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Manhattan Vision Screening and Follow-Up Study: Tele-Retinal Image Findings and Importance of Photography

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Abstract

Purpose: To describe tele-retinal abnormality image findings from the Manhattan Vision Screening and Follow-up Study (NYC-SIGHT), which aims to investigate whether community-based eye health outreach strategies using telemedicine can improve visual outcomes among at-risk populations in Upper Manhattan.

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Methods: A 5-year prospective, cluster-randomized clinical trial was conducted. Eligible individuals aged 40 years and older were recruited from affordable housing developments and senior centers in New York City. Participants underwent on-site eye health screening (best-corrected visual acuity, intraocular pressure [IOP] measurements, and fundus photography). Fundus images were graded via telemedicine by a retina specialist. Multivariate logistic regression modeling was used to assess the factors associated with abnormal retinal findings requiring referral to ophthalmology.

Results: Participants with a retinal abnormality on fundus photography ($n = 157$) were predominantly older adults, with a mean age of 68.4 ± 11.1 years, female (63.7%), African American (50.3%), and Hispanic (43.3%). A total of 32 participants in our study passed the vision and IOP screening but had an abnormal retinal image and ocular pathology that would have been missed without fundus photography. Individuals who self-identified as having preexisting glaucoma (odds ratio [OR] = 3.750, 95% confidence interval [CI] = 1.741–8.074, $p = 0.0001$) and had severe vision impairment (OR = 4.1034, 95% CI = 2.0740–8.1186, $p = 0.000$) at the screening had significantly higher odds of having an abnormal retinal image.

Conclusion: This community-based study targeted populations at-risk for eye disease, improved access to eye care, detected a significant number of retinal image abnormalities requiring follow-up by using telemedicine, and provided evidence of the importance of fundus photography during eye health screenings.

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Keywords

telemedicine; retina; tele-ophthalmology; fundus image; eye health screening

Introduction

According to the U.S. Center for Disease Control and Prevention (CDC), the prevalence of blindness in the United States is projected to reach 9 million people by 2050 due to the rapidly aging population and the increased prevalence of chronic diseases such as diabetes mellitus.[1] Early diagnosis and treatment of chronic ocular conditions, such as diabetic eye disease, are effective means to reduce health care costs, which is especially true since 90% of blindness caused by diabetes is thought to be preventable.[1] These chronic conditions are especially prevalent in at-risk populations, which include individuals belonging to racial/ethnic minorities, socioeconomically disadvantaged groups, and underserved urban and rural populations.[2–6]

Implementation of tele-ophthalmology in detecting retina-related eye conditions in underserved populations has been suggested as a potential solution to ensure that even those with limited resources receive optimal eye care.[7] The use of telemedicine in ophthalmology has risen gradually over the last decade, with an exponential increase after the onset of the COVID-19 pandemic.[8–11]

Within ophthalmology, the subspecialty of retina is one that has relied heavily on manual postmydriatic examination of the fundus via ophthalmoscopy by a highly trained physician, as well as image capture via modalities including visible light photography and optical coherence tomography. An alternative modality, nonmydriatic fundus photography, operated by ancillary staff, is becoming more widespread because it is potentially more accessible in primary care practices for screening of common eye diseases such as diabetic retinopathy and age-related macular degeneration.[12,13] This modality is also used in telemedicine in remote or underserved areas, where fundus photographs are taken and sent out to ophthalmologists for further evaluation.[14] The Food and Drug Administration has approved several devices for primary care screening of diabetic retinopathy, with implementation of these devices in many sectors.[15,16] Numerous studies have attempted to determine the efficacy of telemedicine in preventing complications of retinal disease; however, the expanding role of nonmydriatic fundus cameras in the prevention and treatment of retinal disease is still being studied.[17–22]

In 2019, the Columbia University Department of Ophthalmology clinical researchers initiated the Manhattan Vision Screening and Follow-up Study (NYC-SIGHT), a 5-year community-based study designed to provide evidence that eye health screening can be conducted in underserved populations to detect retinal disease, glaucoma, and other ocular conditions via telemedicine.[23] This is the first study of its kind in New York City (NYC) which targeted residents living in public/affordable housing developments, which offer a unique opportunity to reach socioeconomically disadvantaged and underserved individuals known to have poor access to eye care.

This article describes the detection of retinal pathology using a nonmydriatic, handheld fundus camera and the factors associated with abnormal retinal findings requiring referral to ophthalmology.

Materials and Methods

STUDY DESIGN

This is a subanalysis of a 5-year, prospective, clinical trial, and the methods have been previously described in detail.[23] In brief, this study consisted of an eye health screening and referral for follow-up eye care among eligible participants. The study was approved by the Columbia University Irving Medical Center Ethics Committee and Institutional Review Board (No. AAAR9162). All aspects of the study were conducted in accordance with the Declaration of Helsinki. Before enrollment, informed consent was obtained from all participants, and the study was registered on ClinicalTrials.gov (NCT04271709).

TARGET POPULATION

The study's partner organizations, New York City Housing Authority (NYCHA) and the NYC Department for the Aging (DFTA), selected 10 housing developments for recruitment that were in close proximity to Columbia University Harkness Eye Institute and Harlem Hospital Ophthalmology in Harlem and Washington Heights. This allowed recruitment of at-risk individuals with inadequate eye care and focused on the built environment and access to health care as social determinants of health (SDOH).[23,24] These individuals fall at or below the NYC.gov poverty measure (zip codes 10027, 10030, 10032, 10037, 10039)[25] (Fig. 1).

INCLUSION CRITERIA

Individuals over age 40 living in a NYCHA housing development, or a DFTA Senior Center member over 60 years were included, giving access to 6,640 individuals. Those who met the study's inclusion criteria were consented for a baseline eye health screening over the telephone or in person, in English or Spanish, by bilingual study coordinators.[23]

PRESCREENING ASSESSMENT

Parameters such as date of birth, sex, self-identified race/ethnicity, education level, and employment and marital status were collected, as was health insurance information and transportation needs to reach the screening facility. Access to eye care was assessed by determining whether or not the participant had an eye doctor, the timing of their most recent eye exam, and main reason for not attending an eye exam in the past 2 years. Medical and ocular history, ocular medications, and family history of glaucoma and blindness were also collected.

EYE HEALTH SCREENING

The eye health screening was conducted in either the community room or the senior center at the NYCHA housing developments. Visual acuity (VA) was assessed with correction using a Snellen eye chart at 20 feet, and the corresponding logarithm of the minimum angle of resolution values were used for analysis. Participants with acuity 20/40 or worse in either eye failed the screening.

Intraocular pressure (IOP) was measured in both eyes using the Ic100 iCare rebound tonometer (ICare, Helsinki, Finland). Participants with IOP 22–29 mmHg in either eye failed the screening, while anyone with an IOP ≥30 mmHg were considered "fast tracked" and referred to ophthalmology and were seen within one week.

At least two undilated fundus photographs of the disc and macula of each eye were taken by a trained ophthalmic photographer in a dark environment using a handheld fundus camera (Volk Pictor Prestige; Volk Optical, Mentor, OH). Within 24 h, the ophthalmic photographer uploaded these images to a Health Insurance Portability and Accountability Act (HIPAA)-compliant cloud-based database (Forum, Zeiss Oberkochen, Germany), which were then interpreted by one study ophthalmologist specializing in retina and one specializing in glaucoma. Grading of the quality of each image (good, fair, poor, or unreadable) was based on image features such as spatial resolution, focus, contrast, and illumination.[26] Retinal image findings were classified by the study retina specialist as retinal vascular/ischemic changes, macular pathology, active retinal disease requiring treatment, nonglaucomatous optic nerve findings, posterior segment hemorrhages and choroidal lesions, and multiple categories could be selected for each eye (Fig. 1). These same images were subjected to a separate assessment by a glaucoma specialist for evaluation of glaucomatous pathology; these latter findings are discussed in a separate article.

The purpose of the study was to determine the utility of a fundus camera in community-based eye health screening and not to make a definitive clinical diagnosis. Following image grading and classification by the study ophthalmologists, an overall determination was made for the worse eye as (1) normal or abnormal without significant findings, (2) abnormal with significant findings, or (3) unreadable. Participants with an unreadable fundus image in either eye also failed the eye health screening. All participants who failed the screening due to VA 20/40 or worse, IOP 22–29 mmHg or an unreadable image in the worse eye were scheduled with the study optometrist within 3 weeks at the same location.

REFERRAL TO OPHTHALMOLOGY FOR RETINAL ABNORMALITIES

If a retinal abnormality was seen in either eye by the study retina specialist using telemedicine, participants were referred to Columbia Ophthalmology, Harlem Hospital Ophthalmology, or their own eye care provider for further assessment. All referred participants were assisted by the study team with scheduling their first follow-up eye exam appointment.

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS version 25 (IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 25.0. IBM Corp, Armonk, NY) as well as the R statistical package (Version 4.1.2; Vienna, Austria). Study data were managed with Research Electronic Data Capture (REDCap) tools at Columbia University. Participant characteristics were summarized for the study population using means and standard deviations for continuous variables, and frequencies and percentages for categorical variables.[27,28]

A chi-square test was used to determine significance between those who had an abnormal retinal image and those with a normal image or no significant findings. A multivariate logistic regression model was utilized to assess for potential associations between demographic and clinical characteristics and SDOH in participants referred to ophthalmology because of an abnormal retinal image, excluding all unreadable images. The dependent variable in the model was abnormal retinal image finding. Statistical significance was considered with *p*-values <0.05 at a confidence interval (CI) of 95%.

ETHICAL APPROVAL

This report was conducted in accordance with the Declaration of Helsinki. The collection and evaluation of all protected patient health information was performed in a HIPAA-compliant manner.

STATEMENT OF INFORMED CONSENT

Informed consent was obtained before performing the procedure, including permission for publication of all photographs and images and images included herein.

Results

Eye health screenings were conducted over a 15-month period from March 1, 2021, to May 31, 2022. As shown in Figure 1, 704 participants consented for fundus photography and of those, 125 of 555 (22.5%) who failed the VA and IOP screening had an abnormal retinal image, while 32 of 153 (20.9%) participants who passed the vision and IOP screening had an abnormal retinal image. Classification of the 157 participants ($n = 125 + 32$) with abnormal retinal images included 77 macular pathology, 43 retinal vascular/ischemic changes, 29 posterior segment hemorrhages, 28 active retinal disease requiring treatment, 28 nonglaucomatous optic nerve findings, 5 choroidal lesions, and 4 other retinal findings (Table 1). The total percentage of participants referred to T1 ophthalmology for retina findings ($n = 157$) represents 22% of our screened population ($n = 708$).

DEMOGRAPHICS AND SDOH

Mean age of participants with an abnormal retinal image is 68.4 ± 11.1 years. The majority of participants with an abnormal retinal image were in the 60 to 79-year age group, followed by those over age 80 (Table 2). Similar to the population study demographics, 63.7% of participants with an abnormal retinal image were female, 50.3% were African American, and 43.3% were Hispanic (76.4% were Dominican). Significantly more participants with retinal findings had health insurance (98.1%), including Medicare (60.5%) or Medicaid (63.7%) compared to those with a normal fundus image. Of those with an abnormal retinal image, 35% had their own eye doctor, significantly higher than those with a normal image ($p = 0.03$) (Table 2).

CLINICAL CHARACTERISTICS

Of those with an abnormal retinal image, self-reported medical conditions included hypertension (59.9%), diabetes (35.7%), arthritis/osteoporosis (47.1%), and depression (10.8%) (Table 3). Self-reported ocular conditions included dry eye (49.7%), blurry vision (40.8%), glaucoma (15.3%), and macular degeneration (3.2%). Significantly more participants with an abnormal retinal image self-reported diabetes ($p = 0.021$), glaucoma ($p < 0.001$), and macular degeneration ($p = 0.006$) compared to those with a normal image (Table 3).

EYE HEALTH SCREENING

Significantly more participants with an abnormal retinal image failed the eye health screening compared to those with a normal image (79.6% vs. 68.3%; $p = 0.011$) (Table 3). As shown in Figure 1, 32 abnormal retinal images were still detected in those who passed the vision and IOP screening compared to 125 abnormal retinal images detected in those who failed the eye health screening. Participants with severe vision impairment at screening (20/200 or worse) were significantly more likely to have an abnormal retinal image ($p < 0.001$) (Table 3).

MULTIVARIATE LOGISTIC REGRESSION

Statistically significant factors were included in the logistic regression model and participants who self-identified as having preexisting glaucoma (odds ratio [OR] = 3.750, 95% CI = 1.741–8.074; $p = 0.0001$) or had severe vision impairment (OR = 4.1034, 95% CI = 2.0740–8.1186; $p = 0.000$) had significantly higher odds of having an abnormal retinal image.

Discussion

The NYC-SIGHT is a novel community-based eye health screening study that incorporated a handheld, nonmydriatic fundus camera to detect retinal abnormalities in a diverse, underserved population in public/affordable housing developments and senior centers in Upper Manhattan. This sub-analysis provides important evidence supporting the need for early detection of retinal diseases and other ocular conditions in at-risk populations and highlights the benefits of using tele-ophthalmology within community-based eye health screenings. Fundus photographs were obtained in 704 of the 708 enrolled participants, which show excellent cooperation of study participants and support the feasibility, portability, and ease of use of the handheld camera. Of those that passed the vision and IOP screening, 32 participants had an abnormal retina image, providing evidence of the importance of fundus photography in eye health screenings to detect retinal disease.

Multivariate logistic regression showed that participants with preexisting, self-reported glaucoma or severe visual impairment at the screening had significantly higher odds of having an abnormal retinal image. This data are consistent with prior studies and suggest that in community-based settings, checking VA and taking a medical and ocular history may aid in early detection of retinal pathology, warranting referral to ophthalmology.[19] Of the 157 participants with abnormal retinal findings, 65% did not have an eye doctor and were assisted in making a follow-up retina exam. Consistent with previously reported community-based studies and reports from the CDC, this additional assistance helps improve utilization of eye care.[1,29–31] Additionally, 98% of all participants with abnormal retinal images had Medicare or Medicaid insurance, which reduced the insurance barrier for follow-up eye care. The majority of participants also indicated they did not need transportation assistance, most likely because we were conducting the community-based eye health screenings convenient to where they live, within a dense urban setting.

Ophthalmology as a specialty relies heavily on imaging modalities, such as fundus photography, for the documentation and interpretation of retinal findings. This also allows for consultation with other providers in case of diagnostic difficulty, as well as comparison of ocular conditions between visits, and to aid in surgical and clinical decision making. Advances in technology, including imaging interpretation with artificial intelligence, have facilitated obtaining fundus photographs for screening of treatable ocular diseases such as diabetic retinopathy and retinopathy of prematurity.[21,32,33] Although interpretation of fundus photographs alone is not the gold-standard for diagnosing retinal disease, the reliance of ophthalmology on this imaging modality has allowed for acceptance of its use particularly in remote, underserved areas without adequate eye care coverage.[32] This has allowed for expansion of ophthalmologic care to areas that may previously have not had access and has opened new doors for both patients and providers to collaborate, particularly in treating and examining chronic retinal disease.

According to estimates, only 60% of people with diabetes in the United States receive a dilated eye examination annually, which highlights the need for better access to eye care services across all populations. In addition, 49% of patients who underwent tele-ophthalmology imaging in uninsured/underinsured areas had a follow-up dilated fundus examination.[34] Tele-ophthalmology has the potential to improve access to eye care for underserved patients, but efforts are needed to increase access to this technology and facilitate ophthalmologist visits after receiving the results.[34] Nonetheless, studies have shown that tele-ophthalmology is comparable to an in-person comprehensive eye exam, and patients do in fact view telemedicine assessments as an acceptable form of screening for diabetic retinopathy due to convenience and accessibility.[33,35–37]

STRENGTHS

Despite challenges with recruitment of participants during the COVID-19 pandemic, over 90% of those enrolled in the NYC-SIGHT stated they were satisfied with the convenience and location of the eye health screenings.[38] The study considered SDOH by bringing eye health screenings into the community and included the fundus camera with remote reading to detect ocular pathology. This intervention, along with patient education on the importance of annual eye exams, could be the key to improving eye care access and utilization in at-risk communities and could be replicated and scaled in the future.[39,40]

Other advantages of tele-ophthalmology screening for retinal diseases include cost-effectiveness and decreased clinical burden related to routine screenings.[38] Not only is early detection of ocular disease cost-efficient for the health care sector compared to late-stage treatments, but reducing the workload on eye care providers by using tele-ophthalmology has also been shown to reduce everyday costs compared to in-person eye examinations.[32,33,41] In the case of diabetic retinopathy, the use of tele-ophthalmology has been shown to reduce costs significantly. In fact, one study found that the total cost of tele-ophthalmology was around $8.38 USD per visit, compared to $17.64 USD for an in-person dilated examination done by an optometrist and $41.53 USD for an in-person dilated exam done by an ophthalmologist.[42]

LIMITATIONS

Limitations of this study include selective recruitment of seniors and adults in public housing near Columbia University who self-selected to participate, which may not be reflective of all underserved populations in New York or other cities. While transportation was not a barrier in our urban setting, traveling to eye care providers may be more challenging in other geographic locations. Additionally, the senior-only buildings were more effective than the larger adult housing developments for recruiting and conducting the eye health screenings, which may skew our data to some degree or bias the sample.

Conclusions

In conclusion, the NYC-SIGHT detected retinal abnormalities requiring further follow-up with an ophthalmologist in 22% of our study participants. Most of these participants had failed the vision and IOP screening; however, 20.9% (n = 32) of these would have been missed due to normal vision and IOP results, had it not been for the routine fundus photographs that were also taken. This shows that the utility of a fundus camera is paramount in the community setting, particularly with retinal findings that may not directly affect vision or eye pressure. Through collaboration with community partners, we identified multiple racial/ethnic groups as well as underserved populations at-risk for retinal and other eye diseases and improved their access to eye care via telemedicine. We found that assessment of VA and inquiry of prior history of glaucoma are some of the most important factors in detecting retinal pathology in our study population. These results provide insight into the burden of retinal diseases in this underserved, at-risk population, and the benefit of telemedicine.

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Data Availability Statement

All deidentified participant data, study protocol, statistical plan, and informed consent will be made available by the corresponding author upon e-mail request. The data will be made available with investigator support after approval of a proposal and a signed data access agreement is fully executed. Study materials are available at SIGHTSTUDIES.org

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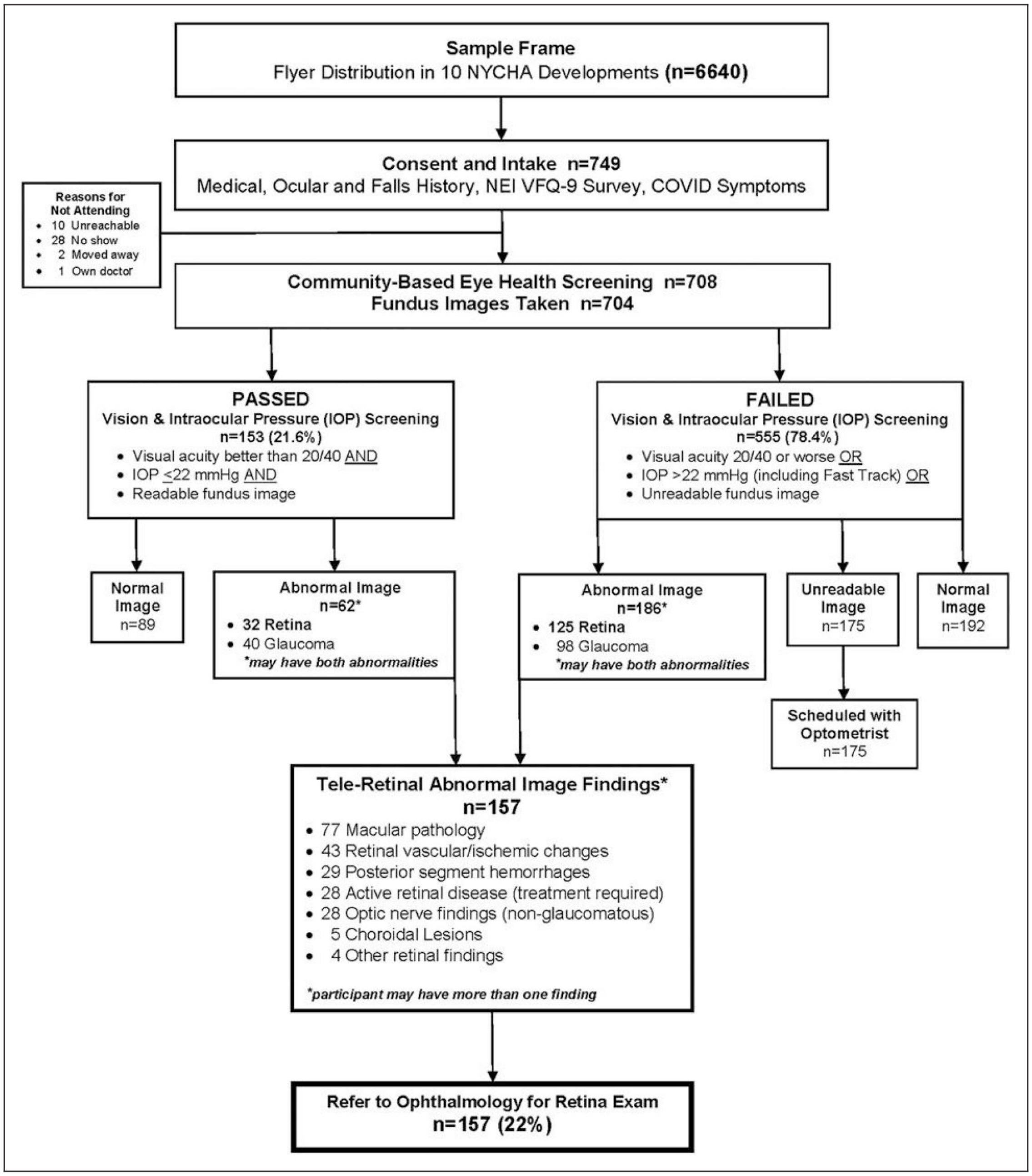

Fig. 1.

Consolidated Standards of Reporting Trials Flow: tele-retinal abnormal image findings requiring referral to ophthalmology. Sample frame of participants (*n* = 6,640) at the housing developments (top center). Informed consent, intake data, medical, ocular, and falls history, and a quality of life survey were obtained before the eye health screening (second row). Enrolled participants completed the community eye health screening including fundus images (third row). Reasons for not attending the eye health screening (third row right). Participants who passed the vision and IOP screening and criteria (fourth row left). Participants who failed the eye health screening and criteria (fourth row right). Tele-ophthalmology reading of normal and abnormal image for those who passed the vision and

IOP check (fifth row left) and abnormal, unreadable, and normal image for those who failed the eye health screening (fifth row right). Participants with an unreadable image scheduled with the on-site study optometrist (sixth row right). Participants with tele-retinal abnormal image findings (seventh row center). Total participants referred to ophthalmology for retina exam (last row). IOP, intraocular pressure.

Table 1.

Manhattan Vision Screening and Follow-Up Study: Tele-Ophthalmology Image Reading Form and Abnormal Retinal Findings

ABNORMAL RETINAL IMAGE READING CATEGORIES	FINDINGS (No.)[a]
Retina vascular/ischemic changes	
Arteriolar attenuation	4
Arteriovenous crossing	1
Venous dilation	1
Central retinal artery occlusion	0
Branch retinal artery occlusion	1
Central retinal vein occlusion	1
Branch retinal vein occlusion	2
Hollenhorst plaques	2
Hard exudates	24
Intraretinal microvascular abnormalities	0
Microaneurysms	2
Cotton wool spots	4
Disc Neovascularization > 10a	0
Disc Neovascularization < 10a	0
Neovascularization elsewhere	1
Total	**43**
Macular pathology	
Macular edema	1
Epiretinal membrane	9
Macular hole	3
Macular retina pigment epithelial changes	17
Large macular drusen	8
Intermediate macular drusen	16
Small macular drusen	17
Macular atrophy	4
Macular fibrosis	1
Macular RPE detachment	1
Total	**77**
Active retinal disease–treatment required	
Suspicion for treatment–requiring proliferative diabetic retinopathy	1
Suspicion for treatment–requiring diabetic macular edema	7
Suspicion for treatment–requiring macular edema of retinal vein occlusion	3
Suspicion for treatment–requiring neovascular age-related macular degeneration	0
Suspicion for treatment–requiring tractional retinal detachment	0

ABNORMAL RETINAL IMAGE READING CATEGORIES	FINDINGS (No.)[a]
Suspicion for treatment–requiring hypertension	4
Suspicion for meeting age-related dietary supplements	13
Total	**28**
Optic nerve findings	
Optic nerve shunt vessels	6
Optic nerve edema	0
Peripapillary atrophy	22
Total	**28**
Posterior segment hemorrhages	
Disc hemorrhage	1
Macular hemorrhage	0
Preretinal hemorrhage	0
Vitreous hemorrhage	1
Dense vitreous hemorrhage	0
Subretinal hemorrhage	0
Nerve fiber layer hemorrhage	6
Dot-blot intraretinal hemorrhage	21
Total	**29**
Choroidal lesions	
Choroidal nevus	**5**
Other findings	**4**

[a]Participants may have more than one finding.

RPE, retina pigment epithelial.

Table 2.

Manhattan Vision Screening and Follow-Up Study: Social Determinants of Health of Study Participants with Normal and Abnormal Tele-Retinal Image Reading Results

VARIABLE	ABNORMAL RETINAL IMAGE [*N*= 157)	NORMAL RETINAL IMAGE + NO SIGNIFICANT FINDINGS (*N*= 281)	*p*-VALUE[a]
Mean age ± SD, (range)	68.4 ± 11.1	65.6 ± 12.2	**0.013**
Age categories			
40–59 years (%)	37 (23.6)	98 (34.9)	**0.014**
60–79 years	99 (63.1)	149 (53.0)	**0.042**
≥80 years	21 (13.4)	34 (12.1)	0.699
Sex, *n* (%)			
Female	100 (63.7)	202 (71.9)	0.076
Male	57 (36.3)	79 (28.1)	0.076
Ethnicity/race, *n* (%)			
Hispanic/Latino	68 (43.3)	124 (44.1)	0.869
Black, non-Hispanic	79 (50.3)	131 (46.6)	0.457
Other (American Indian, multiracial, White, and Asian)	10 (6.4)	26 (9.3)	0.292
Hispanic origin *n*= 297 + multiracial *n*= 17			
Dominican	55 (76.4)	92 (68.1)	0.213
Puerto Rican	9 (12.5)	25 (18.5)	0.266
Mexican	1 (1.4)	1 (0.7)	0.650
Cuban	0 (0.0)	2 (1.5)	0.544
Spanish/South American	7 (9.7)	15 (11.1)	0.757
Education level			
Less than high school	47 (29.9)	82 (29.2)	0.868
High school	60 (38.2)	89 (31.7)	0.166
Some college, college graduate, or graduate degree	50 (31.8)	110 (39.1)	0.128
Employment status			
Employed (full-time, part-time, or self-employed)	27 (17.2)	72 (25.6)	**0.043**
Unemployed	21 (13.4)	36 (12.8)	0.866

VARIABLE	ABNORMAL RETINAL IMAGE [*N*= 157)	NORMAL RETINAL IMAGE + NO SIGNIFICANT FINDINGS (*N*= 281)	*p*-VALUE[a]
Retired	85 (54.1)	135 (48.0)	0.221
Disabled/unable to work	24 (15.3)	38 (13.5)	0.612
Marital status			
Single, divorced, separated, or widowed	121 (77.1)	217 (77.2)	0.971
Married/domestic partner	36 (22.9)	64 (22.8)	0.971
Needs assistance with transportation, *n* (%)	21 (13.4)	20 (7.1)	**0.031**
Has health insurance, *n* (%)	154 (98.1)	262 (93.2)	**0.026**
Insurance type, *n* (%)			
Medicare	95 (60.5)	133 (47.3)	**0.008**
Medicaid	100 (63.7)	148 (52.7)	**0.026**
Private or supplemental	46 (29.3)	88 (31.3)	0.660
Primary language			
English	95 (60.5)	167 (59.4)	0.825
Spanish	59 (37.6)	106 (37.7)	0.976
Other (French/Creole/Arabic/Bengali/Russian)	3 (1.9)	8 (2.8)	0.548
Has own eye doctor (access to eye care), *n* (%)	55 (35.0)	71 (25.3)	**0.030**

[a]Bold *p*-value indicates statistical significance at the $p<0.05$ level.

SD, standard deviation.

Table 3.

Manhattan Vision Screening and Follow-Up Study: Clinical Characteristics of Study Participants with Normal and Abnormal Tele-Retinal Image Reading Results

VARIABLE	ABNORMAL RETINAL IMAGE (*N*= 157)	NORMAL RETINAL IMAGE + NO SIGNIFICANT FINDINGS (*N*= 281)	*p*-VALUE[a]
Medical conditions (self-reported), *n* (%)			
Hypertension	94 (59.9)	168 (59.8)	0.986
Diabetes	56 (35.7)	71 (25.3)	**0.021**
Arth ritis/osteoporosis	74 (47.1)	140 (49.8)	0.589
Foot problems	59 (37.6)	102 (36.3)	0.790
Heart problems	32 (20.4)	46 (16.4)	0.293
Depression	17 (10.8)	57 (20.3)	**0.011**
Asthma/COPD[b]	27 (17.2)	47 (16.7)	0.900
Cancer	8 (5.1)	18 (6.4)	0.578
Other medical conditions	21 (13.4)	28 (10.0)	0.277
No medical conditions	18 (11.5)	42 (14.9)	0.310
Current smoker, *n* (%)	22 (14.0)	39 (13.9)	0.969
Ocular conditions (self-reported), *n* (%)			
Dry eye	78 (49.7)	134 (47.7)	0.689
Blurry vision	64 (40.8)	118 (42.0)	0.802
Cataract	49 (31.2)	71 (25.3)	0181
Glaucoma	24 (15.3)	11 (3.9)	**0.000**
Floaters	26 (16.6)	39 (13.9)	0.449
Double vision	8 (5.1)	23 (8.2)	0.227
Diabetic retinopathy	3 (1.9)	4 (1.4)	0.697
Macular degeneration	5 (3.2)	0 (0.0)	**0.006**
No ocular conditions	32 (20.4)	67 (23.8)	0.406
Last dilated eye exam, *n* (%)			
Within the past year	46 (29.3)	48 (17.1)	**0.003**
Within 1 to 2 years	37 (23.6)	68 (24.2)	0.882

VARIABLE	ABNORMAL RETINAL IMAGE (*N*= 157)	NORMAL RETINAL IMAGE + NO SIGNIFICANT FINDINGS (*N*= 281)	*p*-VALUE[a]
More than 2 years	52 (33.1)	105 (37.4)	0.374
Can't remember	15 (9.6)	34 (12.1)	0.418
Never had eye exam	7 (4.5)	26 (9.3)	0.068
Reason for no eye exam in past 2 years, *n* (%)			
No reason to go	23 (31.1)	52 (31.7)	0.923
Not thought about it	14 (18.9)	21 (12.8)	0.218
No vision insurance	5 (6.8)	16 (9.8)	0.450
Cost of eye exam	2 (2.7)	4 (2.4)	0.904
Don't have an eye doctor	3 (4.1)	5 (3.0)	0.690
Couldn't get appointment	3 (4.1)	6 (3.7)	0.882
No transportation to office	0 (0.0)	1 (0.6)	1.00
Other, including COVID-19	24 (32.4)	59 (36.0)	0.595
Failed eye health screening, *n* (%)	125 (79.6)	192 (68.3)	**0.011**
Reason for failure,[c] *n* (%)			
Visual acuity 20/40 or worse	121 (77.1)	187 (66.5)	**0.021**
IOP[d] ≥ 23–29 mmHg	11 (7.0)	15 (5.3)	0.479
Unreadable image	0 (0.0)	0 (0.0)	N/A
Visual acuity based on worse eye, mean logMAR[e] ± SD	0.63 ± 0.60	0.41 ± 0.38	**0.000**
No vision impairment: logMAR 0–0.18, *n* (%) (20/20, 20/25, 20/30)	36 (22.9)	93 (33.1)	**0.025**
Mild vision impairment: logMAR 0.3–0.48, *n* (%) (20/40, 20/50, 20/60)	41 (26.1)	85 (30.2)	0.359
Moderate vision impairment: logMAR 0.54–0.7, *n* (%) (20/70, 20/80, 20/100)	44 (28.0)	83 (29.5)	0.738
Severe vision impairment: logMAR 1.0–3.0, *n* (%) (20/200, CF, HM, LP, NLP)	36 (22.9)	20 (7.1)	**0.000**
IOP (mmHg), mean ± SD			
Left eye (*n*= 706)	14.3 ± 4.4	14.9 ± 3.9	0.203
Right eye (*n*= 705)	14.5 ± 4.5	14.9 + 3.9	0.288

[a]Bold *p*-value indicates statistical significance at the $p<0.05$ level.

[b]COPD, chronic obstructive pulmonary disease.

[c]Multiple reasons for eye health screening failure possible.

[d] IOP, intraocular pressure.

[e] logMAR, logarithm of the minimum angle of resolution.

CF; HM; LP; N/A; NLP.

Table 4.

Manhattan Vision Screening and Follow-Up Study: Multivariate Regression Model Estimating Factors Associated with Abnormal Retinal Image Requiring Follow-Up

VARIABLES	ODDS RATIO (95% CI)	*p*-VALUE[a]
Glaucoma/glaucoma suspect		
No	Reference	Reference
Yes	3.7494 (1.7412–8.0741)	**0.001**
Visual acuity result (worse eye)		
No vision impairment	Reference	Reference
Severe vision impairment	4.1034 (2.0740–8.1186)	**0.000**

[a] Bold *p*-value indicates statistical significance at the $p<0.05$ level.

CI, confidence interval.