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The Philadelphia Glaucoma Detection and Treatment Project:

Detection Rates and Initial Management

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Abstract

Purpose—To evaluate the detection rates of glaucoma-related diagnoses and the initial treatments received in the Philadelphia Glaucoma Detection and Treatment Project, a communitybased initiative aimed at improving the detection, treatment, and follow-up care of individuals at risk for glaucoma.

Design—Retrospective analysis.

Participants—A total of 1649 individuals at risk for glaucoma who were examined and treated in 43 community centers located in underserved communities of Philadelphia.

Methods—Individuals were enrolled if they were African American aged 50 years, were any other adult aged 60 years, or had a family history of glaucoma. After attending an informational glaucoma workshop, participants underwent a targeted glaucoma examination including an ocular, medical, and family history; visual acuity testing, intraocular pressure (IOP) measurement, and corneal pachymetry; slit-lamp and optic nerve examination; automated visual field testing; and

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fundus color photography. If indicated, treatments included selective laser trabeculoplasty (SLT), laser peripheral iridotomy (LPI), or IOP-lowering medications. Follow-up examinations were scheduled at the community sites after 4 to 6 weeks or 4 to 6 months, depending on the clinical scenario.

Main Outcome Measures—Detection rates of glaucoma-related diagnoses and types of treatments administered.

Results—Of the 1649 individuals enrolled, 645 (39.1%) received a glaucoma-related diagnosis; 20.0% (n = 330) were identified as open-angle glaucoma (OAG) suspects, 9.2% (n = 151) were identified as having narrow angles (or as a primary angle closure/suspect), and 10.0% (n = 164) were diagnosed with glaucoma, including 9.0% (n = 148) with OAG and 1.0% (n = 16) with angle-closure glaucoma. Overall, 39.0% (n = 64 of 164) of those diagnosed with glaucoma were unaware of their diagnosis. A total of 196 patients (11.9%) received glaucoma-related treatment, including 84 (5.1%) who underwent LPI, 13 (0.8%) who underwent SLT, and 103 (6.2%) who were prescribed IOP-lowering medication.

Conclusions—Targeting individuals at risk for glaucoma in underserved communities in Philadelphia yielded a high detection rate (39.1%) of glaucoma-related diagnoses. Providing examinations and offering treatment, including first-line laser procedures, at community-based sites providing services to older adults are effective to improve access to eye care by underserved populations.

Glaucoma is a chronic optic neuropathy representing a significant global public health issue as the leading cause of irreversible blindness in the world. Estimates have projected that 60.5 million people worldwide had glaucoma in 2010, including 8.4 million people with bilateral blindness from the disease. Furthermore, the worldwide prevalence of glaucoma is expected to increase to 111.8 million people by 2040, causing further economic and quality-of-life burdens. In the United States alone, annual health care costs associated with treating glaucoma are estimated at approximately \$3 billion.

Primary open-angle glaucoma (POAG) is believed to comprise the majority of cases worldwide, disproportionately affecting Africans, whereas primary angle-closure glaucoma (PACG) disproportionately affects Asians. In the United States, POAG is the most common type of glaucoma, affecting approximately 2% of adults 40 years of age or older, or approximately 2.2 million US citizens. Risk factors for glaucoma include elevated intraocular pressure (IOP), 5-7 advanced age, a family history of glaucoma, race (African American, Asian), and ethnicity (Hispanic/Latino). More specifically, among African Americans compared with white subjects, the prevalence of POAG is 4 to 5 times as high; POAG may develop at a younger age, and the rate of glaucoma-related blindness is 6 to 8 times higher. The risk of glaucoma increases in all people with age, particularly in Hispanic and African-American adults; approximately one quarter of African Americans older than 75 years of age have glaucoma, after the majority and particularly high risk.

Despite available testing and effective treatment options to prevent vision loss, estimates suggest that 50% to 75% of people with glaucoma remain undiagnosed, 7,11 in part because of barriers in reaching high-risk populations. Previous research on office-based screening programs for underserved populations showed that approximately half of patients found to

be high risk through a vision screening do not return for an eye examination. ^{15,16} Significant barriers preventing high-risk populations from obtaining regular eye examinations include insufficient knowledge about glaucoma and its progression, inadequate insurance, lack of trust, language barriers, difficulty obtaining transportation, need for multiple follow-up visits once glaucoma treatment is initiated, and cost of eye care co-payment. ¹⁶

The Wills Eye Glaucoma Research Center initiated a 2-year demonstration project to develop and implement a community-based intervention to overcome these barriers to educate, detect, and treat individuals with glaucoma in high-risk, underserved populations in Philadelphia and to ultimately prevent the burden of further vision loss. The purpose of this report is to describe the results of the baseline examinations and initial treatments in this project.

Methods

The methods of this project have been described in detail in a previous report. ¹⁷ In brief, a 2-year community outreach initiative, funded by the US Centers for Disease Control and Prevention, was performed between January 1, 2012, and May 31, 2014. Wills Eye Hospital partnered with multiple organizations, in particular those serving African Americans, Hispanics, and older adults in Philadelphia, to establish community-based sites. Partners included governmental agencies, nonprofit organizations, faith-based organizations, human services organizations, and various senior housing and senior centers, which were selected on the basis of their willingness to participate.

Initially, a Wills Eye community health educator led a glaucoma awareness workshop for individuals at risk for glaucoma at each community-based site. Informational materials were distributed in English, Spanish, Cantonese, and Mandarin. Workshop participants were then encouraged to sign up for a glaucoma detection examination, if eligible. Individuals were enrolled if they were African American aged 50 years, were any other adult aged 60 years, or had a family history of glaucoma.

The Wills Eye team consisted of 5 members: an ophthalmologist, a project manager, an ophthalmic technician, a community health educator, and a mobile unit coordinator. The team performed free glaucoma examinations approximately 1 week after the workshop. Walk-ins also were accepted. The team and all equipment were transported via the Wills Eye van to the community-based sites to eliminate patient transportation barriers.

The glaucoma examination consisted of a medical, ocular, and family history; visual acuity testing; corneal pachymetry; slit-lamp biomicroscopy of the anterior segment; IOP measurement by Goldmann applanation tonometry; indentation gonioscopy; undilated fundoscopy with additional dilated fundoscopic examination if deemed necessary by the examining ophthalmologist; automated visual field testing (Octopus 300 Visual Field Analyzer; Haag-Streit Inc., Bern, Switzerland); and fundus-color photography¹⁸ (Volk Pictor; Optomed Oy Ltd., Oulu, Finland) (Fig 1). All patient information was entered into the Wills Eye electronic medical record system. Participants also were asked to complete satisfaction surveys after their eye examinations.

Patients diagnosed with new open-angle glaucoma (OAG) were offered selective laser trabeculoplasty (SLT) as an option for first-line treatment for elevated IOP. Patients who were previously diagnosed with glaucoma and required an IOP-lowering intervention also may have been offered SLT at the physician's discretion. Patients diagnosed with angle closure, including primary angle-closure suspect, primary angle-closure, and PACG, were recommended for laser peripheral iridotomy (LPI). Angle closure was defined as >180 degrees of iridotrabecular contact in primary gaze on gonioscopy. All laser procedures were performed at the community site without charge, either on the same day or at a subsequent follow-up visit at the same site, using the Selecta Duet laser platform (Lumenis Inc., San Jose, CA). Same-day bilateral treatments were encouraged. Patients with OAG who declined laser therapy and patients with PACG or secondary angle-closure glaucoma received a prescription for appropriate IOP-lowering medications as determined by the treating ophthalmologist.

Patients who were diagnosed with glaucoma and received SLT, LPI, or glaucoma medications were scheduled for a follow-up appointment at the community location 4 to 6 weeks and 4 to 6 months from the baseline visit. Follow-up and adherence outcomes will be reported separately. The OAG suspects also were scheduled for community-based follow-up visits in 4 to 6 months. The community health educator contacted all patients to confirm follow-up visits to improve adherence. Patients who did not have glaucoma-related conditions were advised to follow up with their own eye-care provider within 1 year. If other eye diseases were detected, patients were notified and referred to local ophthalmologists or the Wills Eye Hospital Ophthalmology Clinic. Patients without insurance were directed to a "patient navigator," who assisted them in obtaining care through charity resources, Medicaid, or other programs. After the 6-month follow-up visit, all patients were offered future follow-up eye care with the Wills Eye Primary Eye Care Clinic or Glaucoma Service, or other local ophthalmologists in private practice or health centers in Philadelphia.

Baseline characteristics of all patients examined, including demographics, clinical measurements, and diagnosis, are summarized with frequency and percentage for categoric data or with mean and standard deviation for continuous variables. SAS software version 9.4 (SAS Institute, Inc., Cary, NC) was used for all analyses. The institutional review board at Wills Eye Hospital approved the study procedure. The study was Health Insurance Portability and Accountability Act compliant and adhered to the tenets of the Declaration of Helsinki.

Results

The Philadelphia Glaucoma Detection and Treatment Project enrolled 1649 individuals at risk for glaucoma. Figure 2 illustrates a flow chart of patient enrollment and attendance at initial examinations across the 43 community sites. Because of walk-ins (n = 598), more patients were examined than originally scheduled.

Baseline demographic and clinical characteristics of participants are shown in Table 1. The majority of enrolled patients were female (n = 1131; 68.6%) and African American (n = 1146; 69.5%). The mean (standard deviation) age of patients was 68.8 (10.6) years.

Overall, 39.1% (n = 645) of participants were diagnosed with glaucoma-related conditions; 20.0% (n = 330) were identified as OAG suspects, 9.2% (n = 151) were identified as having primary angle-closure suspect/primary angle-closure, and 10.0% (n=164) were diagnosed with glaucoma, including 9.0% (n = 148) with OAG and 1.0% (n=16) with PACG. A total of 39.0% (n = 64 of 164) of those diagnosed with glaucoma were newly diagnosed. Although the remaining 61.0% of those with glaucoma had been previously diagnosed, it was noted that many of them had not been under the care of an ophthalmologist. Of the 645 patients diagnosed with glaucoma-related conditions, African Americans made up the majority (n = 433), followed by white subjects (n = 105) (Table 2). Individuals who were diagnosed with glaucoma-related conditions were more likely to be older, to have higher IOP, to have a larger cup-to-disc ratio and higher disc damage likelihood scale scores, to have worse visual acuity in each eye, and to have a family history of glaucoma. The mean age of glaucoma suspects was 3.7 years (95% confidence interval, 1.2–6.3 years) younger than that of individuals diagnosed with glaucoma.

Overall, 196 patients (11.9% of the 1649 enrolled) received glaucoma-related treatment. Some patients received more than 1 treatment. Ninety-seven patients (5.9%) underwent laser treatment; 13 (0.8%) had SLT, and 84 (5.1%) had LPI (Table 3). A total of 103 patients (6.2%) were prescribed IOP-lowering medications. Fifty-eight patients were prescribed a prostaglandin analog, 8 patients were prescribed an alpha agonist, 5 patients were prescribed a topical carbonic anhydrase inhibitor, 4 patients were prescribed a beta-blocker, 1 patient was prescribed a systemic carbonic anhydrase, and 10 patients were prescribed a combination drop; 17 patients were prescribed more than 1 medication at the baseline visit.

Table 4 shows patient responses to the satisfaction survey taken after the baseline visit. The majority (99.3%) of the responders were very satisfied or satisfied with their glaucoma eye examination, and 99.1% reported that they were very likely or somewhat likely to recommend the glaucoma detection examination to a friend or family member.

Discussion

The Philadelphia Glaucoma Detection and Treatment Project was a community-based intervention that aimed to improve access to and use of eye care, as well as to provide detection and management of glaucoma-related conditions in individuals at risk for glaucoma. This project enrolled African Americans aged 50 years, other adults aged 60 years, and individuals with a family history of glaucoma, and had a 39.1% combined detection rate of glaucoma-related diagnoses, including open-angle and angle-closure glaucoma and glaucoma suspects. This includes both previously undiagnosed individuals and those previously diagnosed who had often been lost to follow-up. Separate reports are being published on other eye diseases detected, adherence to follow-up eye examinations, and cost-effectiveness analysis.

The percentage of individuals with open-angle and angle-closure glaucoma in this study population was 9.0% and 1.0%, respectively. These percentages are higher than the reported population-based prevalence estimates of 1.86% for OAG in the United States⁴ and 0.4% for angle-closure glaucoma in European populations.²⁰ High rates of detection in this self-

selected group may be because it comprised mostly older African Americans and focused on targeting underserved neighborhoods in Philadelphia, where the poverty rates are very high. In fact, Philadelphia retains the unwelcome distinction of having the highest poverty rate among the nation's 10 largest cities. In 2013, the poverty rate in Philadelphia was 26.3%, compared with the national rate of 15.8%.

All patients with newly diagnosed OAG were offered SLT as a first-line treatment, and 13 patients (20.3%; n=13/64) underwent the laser procedure in 1 or both eyes. A total of 103 patients (6.2%) received prescriptions for IOP-lowering medications. The percentage of patients who underwent LPI in this study (5.1%) was higher than expected, possibly because of selection bias of the patient population, as the population may have had more advanced, untreated cataracts, which contributed to the narrowing of their angles.

Despite the disease burden of glaucoma in high-risk populations in the United States and worldwide, no consensus exists regarding the effectiveness of glaucoma screening, even among high-risk populations. The US Preventive Services Task Force recently released a report stating that there is insufficient evidence to assess the risks and benefits of screening for POAG in adults. This report also notes that older African Americans have a higher prevalence of glaucoma and adds that if screening reduces vision impairment, then African Americans probably would have greater absolute benefit than whites.²² Many investigators and physicians have argued for the value in glaucoma screening. ^{23,24} The American Academy of Ophthalmology recommends a comprehensive eye evaluation every 1 to 4 years, depending on age, for adults aged more than 40 years with no risk factors, and more frequently for those with risk factors for glaucoma.²⁵ Furthermore, Medicare, which provides insurance to approximately 50 million Americans, reimburses high-risk individuals for an annual glaucoma examination, including those with diabetes, a family history of glaucoma, African Americans aged more than 50 years, and Hispanic Americans aged more than 65 years. ²⁶ Once glaucoma is identified, studies have shown glaucoma treatment to be both cost-effective²⁷ and effective in preventing vision loss.^{28,29}

The US Preventive Services Task Force recommendations should not be interpreted as a rejection of targeted glaucoma detection examinations by eye-care specialists in high-risk individuals. On the contrary, screening for any disease is most beneficial in populations among which the prevalence is high, rather than the general asymptomatic population. For example, Ladapo and colleagues estimated that implementation of a national glaucoma screening program for African Americans aged 50 to 59 years with unrecognized glaucoma would reduce the lifetime prevalence of undiagnosed glaucoma from 50% to 27%. ³⁰

Previous screening programs focused on high-risk populations have identified high percentages of individuals with glaucoma or glaucoma suspect. For example, more than 25% Haitian Afro-Caribbean individuals residing in South Florida (aged >18 years) were identified as glaucoma suspects. The Salisbury Eye Evaluation Glaucoma Study reported a glaucoma prevalence of 5.7% among black persons aged 73 and 74 years and 23.2% among those aged >75 years. High rates of glaucoma (11.3%) also were detected among elderly African Americans (aged >80 years) in the Baltimore Eye Survey. Other studies from St. Lucia and Barbados reported similar findings. 12.33 These findings are consistent with our

results, with 20% of individuals diagnosed as glaucoma suspects and 10% diagnosed with glaucoma. Moreover, 39.0% of those diagnosed with glaucoma-related conditions in our study were previously unaware of their condition, which is comparable to previous studies. The current study, more female than male subjects were included. Although this finding is consistent with findings from a screening program among Haitian Afro-Caribbean individuals, the investigations reported similar rates of glaucoma between the sexes in African Americans, and a recent glaucoma genetic study in Philadelphia reported lower rates of African-American women in the glaucoma group compared with study controls.

Individuals enrolled in this study were mostly African Americans who resided in underserved neighborhoods of Philadelphia. This patient population is less likely to be treated for glaucoma and tends to seek medical care later in the course of the disease compared with white subjects. ³⁶ Previous studies also have shown that African Americans undergo glaucoma surgery at approximately 47% below the expected rate, ³⁷ and they are less aware of the disease compared with white subjects. ³⁸ Limited access to eye care also was more common among African Americans in rural and urban impoverished areas, ³⁶ which highlights the importance of glaucoma detection projects in these areas. Moreover, because glaucoma suspects in this project were younger than patients diagnosed with definite glaucoma, early detection in a younger population could lead to earlier diagnosis and treatment, and prevent vision loss.

In this study, 11.9% of patients received laser or medical treatment for glaucoma. These data highlight the significant disease burden in this high-risk population, as well as the potential vision-preserving benefits of detection and treatment programs such as this demonstration project.

The innovation of this project lies in its successful community outreach and its linking of examination and treatment. Previously identified barriers to eye care were effectively minimized by this project's design: Workshops were designed to increase awareness and knowledge of glaucoma³⁹; examinations with same-day treatment options were offered at the community-based sites, thus reducing transportation issues, decreasing the number of follow-up visits, and increasing convenience; on-site translators were used if necessary to overcome language barriers; and all eye examinations and interventions were free, except for the cost of any prescribed medications, lessening the barrier of cost of care.

The high rate of glaucoma-related detection, and in particular the high percentage of individuals unaware of their diagnosis, suggests the potential to prevent significant vision loss, as well as personal and economic stress within communities where individuals may never have otherwise received glaucoma care. When targeting populations at risk for glaucoma on the basis of age, race/ethnicity, and likelihood of visiting an eye-care provider, the efforts of eye clinic outreach seem worthwhile.

In conclusion, the Philadelphia Glaucoma Detection and Treatment Project identified 39.1% of patients as having a glaucoma-related diagnosis by targeting populations at high risk on the basis of race, ethnicity, age, and barriers to eye care. In the long-term, this Centers for

Disease Control and Prevention—funded project aims to reduce disability, ocular health disparities, and the economic burden from vision loss due to glaucoma. We believe that this type of targeted, community-based, on-site detection and treatment method is generalizable and scalable to a national level to decrease the growing social and economic burden due to undetected glaucoma.

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Abbreviations and Acronyms

IOP intraocular pressure

LPI laser peripheral iridotomy

OAG open-angle glaucoma

PACG primary angle-closure glaucoma

POAG primary open-angle glaucoma

SLT selective laser trabeculoplasty

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Figure 1.
Photographs of on-site glaucoma detection examinations and treatment. Clockwise from top left: intraocular pressure measurement (Goldmann Applanation Tonometry), Wills Eye Van for team and equipment transportation to community sites, laser peripheral iridotomy, automated visual field examination, and fundus color photography. (Photos courtesy: Roger Barone, Wills Eye Hospital).

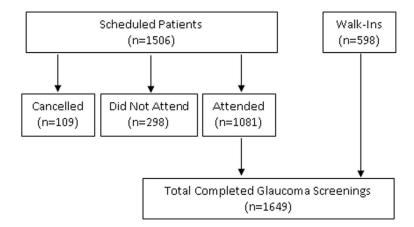


Figure 2.Glaucoma examination attendance in the Philadelphia Glaucoma Detection and Treatment Project (numbers of individuals with available data).

Table 1

Demographic and Clinical Characteristics of Individuals Enrolled in the Philadelphia Glaucoma Detection and Treatment Project

Variable	Total Individuals Enrolled (n = 1649)	No Glaucoma-Related Diagnoses Detected (n = 1004)	Glaucoma-Related Diagnoses Detected (n = 645)	P Value
Age (yrs), mean (SD)	68.8 (10.6)	66.9 (10.5)	71.2 (10.2)	< 0.001
Female sex, n (%)	1131 (68.6)	692 (68.9)	439 (68.1)	0.713
Race, n (%)				0.341
African American	1146 (69.5)	713 (71.0)	433 (67.1)	
White	236 (14.3)	131 (13.1)	105 (16.3)	
Asian	182 (11.0)	106 (10.6)	76 (11.8)	
Hispanic	69 (4.2)	44 (4.4)	25 (3.9)	
Other	16 (1.0)	10(1)	6 (0.9)	
Visual acuity (logMAR), mean (SD))			
Right eye	0.26 (0.35)	0.22 (0.29)	0.31 (0.41)	< 0.001
Left eye	0.29 (0.46)	0.24 (0.41)	0.35 (0.52)	< 0.001
IOP (mmHg), mean (SD)				
Right eye	15.3 (4.2)	14.5 (3.1)	16.6 (5.1)	< 0.001
Left eye	15.3 (4.3)	14.6 (3.5)	16.3 (5.1)	<0.001
CCT (µm), mean (SD)				
Right eye	539.3 (40.1)	538.6 (40.7)	540.3 (39.2)	0.485
Left eye	538.7 (41.9)	538.5 (40.7)	539.0 (43.9)	0.813
C/D ratio, mean (SD)				
Right eye	0.43 (0.2)	0.35 (0.14)	0.54 (0.2)	< 0.001
Left eye	0.42 (0.2)	0.35 (0.14)	0.54 (0.2)	<0.001
DDLS, mean (SD)				
Right eye	2.94 (1.33)	2.45 (0.89)	3.72 (1.52)	< 0.001
Left eye	2.96 (1.45)	2.49 (1.16)	3.71 (1.54)	< 0.001
Family history of glaucoma, n (%)	250 (15.2)	120 (12.0)	130 (20.2)	< 0.001
Systemic diseases, n (%)				
Diabetes	458 (27.8)	286 (28.5)	172 (26.7)	0.421
Hypertension	1079 (65.4)	645 (64.2)	434 (67.3)	0.205

CCT = central corneal thickness; C/D = cup-to-disc; DDLS = Disk Damage Likelihood Scale; IOP = intraocular pressure; logMAR = logarithm of the minimum angle of resolution; N/A = not available; SD = standard deviation.

Bold values indicate statistical significance (P < 0.05).

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Table 2

Glaucoma-Related Diagnoses by Race in the Philadelphia Glaucoma Detection and Treatment Project

	Glaucoma*	oma*			
Race	OAG, n (%)	ACG, n (%)	Glaucoma Suspect, n (%)	PACS/PAC, n (%)	OAG, n (%) ACG, n (%) Glaucoma Suspect, n (%) PACS/PAC, n (%) Any Glaucoma-Related Diagnosis, n (%)
African American (n=1146) 105 (9.2)	105 (9.2)	11 (1.0)	240 (20.9)	77 (6.7)	433 (37.8)
White (n=236)	22 (9.3)	1 (0.4)	53 (22.5)	29 (12.3)	105 (44.5)
Asian (n=182)	13 (7.1)	2 (1.1)	28 (15.4)	33 (18.1)	76 (41.8)
Hispanic (n=69)	6 (8.7)	2 (2.9)	6 (8.7)	11 (15.9)	25 (36.2)
Other (n=16)	2 (12.5)	0 (0)	3 (18.8)	1 (6.3)	6 (37.5)
Total (n=1649)	148 (9.0)	16 (1.0)	330 (20.0)	151 (9.2)	645 (39.1)

ACG = angle-closure glaucoma; OAG = open-angle glaucoma; PACS/PAC = primary-angle closure suspect/primary-angle closure.

 $_{\ast}$ Sixty-four of the 164 patients (39.0%) diagnosed with glaucoma were newly diagnosed.

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 Table 3

 Laser Treatments Administered in the Philadelphia Glaucoma and Treatment Project

	SLT (n)	LPI (n)	Total (n)
Both eyes, same day	8	71	79
Both eyes, separate days	1	7	8
1 eye only	4	6	10
Total	13	84	97

LPI = laser peripheral iridotomy; SLT = selective laser trabeculoplasty.

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 Table 4

 Patient Satisfaction Survey Administered in the Philadelphia Glaucoma Detection and Treatment Project

Question	Patient Response, n (%)			
1. How satisfied were you with your glaucoma eye examination today?	Very satisfied 1247 (80.5%)	Satisfied 292 (18.8%)	Dissatisfied 2 (0.1%)	Very dissatisfied 9 (0.6%)
2. How satisfied were you with the time it took to complete your glaucoma eye examination today?	Very satisfied 988 (64.0%)	Satisfied 506 (32.8%)	Dissatisfied 43 (2.8%)	Very dissatisfied 7 (0.4%)
3. How satisfied were you with the Wills Eye staff who conducted your testing and eye examination today?	Very satisfied 1304 (84.3%)	Satisfied 231 (15.0%)	Dissatisfied 4 (0.3%)	Very dissatisfied 6 (0.4%)
4. How convenient was it to have your eye examination at this community location?	Very convenient 1272 (82.3%)	Convenient 258 (16.7%)	Inconvenient 5 (0.3%)	Very inconvenient 11 (0.7%)
5. How likely are you to recommend this community-based glaucoma eye examination to a friend or family member?	Very likely 1389 (90.0%)	Somewhat likely 140 (9.1%)	Not very likely 11 (0.7%)	Not at all likely 3 (0.2%)
6. How likely are you to follow up with an eye-care provider in the next 6 mos to 1 year?	Very likely 1372 (89.1%)	Somewhat likely 144 (9.3%)	Not very likely 15 (1.0%)	Not at all likely 9 (0.6%)