appointment is defined as the difference between the day the patient contacted the VA for an appointment and the actual date their appointment was scheduled. Wait time—to—appointment calculation was based on the day the patient contacted the VA for an appointment and the actual day of the appointment unless a desired date was requested, in which case the desired date was used in the calculation.

No-Show Rate. The no-show rate was calculated for both TECS and NCC by dividing the number of patients who did not show for their scheduled appointments by the number of appointments made. If a patient called and rescheduled an appointment, then he did not count as a no-show.

Results

Demographic and Comorbidities

In 13 months, across 5 primary care clinics, TECS provided eye screening to 2690 veterans, a 43.8% increase over the main eye

Table 2. Agreement between Technology-Based Eye Care Services Reading and Face-to-Face Examination Results (n = 614)

Diagnosis	Technology-Based Eye Care Services Examination, No. (%)	Face-to-Face Examination, No. (%)	Agreement (%)	κ Value (Confidence Interval)
Glaucoma and glaucoma suspect	254 (41.4)	251 (40.9)	93.6	0.87 (0.83–0.91)
Age-related macular degeneration	53 (8.6)	60 (9.7)	97.2	0.83 (0.76–0.91)
Diabetic retinopathy	48 (7.8)	49 (8.0)	97.6	0.83 (0.75–0.92)
Media opacity/cataract	215 (35.4)	352 (57.3)	71.1	0.45 (0.39–0.51)
Other eye diseases (benign neoplasm of choroid, hypertensive retinopathy, venous tributary occlusion of retina, macular puckering of retina, drusen [degenerative] of retina)	39 (6.4)	28 (4.6)	94.6	0.48 (0.33–0.63)

clinic (NCC) alone during the same period (4790 patients). These patients were significantly older (TECS, 62.8 years; NCC, 58.0 years), were men (TECS, 90.8%; NCC, 84.6%), and were non-Hispanic white persons (TECS, 65.9%; NCC, 25.8%). They were more likely to live in a rural or highly rural area (TECS: rural, 38.2%; highly rural, 4.2%; NCC: rural, 6.8%; highly rural, 0.1%). A slightly higher percentage of Veterans in TECS (20.6%) had not had an eye exam in over 5 years, compared to 18.6% in NCC, though the *P* value was not significant (Table 1).

Patients seen in the TECS clinics were more likely to have diabetes (complicated and uncomplicated), obesity, uncomplicated hypertension, hypothyroidism, cardiac arrhythmias, peripheral vascular disorders, and chronic pulmonary disease than patients seen in the NCC. Patients with conditions requiring frequent visits to the main VA, such as hypertension with complications, alcohol or drug abuse, psychoses, and HIV, were significantly more likely to receive eye care through the NCC (Table 1; Supplemental Table S1, available at www.aaojournal.org).

Program Operation

Patient Satisfaction. The TECS program showed a high level of patient satisfaction, with 99.5% of the 1126 patients who were surveyed (41.9% survey response rate) indicating that they "definitely would recommend (the) clinic" and 91.8% giving the clinic an "excellent rating of overall service." The majority of patients provided a response of "strongly agree" to "clinic provided high-quality service" (93.4%), "information was clear and adequate" (95.6%), "staff provided opportunities to ask questions" (96.7%), and "location of clinic is convenient" (90.2%).

Eyeglass Remakes. The remake rate for eyeglasses through TECS versus the NCC was comparable, with no statistically significant difference between them (Table 2).

Disease Detection. In the TECS cohort, 989 individuals (36.8%) were referred for a conventional eye clinic examination. Most of these follow-up appointments were for a diagnosis of glaucoma or glaucoma suspect or for cataracts or media opacity

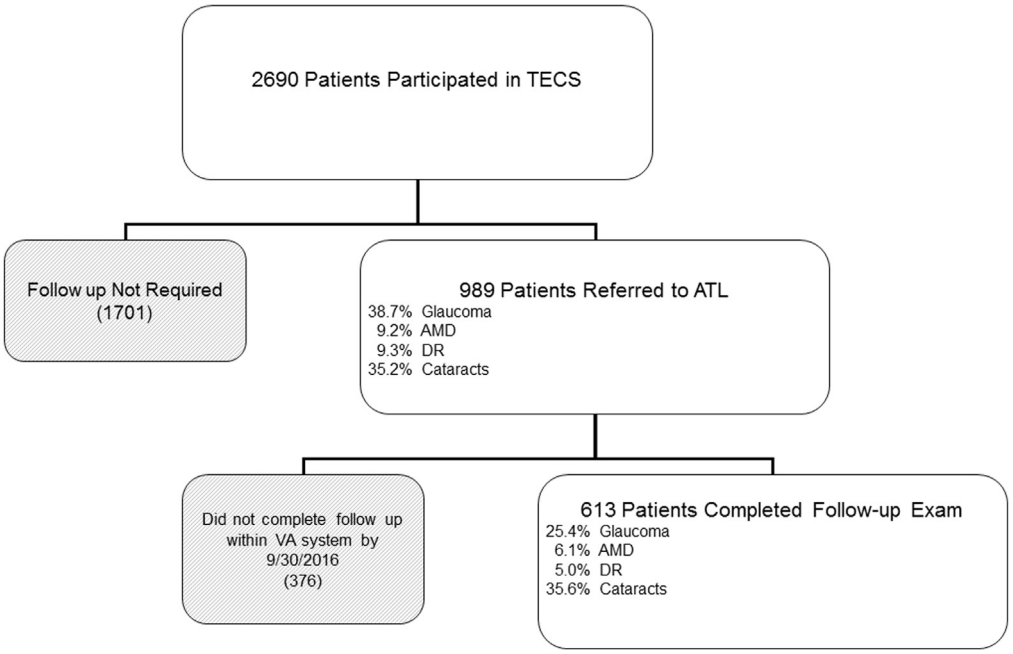

Figure 2. Flowchart showing the determination of cohorts. A total of 2690 patients were seen in the study period. Of these, 989 were referred for possible abnormalities requiring an in-person examination. Among the patients who underwent an in-person examination by September 30, 2016, 613 were seen with the diagnostic results shown. AMD = age-related macular degeneration; ATL = Atlanta; DR = diabetic retinopathy; TECS = Technology-Based Eye Care Services; VA = Veterans Affairs.

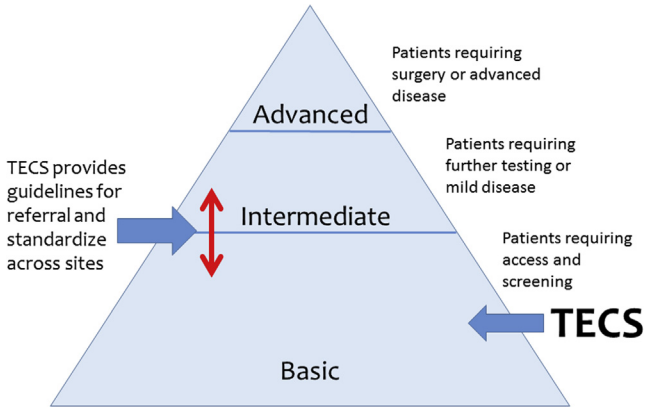

Figure 3. Distribution of eye care resources in the "pyramid model."

(glaucoma or suspect, 38.7%; cataracts/media opacity, 35.2%). Over 60% of the referred patients completed an in-person exam at the Atlanta Main Clinic by September 30, 2016. The follow up show rate for the TECS patients was better than the follow up show rate for patients screened through the Diabetic Teleretinal Imaging Program in Atlanta (approximately 50%)[17,22] (Fig 2). A comparison of the results of the TECS and the face-to-face examinations showed very high agreement between diagnoses. Except for cataracts, all diagnoses of interest had more than 90% agreement. The κ statistic, indicating the percent agreement adjusted for chance, indicated a moderate to almost perfect agreement for all diagnoses (Table 2). Some patients (n = 56) with a normal TECS screening results did undergo a face-to-face examination 1-12 months after their TECS visit, 53 were confirmed to be normal. The remaining 3 patients were found to have a mildly increased cup-to-disc ratio 0.6 or smaller on their face-to-face examination; however, subsequent glaucoma testing revealed no visual field deficit and normal intraocular pressure. None of these 3 patients were started on therapy.

Length of Visit (Cycle Time). The median total patient time spent in TECS was shorter by more than 25% (TECS, 63 minutes; NCC, 85 minutes). Most importantly, the physician time required per TECS visit was half that required for the NCC visit (TECS, 5 minutes; NCC, 10 minutes; Table 1; Fig 1).

Access to Care

Wait Time to Appointment. The wait time for TECS appointments was considerably less when compared with the NCC, with most TECS patients being seen within 1 week (TECS, 71%; NCC, 37%). Although 42% of NCC patients waited more than 2 weeks for an appointment, only 2% of TECS patients waited that long. Twenty-seven percent of the TECS patients received same-day access versus 5% of the NCC patients.

No-Show Rate. The TECS no-show rate was considerably less than the NCC no show rate (TECS, 5.2%; NCC, 17.0%).

Discussion

Technology-Based Eye Care Services is a comprehensive tele-ophthalmology screening program that combines elements of the standard ocular examination with photographs into a single protocol. Program operation results were positive, demonstrating high patient satisfaction, indicating that patients find telemedicine acceptable and are willing to receive care remotely. Interestingly, although the TECS patients had more comorbidities than the NCC cohort and were older, they were less likely to receive eye care than the NCC cohort who frequented the main hospital for their medical care. This stresses the importance of reaching out to remote areas, because those patients are far less likely to seek care because of distance, but simultaneously are more at risk and more likely to have undiagnosed ocular disease than urban veterans. Second, the eyeglass remake rate shows that eyeglass prescriptions derived mostly from autorefraction alone seem to be well tolerated by the majority of patients, as TECS eyeglasses did not result in significantly higher returns compared to NCC eyeglasses, whose prescriptions derived from traditional manifest refraction techniques. These findings are supported by other previously published literature.[12,23,24] Third, TECS appears to be an effective technique to detect and screen veterans for eye disease. There was a high correlation between the reading and face-to-face physician examination with the κ values and percent agreements consistent with those of other published studies.[25–27] Multiple additional papers also validate the ability of diabetic teleretinal photographs to detect nondiabetic disease.[25–29] Further studies may be warranted, however, because there are limitations to the TECS disease detection metric utilized in this report. The limitations include the inability to calculate sensitivity or specificity because those interpreted as normal generally do not return for a second face-to-face exam. A review of the 56 patients who had a normal TECS screening result and subsequently had an in-person exam showed only 3 discrepancies, all based on borderline increased cup-to-disc ratio with no evidence of glaucoma on further testing, but the number is too small to interpret with statistical confidence and uses a sample of convenience rather than a random sample. Furthermore, specificity and percent agreement may be artificially elevated because of bias created when face-to-face providers can review existing TECS interpretations. Another limitation is that the chosen eyeglasses remake rate may not completely reflect whether patients tolerate their glasses as some veterans may not return for a remake. However, this scenario would also apply to patients cared for through a more traditional clinic-based visit.

Finally, data on cycle time indicated that a TECS visit was shorter than an NCC visit, a finding consistent with other literature on telehealth.[30,31] The cycle time is shorter primarily because the patient does not wait for a face-to-face evaluation and because optical assessment is integrated into the TECS visit, with selection of glasses done during the dilation waiting period. Segment height and pupillary distance are measured prior to dilation. In a typical face-to-face examination, patients go to optical after their examination because it is usually located in a separate place. Finally, the physician time was 50% shorter in TECS, likely because the examination itself is not limited by factors such as patient movement in the clinic, positioning or mobility.

In terms of access metrics, TECS was able to provide an appointment to 98% of veterans within 14 days of desired

date, 27% received same day access. This is a substantial improvement over NCC, where 27% of patients wait over 30 days and same-day access for routine care is unusual (5%). The lower no-show rate, probably because of the location of the clinic and ease of combining the eye visit with another primary care visit.

Through TECS, the Atlanta VA Eye Clinic was able to provide needed access to eye care and improve Eye Clinic operational efficiency. It is the authors' belief that in order to deliver the most cost-effective and efficient eye care from a large population management healthcare perspective, a system should concentrate specific resources on specific areas of need. Eye care should be viewed as a spectrum of needs: basic, intermediate and advanced (Fig 3). The most valuable resources, clinic availability and subspecialty care at the main medical center Eye Clinic, should be dedicated to the most complex and advanced conditions. Prior to TECS, the Eye Clinic used the standard NCC delivery model in which patients with all levels of eye care needs were managed with essentially the same process. This care delivery system did not address logistical barriers patients' faced nor did it allow for 'pre-triage' to separate the needs of routine and diseased patients. TECS has allowed the Atlanta VA Eye Clinic to be more efficient. TECS provides a working diagnosis prior to the in-person clinic visit thereby allowing appropriate coordination of ancillary testing and/or sub-specialty care. Second, physician time is valuable and TECS allowed for a 50% reduction in provider time caring for basic eye care patients, thereby leaving more time to spend on patients with more serious disease. Furthermore, each TECS appointment represents a patient slot that increased the capacity of the Eye Clinic to see basic eye care patients while using less costly personnel and equipment. TECS also decreased missed opportunities with a lower no show rate, permitting the Eye Clinic to improve clinical utilization. Reduced space requirement (TECS 120 square feet vs NCC 500 square feet), less costly technician time, and decreased equipment cost should keep the program sustainable while still helping to address the 12.2% per year growth that Atlanta is experiencing.

Preliminary cost data on TECS for the rural sites has been published and illustrated an average of 90 miles round trip driving distance saved, with 85 minutes of driving time, or $32 in time cost savings for travel, per veteran.[32] In addition, cycle time data shows that patients saved 22 minutes, or $8.50, when completing a TECS vs NCC visit. A more detailed cost analysis from the VA perspective is underway but preliminary data also illustrates that TECS is cost-saving to the VA system since the VA reduces beneficiary travel pay (mileage reimbursement) if patients can be cared for at their primary medical care home ($52/patient) to NCC because the space required is smaller, less equipment is required, and personnel is not as expensive.[32]

After further study, the TECS model may be applicable in the greater ophthalmology community as it can expand the reach of ophthalmic services to a population of patients that otherwise has limited or no access, such as patients who are home bound, rural, homeless, or medically underserved.[33] Versions of this model could be applied to other settings, such as the emergency room (ER) to gather important information for triage purposes,[34] or to provide follow up care for patients while the physician is away from the clinic location.

Early experience with TECS has been promising. From the QA/QI data, TECS achieved the goals of providing more patient-centric care by decreasing the veteran's logistical burden to receive care, improved access, and provided an alternative eye care delivery path that is more operationally efficient and potentially cost-saving. Further avenues of study include looking at the impact of TECS on the main Eye Clinic's resources, possible enhancements to the TECS protocol, and a more thorough cost study from different economic perspectives.

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Abbreviations and Acronyms:
EMR = electronic medical record; **NCC** = New Comprehensive Clinic; **TECS** = Technology-Based Eye Care Services; **VA** = Veterans Affairs; **VAMC** = Veterans Affairs Medical Center.

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