

# Longitudinal Use of Telehealth During the COVID-19 Pandemic and Utility of Asynchronous Testing for Subspecialty-Level Ophthalmic Care

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**IMPORTANCE** Telehealth in ophthalmology has traditionally focused on preventive disease screening with limited use in outpatient evaluation. The unique conditions of the COVID-19 pandemic afforded the opportunity to evaluate different implementations of teleophthalmology at scale, providing insight into expanding teleophthalmology care.

**OBJECTIVE** To compare telehealth use in ophthalmology with other specialties and assess the feasibility of augmenting ophthalmic telehealth encounters with asynchronous testing during the COVID-19 pandemic.

**DESIGN, SETTING, AND PARTICIPANTS** This quality improvement study evaluated retrospective, longitudinal, observational data from the first 18 months of the COVID-19 pandemic (January 1, 2020, through July 31, 2021) for 881 080 patients receiving care from outpatient primary care, cardiology, neurology, gastroenterology, surgery, neurosurgery, urology, orthopedic surgery, otolaryngology, obstetrics/gynecology, and ophthalmology clinics of the University of California, San Francisco. Asynchronous testing was evaluated for teleophthalmology encounters.

**INTERVENTIONS** A hybrid care model wherein ophthalmic testing data were acquired asynchronously and used to augment telehealth encounters.

**MAIN OUTCOMES AND MEASURES** Telehealth as a percentage of total volume of ambulatory care and use of asynchronous testing for ophthalmic conditions.

**RESULTS** The volume of in-person outpatient visits dropped by 83.3% (39 488 of 47 390) across the evaluated specialties at the onset of shelter-in-place orders for the COVID-19 pandemic, and the initial use of telehealth increased for these specialties before stabilizing over the 18-month study period. In ophthalmology, telehealth use peaked at 488 of 1575 encounters (31.0%) early in the pandemic and returned to mostly in-person visits as COVID-19 restrictions lifted. Elective use of telehealth was highest in gastroenterology, urology, neurology, and neurosurgery and lowest in ophthalmology. Asynchronous testing was combined with 126 teleophthalmology encounters, resulting in change of clinical management for 32 patients (25.4%) and no change for 91 (72.2%).

**CONCLUSIONS AND RELEVANCE** Telehealth increased across various specialties during the COVID-19 pandemic. Combining teleophthalmic visits with asynchronous testing suggested that this approach is feasible for subspecialty-level evaluation. Additional study is needed to evaluate whether asynchronous testing outside the same institution could provide an effective and lasting approach for expanding the reach of ophthalmic telehealth.

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Use of telehealth increased during the COVID-19 pandemic to maintain patient access to care while minimizing person-to-person transmission of the SARS-CoV-2 virus. In the US, telehealth use among Medicare beneficiaries rose more than 130-fold in the early months of the pandemic<sup>1</sup>; however, adoption was not uniform. Medical specialties used remote services significantly more than their surgical counterparts.<sup>2</sup> Telehealth in ophthalmology has historically followed the store-and-forward model, wherein retinal photography is combined with remote interpretation for screening of ophthalmic diseases, such as diabetic retinopathy and retinopathy of prematurity.<sup>3</sup> In 2018, the American Academy of Ophthalmology highlighted the increasing importance of telehealth and its potential to enhance existing practices while enabling new care paradigms.<sup>4</sup> Recent work has sought to expand the scope of telehealth in ophthalmology to include outpatient consultation and monitoring of additional diseases, such as glaucoma.<sup>5</sup> Nevertheless, telehealth use by ophthalmology was modest compared with other specialties at the onset of the COVID-19 pandemic,<sup>6-8</sup> presenting a unique opportunity to evaluate the feasibility of different models of ophthalmic telehealth implemented at scale. In this study, we compared telehealth trends between different clinical specialties and ophthalmic subspecialties at a major academic institution over 18 months, beginning at the onset of the COVID-19 pandemic. We also evaluated a model of asynchronous testing as an approach to augment telehealth care within ophthalmology.

## Methods

The University of California, San Francisco (UCSF), institutional review board approved this study. A waiver of consent for medical record review was approved because this retrospective quality improvement study presented no more than minimal risk of harm to participants and involved no procedures for which written consent is normally required outside of the research context. This study followed the tenets of the Declaration of Helsinki and the Standards for Quality Improvement Reporting Excellence (SQUIRE) reporting guideline.

### Specialty and Ophthalmic Subspecialty Telehealth Trends

We compared telehealth use in ophthalmology with a range of surgical specialties previously evaluated for telehealth use before the COVID-19 pandemic.<sup>9</sup> Several medical specialties were also added to compare nonsurgical specialties with surgical ones. The number of ambulatory visits (a total of 881 080 encounters) conducted from January 1, 2020, to July 31, 2021, across 11 specialties, including ophthalmology, were obtained through the UCSF Ambulatory Recovery dashboard. This dashboard, which was developed by the institutional Digital Patient Experience Analytics program, visualizes Direct Access Reporting Tool data. Encounters were stratified by type (video, nonvideo, and procedure) and completion status (scheduled, arrived, or completed). Additional subspecialty-level data within ophthalmology were acquired from billing data in the same fashion.

## Key Points

**Question** How did telehealth use compare among clinical specialties during the COVID-19 pandemic, and was there utility for asynchronous testing in teleophthalmology at an academic institution?

**Findings** In this quality improvement study of 881 080 patient encounters over the first 18 months of the COVID-19 pandemic, use of telehealth increased across specialties before stabilizing, with the highest use in gastroenterology, urology, neurosurgery, and neurology and lowest use in ophthalmology. Asynchronous testing was used to augment teleophthalmology and, when used, was associated with change in management for 25.4% of encounters.

**Meaning** The COVID-19 pandemic was associated with increased telehealth use across specialties, with asynchronous testing appearing to be a feasible approach to expanding teleophthalmic subspecialty care.

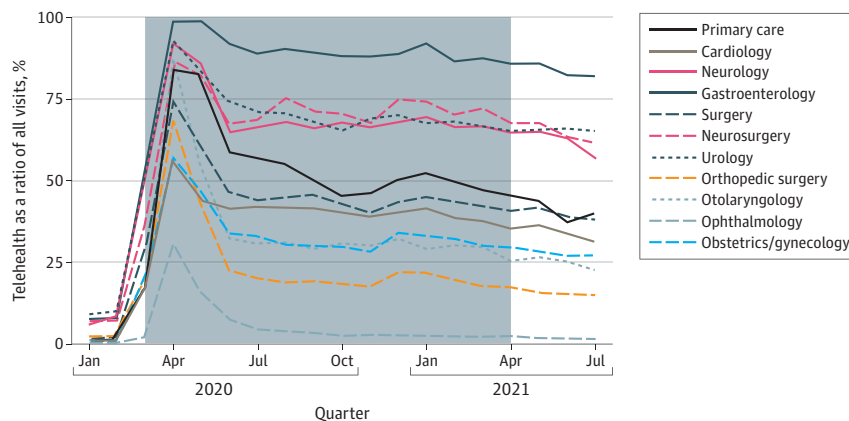
### Ophthalmic Telehealth With Asynchronous Testing

After local shelter-in-place orders were placed in March 2020, patients of the UCSF Department of Ophthalmology whose visits were postponed were contacted by phone to review their care plan. If a new concern was present or additional evaluation was indicated, patients were scheduled for remote or in-person evaluation. In April 2020, a hybrid model of care delivery was implemented wherein asynchronous data could be collected to enhance telehealth consultation with eye care clinicians, which we refer to as augmented telehealth. These data included visual acuity, intraocular pressure (IOP) measurement, pachymetry, visual field testing, optical coherence tomography (OCT) (macula or optic nerve), retinal photography, specular microscopy, and slitlamp photography. Tests and examinations were performed by trained technicians at 1 of 2 main UCSF ophthalmology facilities under a strict COVID-19 protocol to minimize human interaction and risk of viral transmission. If testing was limited to IOP, data were acquired in a drive-through fashion where patients remained in their vehicles and IOP was measured with iCare IC200 and TA01i model tonometers (iCare Finland).<sup>10</sup> Results were recorded as a diagnostic test appointment in patients' electronic medical records and were readily accessible by clinicians. A telehealth encounter was conducted by phone or video call to discuss the assessment and care plan within 6 weeks.

### Collection of Data for Hybrid Care Delivery

Patients who were evaluated with video or phone encounters by the department of ophthalmology from April 1 to October 1, 2020, were identified through UCSF Clinical and Translational Science Institute consultation services. Lists of patients who were scheduled for various testing and examinations, such as slitlamp examination, visual field testing, and OCT, were obtained in the same fashion by querying electronic health scheduling records using Epic Clarity via SQL Server, version 15.0 (Microsoft). Medical records of patients who were evaluated remotely were matched with those who received examination or testing within the same time frame using R, version 4.1.1 (R Foundation for Statistical Computing). Patients with asynchronous testing or examination scheduled within a 6-week cutoff of their visit were considered as

**Figure 1. Use of Telehealth per Month for Outpatient Encounters Across Surgical and Medical Specialties at the University of California, San Francisco, January 1, 2020, through July 31, 2021**



Solid and dashed lines correspond to medical and surgical specialties, respectively. The shaded area represents the period of statewide shelter-in-place orders for the COVID-19 pandemic, spanning March 2020 until April 2021.

participants in the augmented telehealth program. A retrospective review of patients' medical records was conducted to confirm their participation in the program and to extract encounter primary diagnosis and demographic characteristics, including sex, age, and race and ethnicity as categorized and reported in the electronic health record. Associated clinical notes were reviewed independently by 2 reviewers (A.M. and T.N.K.) to evaluate whether asynchronous data influenced assessment and management decisions, for example, to change medications, alter the follow-up interval, or recommend surgical/procedural intervention.

### Patient-Reported Quality of Care

Patient-reported quality of telehealth care was obtained from UCSF Consumer Assessment of Healthcare Providers and Systems Clinician and Group Surveys to characterize satisfaction with quality and accessibility of care, the clinicians, access to care, and other domains.<sup>11</sup> The percentage of respondents selecting the highest possible rating (always; yes, definitely; yes; or a lot), depending on the question, were extracted.

### Statistical Analysis

A  $\chi^2$  test of independence was used to determine whether patient satisfaction metrics depended on the type of visit (telehealth or in-person). Contingency tables were created, and 2-tailed *P* values were calculated in Prism, version 9.0 (GraphPad Software).

## Results

### Telehealth Trends by Specialty

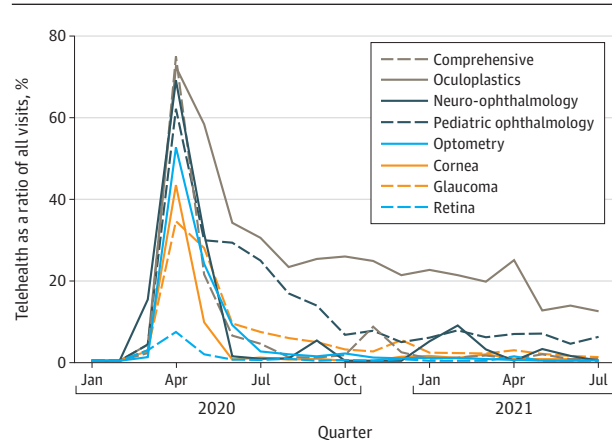
For 881 080 patient encounters, we evaluated the macro-level trends in several medical and surgical specialties at UCSF, including primary care, cardiology, neurology, gastroenterology, surgery, neurosurgery, urology, orthopedic surgery, otolaryngology, obstetrics/gynecology, and ophthalmology. In April 2020, after COVID-19 shelter-in-place orders were introduced, in-person outpatient visits among these specialties

dropped by 83.3% (39 488 of 47 390) from January 2020. During this period, telehealth use rose by 2366.5% (19 524 vs 825 encounters), representing 71.2% of all 27 426 outpatient encounters by these specialties. In January 2020, telehealth use ranged from a minimum of 0% (0 of 6989 encounters) in ophthalmology to a maximum of 8.8% (121 of 1373 encounters) in urology. In April 2020, telehealth use peaked across all specialties, ranging from a minimum of 31.0% (488 of 1575 encounters) in ophthalmology to a maximum of 100% (748 encounters) in gastroenterology (Figure 1) (eTable in the Supplement). In the second quarter of 2020, telehealth use decreased across all specialties and plateaued thereafter. One year later in April 2021, when COVID-19 shelter-in-place orders were lifted, telehealth use remained high for several specialties, including gastroenterology (930 of 1072 [86.6%]), neurosurgery (1188 of 1741 encounters [68.2%]), urology (1198 of 1823 encounters [65.7%]), and neurology (2657 of 4049 encounters [65.6%]), whereas in ophthalmology, it returned to nearly prepandemic levels and comprised 2.0% (150 of 7459) of all encounters (Figure 1) (eTable in the Supplement).

### Telehealth Trends by Ophthalmic Subspecialty

Telehealth within ophthalmology was further characterized by subspecialty. In-person outpatient encounters at the UCSF Department of Ophthalmology dropped by 84.4% (5902 of 6989) in April 2020 from January 2020; this decline was highest in comprehensive ophthalmology (449 of 466 encounters [96.4%]) and neuro-ophthalmology (509 of 610 encounters [92.1%]) and lowest in retina (386 of 517 encounters [74.6%]) and glaucoma (509 of 610 encounters [83.4%]) services. In the same time frame, telehealth use peaked across all subspecialties of ophthalmology to a variable degree. This peak was more modest for retina (10 of 141 encounters [7.1%]), glaucoma (53 of 154 encounters [34.4%]), and cornea (42 of 97 encounters [43.3%]) subspecialties (Figure 2). Conversely, telehealth was the predominant method of care delivery in all other subspecialties, and as many as 75.0% of encounters (51 of 68) were completed remotely in comprehensive ophthalmology. One year later in July 2021, oculoplastics (29 of 238 encounters

**Figure 2. Use of Telehealth Within Ophthalmology per Quarter for Outpatient Encounters Across Subspecialties at the University of California, San Francisco, January 1, 2020, through July 31, 2021**



[12.2%]) and pediatric ophthalmology (34 of 575 encounters [5.9%]) were using telehealth to deliver care in a considerably higher proportion of their visits than other subspecialties of ophthalmology (<1%) (Figure 2).

### Trends in Ophthalmic Telehealth With Asynchronous Testing

A total of 126 patients had remote encounters that were supplemented with asynchronous examination and testing from April 1, 2020, to October 1, 2020, including 57 of 256 glaucoma (22.3%), 49 of 237 optometry (20.7%), and 13 of 72 (18.1%) cornea encounters (Table 1). Asynchronous testing in other subspecialties was negligible. Forty-three encounters (34.1%) were completed on the same day, and 93 (73.8%) were within a week of in-person testing. Patients' mean (SD) age was 63.9 (15.3) years (range, 9-83 years); 61 (48.4%) were female and 65 (51.6%) were male; 13 (10.3%) were African American, 37 (29.4%) were Asian, 14 (11.1%) were Hispanic, and 59 (46.8%) were White.

A total of 104 encounters (82.5%) were for the evaluation of glaucoma or ocular hypertension. From this group, 77 patients (74.0%) received IOP testing, and OCT (macula or optic nerve) and visual field testing were completed for 50 patients (48.1%). In 24 patients (23.1%), OCT (macula or optic nerve), IOP measurements, and visual field testing were completed in the same visit. The second highest clinical indication was graft evaluation, with all 9 patients (100%) receiving specular microscopy. Pachymetry (6 of 9 encounters [66.7%]), IOP (6 of 9 encounters [66.7%]), and visual acuity testing (6 of 11 encounters [54.5%]) were also commonly used for this indication. The remaining patients were evaluated for postoperative management, medication adverse effects, age-related macular degeneration, uveitis, Graves ophthalmopathy, and ptosis.

### Change in Clinical Management

Examination data contributed to ensuring the safety of no change in management with or without regular interval follow up in 91 of 126 encounters (72.2%). Alternatively, it changed the clinical plan in 32 of 126 cases (25.4%) (Table 2). The most frequent instances of change in management were a medica-

**Table 1. Ophthalmic Subspecialty-Level Relative Use of Augmented Telehealth<sup>a</sup>**

Subspecialty	No./total No. of encounters (%)	
	Telehealth	Augmented
Optometry	237/4086 (5.8)	49/237 (20.7)
Retina	25/2318 (1.1)	0/25 (0)
Neuro-ophthalmology	88/937 (9.4)	0/88 (0)
Oculoplastics	492/1577 (31.2)	3/492 (0.6)
Pediatric ophthalmology	713/2926 (24.4)	1/625 (0.2)
Glaucoma	256/2753 (9.3)	57/256 (22.3)
Cornea	72/2066 (3.5)	13/72 (18.1)
Comprehensive ophthalmology	120/1668 (7.2)	3/120 (3.0)

<sup>a</sup> Ratio of telehealth use across various subspecialties of ophthalmology from March 1 to October 1, 2020, and percentage of telehealth encounters that were augmented with remote examination data within the same time frame.

**Table 2. Change in Clinical Management Due to Incorporating Asynchronous Testing Data in Telehealth**

Change in management	No. (%) <sup>a</sup>
Change in follow-up plan	16 (12.7)
Medication change	16 (12.7)
Procedural/surgical intervention	5 (4.0)
Referral to another service	3 (2.4)

<sup>a</sup> Percentages are reported as a ratio of 126 hybrid encounters. Clinical management in some encounters was changed in multiple ways.

tion change (12.7%; 16 encounters) or change in follow-up plan (12.7%; 16 encounters).

### Patient Perspective of Telehealth

Patient satisfaction metrics were comparable between telehealth and in-person visits throughout the 5-month period with the highest number of telehealth visits occurring after local shelter-in-place orders were enacted (Table 3). One hundred fourteen of 124 patients (91.9%) with telehealth visits and 755 of 820 patients (92.1%) with in-person visits agreed their physician spent enough time with them. One hundred fifteen of 123 patients (93.5%) with telehealth visits and 764 of 823 patients (92.8%) with in-person visits reported that their physician listened to them carefully. One hundred seventeen of 123 patients (95.1%) undergoing telehealth visits were able to see their providers within 15 minutes, whereas 669 of 820 patients (81.6%) with in-person visits claimed the same ( $P < .001$ ).

## Discussion

The COVID-19 pandemic has presented a unique opportunity to evaluate ophthalmic telehealth implementation at scale. In this quality improvement study, we compared telehealth trends among various clinical specialties and ophthalmic subspecialties at a major academic institution and evaluated the feasibility of using asynchronous ophthalmic testing to augment telehealth encounters between patients and eye care clinicians. During the shelter-in-place orders, telehealth use surged across all specialties.<sup>2,12</sup> As the number of outpatient visits recovered to pre-COVID-19 levels, telehealth use decreased but

**Table 3. Patient-Reported Quality of Care Outcomes for the First 5 Months After Local COVID-19 Shelter-in-Place Orders<sup>a</sup>**

	No. who agreed/total No. (%)		P value
	In-person visits	Telehealth visits	
Saw physician within 15 min	669/820 (81.6)	117/123 (95.1)	<.001
Physician spent enough time	755/820 (92.1)	114/124 (91.9)	.96
Physician listened carefully	764/823 (92.8)	115/123 (93.5)	.79
Would recommend	751/816 (92.0)	117/123 (95.1)	.23

<sup>a</sup> From University of California, San Francisco, Consumer Assessment of Healthcare Providers and Systems Clinician and Group Survey responses with the highest possible rating (always; yes, definitely; yes; or a lot), depending on the question.

remained a stable proportion of ambulatory encounters in most specialties, suggesting a paradigm shift in remote care delivery after the pandemic. Many specialties, including obstetrics/gynecology and gastroenterology, which were lower users of telehealth compared with other specialties before the pandemic,<sup>9</sup> saw a continued use of telehealth for patient care. Telehealth use by ophthalmology was modest compared with other specialties, and patient care returned almost entirely to in-person settings by October 2020. These trends during the COVID-19 pandemic validated intrinsic barriers to ophthalmic telehealth while also providing opportunities to evaluate feasibility of alternate ophthalmic telehealth care paradigms.

A well-recognized limiting factor in ophthalmic telehealth is the need for physical examination and difficulty of remote data collection,<sup>6,7</sup> and a survey of eye care clinicians at UCSF similarly identified the inability to perform adequate examination and testing as the top barrier to adopting telehealth.<sup>13</sup> Most survey responders were able to document and assess external examination and extraocular motility during video encounters. Consistently, oculoplastics and pediatric ophthalmology, which often rely on external examination of the eye, had the greatest telehealth use during the COVID-19 shelter-in-place orders and, interestingly, maintained some level of telehealth even after the orders were lifted. In contrast, the retina, glaucoma, and cornea subspecialties, which rely more heavily on microscopic examinations and specialized tools to evaluate ocular health and anatomy,<sup>6,7</sup> were lower users of telehealth services. These results highlight the importance of instrument-dependent eye examination and the subspecialty-level differences in adoption of remote care delivery.

The hybrid model of augmented telehealth in this study increased the depth of remote evaluation across several subspecialties. Hybrid models have been used to study specific conditions or triage emergencies<sup>5,10</sup>; however, to our knowledge, this is the first report of such hybrid use to deliver routine care across multiple ophthalmic subspecialties at a major academic institution in the US. Despite considerable use of telehealth by oculoplastics and pediatric ophthalmology, these services did not use asynchronous testing, suggesting a relative reliance on external video examination. On the other hand, its highest users were specialties that had lower telehealth use and are known to be less amenable to virtual practice (eg, cornea and glaucoma). Moreover, asynchronous testing data from this program changed management in 25.4% of encounters and expanded telehealth use to new indications, including the postoperative assessment of corneal transplantation.

Additional benefits of augmented telehealth include improved practice efficiency. Our departmental survey data show

that patients who were evaluated remotely were seen significantly more often within 15 minutes of their scheduled time, whereas many other quality metrics remained the same (Table 3). Ophthalmology appointments are often prolonged compared with other specialty clinic visits because of the frequent need for specialized imaging.<sup>14</sup> Separating ancillary testing from clinician consultation may streamline traditional clinic workflow, increase the use of otherwise idle testing equipment, and decrease wait times for some patients.

### Limitations

This study has several limitations. First, the use of telehealth with asynchronous testing varied at the discretion of clinicians. For example, the retina service maintained in-person visits more readily and was a low user of telehealth in general. Thus, results of this study demonstrate feasibility but do not reflect the maximum benefit of asynchronous testing to augment telehealth across subspecialties. Additional work is needed to evaluate the effectiveness of asynchronous testing in ophthalmic telehealth in a controlled fashion. Second, asynchronous testing was performed by trained personnel in a fully equipped ophthalmic facility at a major academic center. Although this approach overcomes barriers to ophthalmic telehealth within 1 institution, such implementation does not intrinsically expand the accessibility of eye care to new or underserved populations. Third, this study is not powered to evaluate disease that may be missed by teleophthalmology that would otherwise be identified by a traditional patient care model, an important safety consideration for the adoption of telehealth. Additional work is needed to rigorously evaluate safe protocols for wide implementation of teleophthalmology. Fourth, our study did not include or evaluate traditional implementations of teleophthalmology, such as photography-based screening for diabetic retinopathy and retinopathy of prematurity, and future study could evaluate these applications in workflows including virtual encounters with ophthalmologists. Nevertheless, this study demonstrates the feasibility of augmenting teleophthalmology with asynchronous testing and suggests that additional tools and paradigms to expand the use of such testing safely into the community may significantly increase the reach of ophthalmic telehealth care.

### Conclusions

Ophthalmology is a pioneering field for telemedicine, but its use has traditionally focused on preventive disease screening. The COVID-19 pandemic increased the need for tele-

health and presented a unique opportunity to test different implementations of ophthalmic telehealth at scale. Within a major academic center, this quality improvement study demonstrated the feasibility of enhancing ophthalmic telehealth with asynchronous testing, which was found to be effective

for some subspecialty-level care. Additional work is needed to evaluate asynchronous testing in a subspecialty-controlled fashion and whether implementation outside the same institution may also be an effective approach for expanding the reach of ophthalmic telehealth care into the community.

#### ARTICLE INFORMATION

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**Author Contributions:** Dr Kim had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

**Concept and design:** Mosenia, Li, Seitzman, Sun, Kim.

**Acquisition, analysis, or interpretation of data:** Mosenia, Li, Seefeldt, Kim.

**Drafting of the manuscript:** Mosenia, Li, Seefeldt, Kim.  
**Critical revision of the manuscript for important intellectual content:** Mosenia, Li, Seitzman, Sun, Kim.

**Statistical analysis:** Mosenia, Kim.

**Obtained funding:** Kim.

**Administrative, technical, or material support:** Mosenia, Seefeldt, Sun, Kim.

**Supervision:** Seitzman, Kim.

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#### Invited Commentary

## Is There a Future for Telehealth in Ophthalmology?

David B. Glasser, MD

**Mosenia et al<sup>1</sup>** report on the use of telehealth services across 11 surgical and nonsurgical specialties, including ophthalmology, at the University of California San Francisco before, during, and after shelter-in-place orders related to the COVID-19 pandemic.

Despite creative implementation of a hybrid care delivery system using a combination of asynchronous data from in-person testing followed by remote visits, the authors found that the surge in use of telehealth services by ophthalmologists lagged that of all other specialties when the shelter-in-place order was implemented.

Unique among the specialties studied, the percentage of remotely delivered ophthalmic visits dropped dramatically within 6 months while shelter-in-place orders were still in effect.

After the orders were lifted, ophthalmic use of telemedicine (1.1%) returned almost entirely to prepandemic levels, while other specialties continued to provide a considerable percentage of visits remotely (14.9% to 65.9%).<sup>1</sup>

These findings offer insights into the unique nature of telehealth in ophthalmology. They also raise questions beyond the topic of telemedicine. Corneal allografts, lasers, gene therapy, artificial intelligence, clinical data registries: these are all examples of ophthalmology at the forefront of creative solutions advancing quality patient care. Why the difference with telehealth, particularly at a major academic institution with greater resources than those available to many ophthalmologists?

Perhaps the most important reason for the lag in ophthalmology's adoption of telehealth during the COVID-19 public health emergency lies in the visual nature of our work. Literally



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