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Factors Associated with Follow-Up Adherence After Teleophthalmology for Diabetic Eye Screening Before and During the COVID-19 Pandemic

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Abstract

Background: *Follow-up adherence with in-person care is critical for achieving improved clinical outcomes in telemedicine screening programs. We sought to quantify the impact of the COVID-19 pandemic upon follow-up adherence and factors associated with follow-up adherence after teleophthalmology for diabetic eye screening.*

Methods: *We retrospectively reviewed medical records of adults screened in a clinical teleophthalmology program at urban and rural primary care clinics between May 2015 and December 2020. We defined follow-up adherence as medical record documentation of an in-person eye exam within 1 year among patients referred for further care. Regression models were used to identify factors associated with follow-up adherence.*

Results: *Among 948 patients, 925 (97.6%) had health insurance and 170 (17.9%) were referred for follow-up. Follow-up adherence declined from 62.7% (*$n = 52$*) pre-pandemic to 46.0% (*$n = 40$*) during the pandemic (*$p = 0.04$*). There was a significant decline in follow-up adherence among patients from rural (*$p < 0.001$*), but not urban (*$p = 0.72$*) primary care clinics. Higher median household income (odds ratio [OR] 1.68, 95% confidence interval [CI]: 1.19–2.36) and obtaining care from an urban clinic (OR 5.29, 95% CI: 2.09–13.43) were associated with greater likelihood of follow-up during the pandemic.*

Discussion: *Follow-up adherence remains limited after teleophthalmology screening even in a highly insured patient population, with a further decline observed during the COVID-19 pandemic. Our results suggest that rural patients and those with lower socioeconomic status experienced greater barriers to follow-up eye care during the COVID-19 pandemic.*

Conclusions: *Addressing barriers to in-person follow-up care is needed to effectively improve clinical outcomes after teleophthalmology screening.*

Keywords: *teleophthalmology, ocular telehealth, diabetic retinopathy, follow-up, telemedicine, COVID-19 pandemic*

Introduction

Diabetic retinopathy is the leading cause of vision loss among working-age adults in the United States even though early detection and treatment of diabetic eye disease can reduce the risk of severe vision loss by 95%.[1] Teleophthalmology provides evidence-based diabetic eye screening using a store-and-forward telemedicine model in which retinal photos are taken in primary care clinics.[2,3] Primary care clinics are an ideal setting for teleophthalmology because nearly 90% of U.S. adults with diabetes regularly visit their primary care clinician.[4] Among patients who screen positive for vision-threatening disease, follow-up adherence with in-person eye care is critical for improving clinical outcomes in teleophthalmology screening programs.[5]

Unfortunately, follow-up adherence after teleophthalmology has been reported to be as low as 9.5–27% within 1 year of screening.[5–7] Factors associated with follow-up adherence reported in underinsured populations include older age and knowledge of one's hemoglobin A1c.[5] However, follow-up adherence even in highly insured patient populations has been reported to be as low as 9.5%.[7] Factors associated with follow-up adherence in highly insured populations have not been reported and may not be the same as those found in underserved populations. An improved understanding of factors associated with follow-up adherence after teleophthalmology screening can inform the development of effective interventions to improve follow-up adherence and clinical outcomes.

Furthermore, we hypothesized that there may have been additional impacts on follow-up adherence resulting from the SARS-CoV-2 (i.e., coronavirus disease 2019 [COVID-19]) pandemic, which has led to global disruptions in health care services. Nearly all countries worldwide continue to experience health care challenges more than 2 years since the World Health Organization (WHO)'s initial COVID-19 pandemic declaration in March 2020.[8] Early in the pandemic, ophthalmology experienced the greatest decline in U.S. outpatient clinic visits of any specialty due to safety concerns.[9] Guidelines initially released by the American Academy of Ophthalmology recommended completely ceasing in-person eye examinations, except for patients with urgent, vision-threatening eye conditions.[10] As a result, real-time virtual telemedicine (i.e., phone or video based) experienced a period of substantial growth to expand access to care, including eye care services, during the COVID-19 pandemic.[9,11]

While real-time telemedicine eye care provided critical access to care for patients during the COVID-19 pandemic, significant disparities in its utilization by underserved populations have been reported and have led to concerns about equity in its implementation.[11] However, the impact of the pandemic on follow-up adherence and possible disparities in follow-up among store-and-forward teleophthalmology programs have not been previously reported. In this study, we sought to quantify the impact of the COVID-19 pandemic upon follow-up adherence and factors associated with follow-up adherence after teleophthalmology for diabetic eye screening.

Methods

RESEARCH SETTING

A teleophthalmology diabetic retinopathy screening program was established in 2015 at primary care clinics associated with the Mile Bluff Medical Center (MBMC) in Mauston, WI and in 2017 at the University of Wisconsin (UW) Health in Madison, WI. Both MBMC and UW Health are multipayer health systems. MBMC serves a rural population (83% rural, population density: 34.5/square mile) in Juneau County, WI, and ranks among the bottom quartile for health and socioeconomic metrics by county in Wisconsin.[12,13] In comparison to statewide averages, Juneau County's population has a 13% lower median household income and a 12% higher prevalence.[13] In contrast, UW Health serves a predominantly urban population (12% rural, population density: 407.7/square mile) in Dane County, WI and ranks among the top quartile for health and socioeconomic metrics by county in Wisconsin.[14–16] In comparison to statewide averages in 2022, Dane County's population has a 21.2% higher median household income, 28% lower prevalence of adult obesity, and a 40% lower prevalence of diabetes.[16]

The teleophthalmology program was established based on the 2011 *American Telemedicine Association Telehealth Practice Recommendations for Diabetic Retinopathy*.[17] The details of this teleophthalmology program have previously been published.[18] In brief, ocular imaging was performed by clinic staff using a Topcon TRC NW400 nonmydriatic retinal camera (Topcon Medical Systems, Inc., Oakland, NJ, USA). Single-field 45° images of the fundus and anterior photos of each eye were obtained and uploaded to a secure imaging server. Eye care specialists from the UW evaluated the images for ocular pathology. The results were sent within one week through mail to the patient and electronically to the primary care provider (either faxed or as a message sent within the electronic health record [EHR]). The result report included a summary of ocular findings and when indicated, recommendations for follow-up in-person eye care, as well as the recommended time frame for follow-up.

Recommended time frames for follow-up in-person eye care were classified as either urgent (within 2 months) or nonurgent (within 4–6 months), as determined by the interpreting eye care provider following the American Academy of Ophthalmology guidelines.[19–23] Patients recommended to have follow-up in-person eye care were also contacted up to three times by phone to assist in scheduling their appointment.

STUDY DESIGN

We performed a retrospective analysis of EHR data among all patients 18 years and older with a diagnosis of type 1 or type 2 diabetes who had teleophthalmology imaging performed between May 2015 and December 2020 at MBMC and UW Health. Patients imaged before March 11, 2020 (i.e., the date the WHO declared COVID-19 to be a global pandemic) were considered to be in the "prepandemic" time period and

those imaged after March 11, 2020 were considered to be in the "pandemic" time period. Data from the first teleophthalmology imaging date were collected. Within the subset of patients who completed teleophthalmology imaging more than once and were referred for a follow-up in-person eye exam, we used data only from the first imaging date for which there was a referral for follow-up.

ASSESSMENT OF DEMOGRAPHIC/CLINICAL VARIABLES AND PRIMARY OUTCOME MEASURE

From the MBMC and UW Health electronic medical records, we collected demographic and clinical information regarding patients' age, sex, self-reported race and ethnicity, type of health insurance (i.e., Commercial, Medicare, Medicaid, or none), median annual household income based on their home address zip code (Data USA, USA; datausa.io), diabetes diagnosis (type 1 or 2), hemoglobin A1c, primary care clinic, and travel distance from their home to their primary care clinic based on Google maps (Google LLC, Mountain View, CA, USA). MBMC primary care clinics were considered "rural" and UW Health primary care clinics were considered "urban."

The primary outcome measure was follow-up adherence among those recommended to have an in-person eye exam, which required medical record documentation of an in-person clinic visit with an eye care provider within 1 year from the date of teleophthalmology imaging. We excluded from the analysis any patients who had not completed follow-up, but were documented in the EHR to be deceased within 1 year following the date of their teleophthalmology imaging.

STATISTICAL ANALYSES

We compared patient characteristics based on referral status and primary care clinic rurality using Fisher's exact tests and chi-squared tests for categorical data and *t*-tests for continuous data. We then created univariable linear and logistic regression models to assess for factors associated with follow-up adherence before and during the COVID-19 pandemic. These factors included age, sex, insurance type, median household income, primary care clinic rurality, hemoglobin A1c, and the presence of diabetic retinopathy. Of note, we did not evaluate variables in the regression analyses for which the sample size was too small to obtain reliable estimates of their association with follow-up adherence (i.e., patients with Medicaid or no health insurance, as well as type 1 vs. type 2 diabetes). Statistical analyses were performed using Microsoft Excel (Microsoft Corp., Redmond, WA, USA), GraphPad Prism (GraphPad Software, San Diego, CA, USA), and SAS 3.8 (SAS Institute, Cary, NC, USA). Statistical significance was set at $p < 0.05$.

ETHICS AND INSTITUTIONAL REVIEW BOARD REVIEW

This study was reviewed with the UW Health Sciences Institutional Review Board (IRB) staff and deemed not to constitute human subjects research as the activities were consistent with quality improvement. All research activities were conducted in accordance with the Declaration of Helsinki and all federal and state laws. Data cannot be shared publicly because of legal approval requirements for access to patient health identifier data according to U.S. HIPAA regulations and the UW IRB. Data will be available from the UW IRB for researchers who meet the criteria for access to confidential data.

Results

A total of 948 patients with diabetes obtained teleophthalmology imaging. The average age was 61.2 years (range: 21–97 years) (*Table 1*). Most were male (57.4%, $n = 544$), white non-Hispanic (88.4%, $n = 838$), and had health insurance (97.6%, $n = 925$) (*Table 1*). Nearly all patients had a diagnosis of type 2 diabetes (98.2%, $n = 931$) with an average hemoglobin A1c of 7.8% (±1.8%). The majority of patients were from rural primary care clinics (61.5%, $n = 583$). The average travel distance from a patient's home to their primary care clinic was 13.6 miles (range: 0.1 to 138 miles). Patients from rural clinics were older ($p < 0.001$), more likely to have Medicare insurance ($p < 0.001$), had a lower median household income ($p < 0.001$), and were more likely to have type 2 (vs. type 1) diabetes ($p = 0.04$) compared with patients from urban clinics (*Supplementary Table S1*).

Overall, 170 patients (17.9%) were referred for follow-up in-person eye care due to either ocular pathology (11.7%, $n = 111$) or ungradable images (6.2%, $n = 59$) (*Table 1*). Patients referred for follow-up were older ($p < 0.001$), had a higher hemoglobin A1c ($p < 0.001$), were more likely to have diabetic retinopathy ($p < 0.001$), and were more likely to have Medicare insurance ($p = 0.005$). The proportions of patients referred for a follow-up in-person eye exam were similar between patients from rural and urban primary care clinics (16.8% [$n = 98$] vs. 19.7% [$n = 72$], respectively, $p = 0.26$) (*Supplementary Table S1*). The primary indications for referral included ungradable images (34.7%, $n = 59$), diabetic eye disease (25.8%, $n = 44$), glaucoma suspects (21.8%, $n = 37$), advanced-stage macular degeneration (7.1%, $n = 12$), other ocular pathology (7.1%, $n = 12$), and cataracts (3.5%, $n = 6$) (*Table 2*).

Overall follow-up adherence was 54.4% ($n = 92$) within 1 year of teleophthalmology imaging, with 35.5% ($n = 60$)

Table 1. Characteristics of Patients with Teleophthalmology Imaging by Referral for Follow-Up (*N* = 948)

CHARACTERISTICS	ALL PATIENTS (*N* = 948)	NOT REFERRED (*N* = 778)	REFERRED (*N* = 170)	*P*
Age (years), mean ± SD (range)	61.2 ± 12.5 (21–97)	60.2 ± 12.2 (21–94)	66.0 ± 12.7 (32–97)	<0.001
Male, *n* (%)	544 (57.4)	437 (56.1)	107 (63.3)	0.09
Race and ethnicity, *n* (%)				0.86
Non-Hispanic, White	838 (88.4)	691 (88.8)	147 (86.5)	
Black or African American	38 (4.0)	29 (3.7)	9 (5.3)	
Hispanic	23 (2.4)	19 (2.4)	4 (2.4)	
Asian	17 (1.8)	14 (1.8)	3 (1.8)	
Other[a]	32 (3.4)	25 (3.2)	7 (4.1)	
Insurance type, *n* (%)				
Any	925 (97.6)	756 (97.2)	169 (99.4)	0.005
Commercial	449 (47.4)	388 (49.9)	61 (35.9)	
Medicare	416 (43.9)	318 (40.9)	98 (57.6)	
Medicaid	60 (6.3)	50 (6.4)	10 (5.9)	
Median household income (dollars), mean ± SD (range)	55,469 ± 15,304 (30,806–112,845)	55,360 ± 15,658 (30,806–112,845)	55,969 ± 13,599 (30,806–99,322)	0.64
Rural primary care clinic, *n* (%)	583 (61.5)	485 (62.3)	98 (57.6)	0.26
Distance to primary care clinic (miles), mean ± SD (range)	13.6 ± 15.1 (0.1–138)	13.4 ± 14.2 (0.1–131)	14.7 ± 18.7 (0.5–138)	0.31
Type 2 diabetes, *n* (%)	931 (98.2)	764 (98.2)	167 (98.2)	1.00
Hemoglobin A1c (%), mean ± SD (range)	7.8 ± 1.8 (4.8–15.2)	7.7 ± 1.7 (4.8–15.2)	8.4 ± 2.0 (5.4–14.6)	<0.001
Diabetic Retinopathy, *n* (%)				
Any	127 (13.4)	73 (9.4)	54 (31.8)	<0.001
Mild	85 (9.0)	73 (9.4)	12 (7.1)	
Moderate	32 (3.4)	0 (0.0)	32 (18.8)	
Severe	8 (0.8)	0 (0.0)	8 (4.7)	
Proliferative	2 (0.2)	0 (0.0)	2 (1.2)	
Ungradable images, *n* (%)	59 (6.2)	0 (0.0)	59 (34.7)	<0.001

[a]Other includes the five smallest categories: American Indian or Alaska Native, Multiracial[b], Native Hawaiian or Other Pacific Islander, and Unavailable.

[b]Multiracial includes: American Indian or Alaska Native, Hispanic/Latino; American Indian or Alaska Native, White; Black or African American, White; Native Hawaiian or Other Pacific Islander, Hispanic/Latino; Native Hawaiian or Other Pacific Islander, White.

SD, standard deviation.

completing follow-up within the recommended time frame (*Table 3*). Patients from urban clinics had higher follow-up adherence within 1 year compared with those from rural clinics (65.3% [$n = 47$] vs. 46.4% [$n = 45$] respectively, $p < 0.05$). For each primary indication for referral, follow-up adherence ranged from 16.7% to 55.6% within the recommended time frame and ranged from 33.3% to 100% within 1 year (*Table 2*). Follow-up adherence within 1 year was highest among patients for whom the primary indication for referral was severe nonproliferative (77.8%, $n = 7$) and proliferative (100%, $n = 2$) diabetic retinopathy, as well as for cataract (83.3%, $n = 5$).

We then compared follow-up adherence between the time periods before and during the COVID-19 pandemic. During

Table 2. Follow-Up Adherence by Primary Reason for Referral ($N=170$)

PRIMARY REASON FOR REFERRAL	TOTAL ($N=170$), n (%)	FOLLOW-UP ADHERENCE	
		WITHIN RECOMMENDED TIME FRAME, n (%)	WITHIN 1 YEAR, n (%)
Diabetic eye disease	44 (25.8)	19 (43.2)	28 (63.6)
Moderate NPDR	31 (18.2)	13 (41.9)	19 (61.3)
Severe NPDR	9 (5.3)	5 (55.6)	7 (77.8)
Proliferative DR	2 (1.2)	1 (50.0)	2 (100.0)
Diabetic macular edema[a]	6 (3.5)	1 (16.7)	2 (33.3)
Ungradable images	59 (34.7)	21 (35.6)	30 (50.8)
Glaucoma suspect	37 (21.8)	11 (29.7)	20 (54.1)
Advanced-stage macular degeneration	12 (7.1)	3 (25.0)	4 (33.3)
Cataract	6 (3.5)	3 (50.0)	5 (83.3)
Other ocular pathology[b]	12 (7.1)	3 (25.0)	5 (41.7)

[a]Patients with diabetic macular edema had coexisting mild ($n=2$), moderate, ($n=1$) and severe NPDR ($n=3$).

[b]Other ocular pathology included: chorioretinal atrophy ($n=3$), choroidal nevus ($n=2$), hypertensive retinopathy ($n=2$), branch retinal artery occlusion ($n=1$), branch retinal vein occlusion ($n=1$), central retinal artery occlusion ($n=1$), macular scar ($n=1$), and retinal detachment ($n=1$).

DR, diabetic retinopathy; NPDR, nonproliferative diabetic retinopathy.

the prepandemic time period, there were 83 patients (18.2%) referred for in-person follow-up care, among whom follow-up adherence was 62.7% ($n=52$) within 1 year of teleophthalmology screening and 43.4% ($n=36$) within the recommended time frame (*Table 3*). During the pandemic, there were 87 patients (17.7%) referred for in-person follow-up care. Follow-up adherence decreased to 46.0% ($n=40$) within one year of screening and 27.6% ($n=24$) within the recommended time frame. There was a greater decline in follow-up adherence among patients from rural clinics (60.3% [$n=35$ to 25.0% [$n=10$], $p<0.001$), than urban clinics (68.0% [$n=17$] to 63.8% [$n=30$], $p=0.72$) between the prepandemic and pandemic time periods.

Table 3. Follow-Up Adherence by Clinic Rurality in the Pre- and Pandemic Time Frames ($N=170$)

	TOTAL	PREPANDEMIC	PANDEMIC	P
All clinics	$N=170$	$N=83$	$N=87$	
Within 1 year, n (%)	92 (54.4)	52 (62.7)	40 (46.0)	0.04
Within recommended time frame, n (%)	60 (35.5)	36 (43.4)	24 (27.6)	0.04
Rural clinics	$N=98$	$N=58$	$N=40$	
Within 1 year, n (%)	45 (46.4)	35 (60.3)	10 (25.0)	<0.001
Within recommended time frame, n (%)	28 (28.9)	22 (37.9)	6 (15.0)	0.01
Urban clinics	$N=72$	$N=25$	$N=47$	
Within 1 year, n (%)	47 (65.3)	17 (68.0)	30 (63.8)	0.72
Within recommended time frame, n (%)	32 (44.4)	14 (56.0)	18 (38.3)	0.15

In our regression analyses, we observed that higher median household income (odds ratio [OR] 1.68, 95% confidence interval [CI]: 1.19–2.36) and obtaining care from an urban primary care clinic (OR 5.29, 95% CI: 2:09–13.43) were each associated with greater likelihood of follow-up during the pandemic period, but not during the prepandemic period (*Table 4*). There was no significant association in the likelihood of follow-up adherence with age, sex, Medicare versus Commercial insurance, hemoglobin A1c, or the presence of diabetic retinopathy in either the pre- or pandemic time periods.

Discussion

In this study, follow-up adherence for in-person eye care within 1 year after teleophthalmology for diabetic eye screening was limited, even in a highly insured patient population. We observed a significant disparity in follow-up adherence during the COVID-19 pandemic. Patients from rural primary care clinics experienced a greater decline in follow-up adherence compared with patients from urban clinics. Obtaining care from an urban primary care clinic and higher median household income were each associated with greater likelihood of follow-up adherence during the pandemic time period. Given that timely screening and treatment are needed to prevent blindness from diabetes, interventions to address barriers to follow-up adherence for in-person eye care after teleophthalmology screening are needed to fully realize the benefits of these programs.

Our results add important information to the existing literature that has described

Table 4. Odds Ratios and 95% Confidence Intervals for the Relationships Between Patient Characteristics with Follow-Up Adherence by Pandemic Time Frame ($N = 170$)

	PREPANDEMIC ($N = 83$)	PANDEMIC ($N = 87$)
CHARACTERISTIC	OR (95% CI)	OR (95% CI)
Age (years)	0.98 (0.94–1.02)	1.01 (0.98–1.04)
Male[a]	0.66 (0.25–1.76)	1.47 (0.62–3.46)
Medicare insurance[b]	1.62 (0.62–4.23)	0.89 (0.37–2.15)
Median household income (per $10,000 increase)	1.17 (0.81–1.69)	1.68 (1.19–2.36)
Urban primary care clinic[c]	1.40 (0.52–3.76)	5.29 (2.09–13.43)
Hemoglobin A1c (%)	0.96 (0.75–1.22)	0.93 (0.76–1.14)
Diabetic retinopathy present[d]	1.36 (0.55–3.36)	1.23 (0.43–3.46)

Reference groups are:

[a]Female.

[b]Commercial.

[c]Rural primary care clinic.

[d]Diabetic retinopathy not present.

CI, confidence interval; OR, odds ratio.

disparities in access to virtual eye care during the COVID-19 pandemic (i.e., by phone or video).[11,24–26] Successful video visits require access to reliable broadband internet services and digital literacy.[11,24] Non-white race and ethnicity, older age, rural populations, and those with lower income or education levels are associated with a lower likelihood of having internet broadband services at home.[27] In addition, during the pandemic, Black patients were less likely to be seen in-person in retina clinic, with no corresponding increase in telemedicine visits, suggesting a reduction in seeking eye care, rather than a shift in care from in-person to virtual.[24] In comparison to virtual eye care, there have been few reports on the impact of the COVID-19 pandemic on teleophthalmology for diabetic eye screening in primary care clinics. One study described a short-term expansion in the use of teleophthalmology screening, but this effect was not sustained.[28]

Our study takes the next critical step of analyzing the impact of the pandemic on follow-up adherence after teleophthalmology for diabetic eye screening and adds important information regarding disparities in access to follow-up care among rural and lower income populations.

Previous reports on follow-up adherence for in-person eye care after teleophthalmology screening in the United States were conducted before the COVID-19 pandemic. Follow-up adherence ranged widely from 9.5% to 81.9%, with most studies reporting between 30% and 60%.[5–7,29–32] Notably, direct comparisons between studies are somewhat challenging due to variation in clinical criteria for referral and the time frame used to define follow-up. Prepandemic follow-up adherence in our study at 1 year and within the recommended time frame (62.7% and 43.4%, respectively) was greater than that reported by Keenum et al (49.0% vs. 29.9%, respectively), which also assessed factors associated with follow-up adherence.[5] This was likely because Keenum et al studied a safety-net population that may have experienced greater barriers to follow-up due to their lower socioeconomic and insurance status compared with our patient population. However, as the results of our study demonstrate, there remains much room for improvement in overcoming barriers to follow-up eye care even in highly insured populations.

While barriers to in-person eye care in general have been previously identified (i.e., cost, lack of convenience, insurance, and transportation, etc.), less is known about how to improve follow-up adherence after telemedicine-based eye care.[17,33–35] Keenum et al reported that older age and knowledge of one's hemoglobin A1c were associated with greater follow-up adherence after teleophthalmology screening.[5] Personalized interventions, as well as support from patient navigators and social workers, have been reported to increase eye clinic appointment scheduling and attendance at follow-up appointments.[34,36,37] A possible contributor to higher follow-up adherence in our program was that eye clinic schedulers directly contacted patients within 1 week of their screening visit to facilitate scheduling of their follow-up eye clinic appointments in 2–6 months. In the study by Martinez et al, which had the highest reported rate of follow-up adherence of any U.S. teleophthalmology program (81.9%), patients were contacted within 24 h of their screening visit by the image reading center staff to schedule an eye exam with a retina specialist within 1 month.

However, this prompt turnaround may not be feasible for most teleophthalmology programs, which typically do not have the staffing to interpret images or to schedule patients for eye clinic visits within such a short time frame. As an alternative to human image readers, the use of an autonomous artificial intelligence algorithm for point-of-care diagnosis has been shown to increase follow-up adherence after teleophthalmology screening in a single U.S. urban, low-income primary care clinic from 18.7% to 55.4%.[38] Interventions that rapidly provide patients with their screening results, facilitate appointment scheduling, and overcome logistical barriers to in-person eye care attendance may enhance follow-up adherence after teleophthalmology screening.

While our study had many strengths, some limitations include that our population was predominantly white, non-Hispanic, and our results may not be generalizable to other populations. While we used the date the WHO declared COVID-19 to be a global pandemic to distinguish between the prepandemic and pandemic periods, follow-up adherence among some patients in the prepandemic period may have been affected by pandemic considerations. However, this would have biased our study toward being less, rather than more, sensitive for detecting the associations we identified. Finally, we may have slightly underestimated follow-up adherence due to limitations in obtaining complete medical record documentation due to the lack of interoperability across EHR systems. However, we did have access to medical records from a large number of eye care providers through Care Everywhere (Epic Systems Corporation, Verona, Wisconsin, USA) and limitations in obtaining complete medical record documentation would have equally affected our assessment of follow-up adherence in the pre- and pandemic time periods.

Conclusions

Follow-up adherence for in-person eye care after teleophthalmology for diabetic eye screening remains limited, even in a highly insured patient population, and declined during the COVID-19 pandemic. We observed a disparity in follow-up adherence during the pandemic with lower follow-up among rural patients and those with lower median household income. These results suggest that rural patients and those with lower socioeconomic status are more vulnerable to disruptions such as those posed by the pandemic in obtaining vital follow-up eye care. Interventions designed to address barriers to follow-up in-person care are needed to effectively improve clinical outcomes after telemedicine-based screening, particularly among disadvantaged patient populations.

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Authors' Contributions

S.L.: formal analysis (equal); investigation (equal); visualization (lead); writing—original draft (lead); and writing—review and editing (equal). L.L.: formal analysis (equal), methodology (supporting), visualization (supporting), writing—review and editing (equal). B.X., M.W., and R.C.: investigation (equal), writing—view and editing (equal). Y.L.: conceptualization (lead), funding acquisition (lead), methodology (lead), supervision (lead), visualization (supporting), writing—original draft (supporting), writing—review and editing (equal).

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No competing financial interests exist.

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Supplementary Material

Supplementary Table S1

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