Racial Disparities in the Use of Ancillary Testing to Evaluate Individuals With Open-Angle Glaucoma

Joshua D. Stein, MD, MS; Nidhi Talwar, MA; Alejandra M. LaVerne, BS; Bin Nan, PhD; Paul R. Lichter, MD

Objective: To determine whether racial disparities exist in the use of ancillary testing to evaluate individuals with open-angle glaucoma.

Methods: We identified all enrollees aged 40 years and older in a large US managed care network with retinal or optic nerve conditions that could warrant the use of ancillary testing. Among persons with open-angle glaucoma or glaucoma suspects, we performed repeated-measures multivariable logistic regression to determine the odds and probabilities each year of undergoing visual field testing, fundus photography, and other ocular imaging for black, white, Hispanic, and Asian American men and women and compared the groups.

Results: Among the 797,879 eligible enrollees, 149,018 individuals had open-angle glaucoma. The odds of undergoing visual field testing decreased for all groups from 2001 through 2009, decreasing most for Hispanic men and women (63% and 57%, respectively) (adjusted odds ratio [AOR], 0.37; 95% CI, 0.31-0.43 and AOR, 0.43; 95% CI, 0.37-0.50, respectively) and least (36%) for Asian American men (AOR, 0.64; 95% CI, 0.51-0.80). By comparison, the odds of undergoing other ocular imaging increased for all groups from 2001 through 2009, increasing most (173%) for black men and women (AOR, 2.73; 95% CI, 2.34-3.18 for men and AOR, 2.73; 95% CI, 2.40-3.09 for women) and least (77%) for Hispanic women (AOR, 1.77; 95% CI, 1.49-2.09).

Conclusion: Hispanic men and women had considerably reduced odds of undergoing visual field testing and other ocular imaging compared with other groups during the decade. Although increases in glaucoma testing have been noted in recent years among Hispanic men and women for some types of ancillary tests, efforts should be made to better understand and overcome some of the persistent barriers to monitoring for glaucoma in this group.

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OPEN-ANGLE GLAUCOMA (OAG) is a major cause of visual impairment, affecting more than 3 million individuals in the United States.1 With the aging of the US population, these numbers are expected to increase considerably in the coming decades. Because most patients with OAG are asymptomatic until rather late in the disease course and given that there are many effective medical and surgical treatments that can slow down or halt disease progression, it is imperative to identify and treat high-risk patients early in the course of the disease before they develop significant visual impairment. Numerous studies have found that OAG is more prevalent in racial minorities relative to the white population.2-5 Other studies have shown that racial minorities are more likely to experience vision loss and blindness from OAG.6 Several studies indicated that disparities existed in glaucoma care in the 1990s. Two research groups have reported that black individuals were less likely to undergo examinations for glaucoma relative to white individuals.7,8 Using Medicare claims data from 1995 through 1999, Coleman and colleagues7 found that black and other individuals of nonwhite race had lower rates of undergoing visual field (VF) testing relative to white individuals in the year before glaucoma surgery. Other studies noted lower rates of medical and surgical treatment among racial minorities, despite the known higher incidence of OAG among these individuals.10 In January 2000, the US Department of Health and Human Services launched Healthy People 2010, a comprehensive program focused on disease prevention and health promotion. Reducing disparities in vision care, including care of individuals with OAG, was a specific focus of the Healthy People 2010 initiative.11

For editorial comment see page 1601

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PATIENTS

All individuals aged 40 years and older who were in the database for 1 consecutive year or more and had 1 eye care provider or more (ophthalmologist or optometrist) visits during their time in the plan were identified. Individuals in the plan for less than 365 days and beneficiaries who were not in the plan continuously were excluded. Next, we identified those enrollees who had 1 or more diagnoses of conditions affecting the optic nerve (including different forms of glaucoma and other optic neuropathies) or retina (such as exudative macular degeneration and cystoid macular edema) that could warrant the use of ancillary testing (Figure 1). Next, ICD-9-CM diagnosis codes were used to identify individuals specifically diagnosed with OAG (codes 365.1, 365.10, 365.11, 365.12, and 365.13) and glaucoma suspects (codes 365.0, 365.00, 365.01, and 365.04). If a beneficiary was coded as a glaucoma suspect and as having OAG, they counted as a glaucoma suspect from the first glaucoma suspect diagnosis until they were first diagnosed with OAG, and they were counted as possessing OAG thereafter.

The race/ethnicity of each beneficiary was identified by the managed care company using information provided from 2 sources: public records (driver’s license data) and E-Tech (Ethnic Technologies LLC), a tool that uses information from the name of the beneficiary and the census block he or she lives in to assign race/ethnicity. Enrollees were assigned to 1 mutually exclusive race/ethnicity: white, black, Hispanic, or Asian American. Previous comparisons between assignment of race/ethnicity using E-Tech and information collected from patient self-report demonstrated that E-Tech has a positive predictive value of 71% and the company reports an accuracy of properly identifying race of 96%.

ANALYSES

Statistical analyses were performed using SAS version 9.2 (SAS Institute). Participant characteristics were summarized for the sample using means and standard deviations for continuous variables and frequencies and percentages for categorical variables.

ANCILLARY TESTING AMONG MEN AND WOMEN OF DIFFERENT RACES/ETHNICITIES WITH OAG IN 2003 AND 2007

For this analysis, we identified 2 groups: patients with incident OAG diagnosed in 2003 and those diagnosed in 2007. To be considered to have incident OAG, a patient must have received no OAG diagnosis during a look-back period of 2 or more years (2001-2002 for the 2003 cohort and 2001-2006 for the 2007 cohort); had at least 1 OAG diagnosis during 2003 and 2007; and had at least 2 years of continuous coverage in the plan after OAG diagnosis. These 2 cohorts were followed up from their initial OAG diagnosis to determine the proportions undergoing 1 or more of each of the following tests: VF testing (Current Procedural Terminology, Fourth Edition codes 92081, 92082, and 92083), fundus photography (FP; code 92250), and other ocular imaging (OOI; code 92135) in the first 24 months following OAG diagnosis. Results of this analysis were stratified by race/ethnicity and also by each race/ethnicity and sex combination. χ² Testing was performed to compare proportions undergoing ancillary glaucoma testing in the 2003 cohort and the 2007 cohort separately for each race/ethnicity and sex combination. A similar analysis was performed for glaucoma suspects.

METHODS

DATA SOURCE

The i3 InVision Data Mart database (Ingenix) contains detailed fully de-identified records of all beneficiaries in a large, national managed care network in the United States. We had access to data for a subset of beneficiaries who had any form of eye care from January 1, 2001, through December 31, 2009. This subset consisted of beneficiaries who had 1 or more International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diag-

Figure 1. Sample patient selection. FP indicates fundus photography; OOI, other ocular imaging; and VF, visual field.
CHANGES IN THE ODDS OF UNDERGOING EACH ANCILLARY TEST OVER TIME AMONG INDIVIDUALS WITH GLAUCOMA

For the next analysis, repeated-measures multivariable logistic regression was performed to compare the odds of undergoing VF testing, FP, and OOI for OAG during each year from 2001 through 2009 and these models were stratified by race/ethnicity and sex. The regression models were adjusted for age; education level; household net worth; region of residence; insurance plan type; type of eye care professional providing care (ophthalmologist only, optometrist only, or both provider types during their time in the plan); amount of time in the plan (by year); hypertension; hyperlipidemia; diabetes mellitus; obesity; and comorbid ocular conditions including those that would necessitate the use of these diagnostic tests such as cystoid and diabetic macular edema, exudative age-related macular degeneration, nonproliferative and proliferative diabetic retinopathy, other retinal diseases, and other conditions that can affect the optic nerve (ie, other forms of glaucoma and optic neuropathies). Preliminary analysis showed evidence of a quadratic trend in the use of these procedures hence, the effect of time was modeled as quadratic in the regression models. Furthermore, because this quadratic effect of time could have been different in the presence of different visual conditions, interactions were included between the effect of time and each of the following conditions: OAG, glaucoma suspect, macular edema, exudative macular degeneration, other retinal diseases, and other diseases of the optic nerve for the OOI and FP models as well as interactions between time and each of the following conditions: OAG, glaucoma suspect and other diseases of the optic nerve for the VF model. For white, black, Hispanic, and Asian men and women, we used the estimated model parameters to compare odds of receiving the relevant testing in 2001 vs 2005, 2005 vs 2009, and 2001 vs 2009 for an enrollee with OAG. A similar analysis was performed for glaucoma suspects. These odds were estimated assuming absence of other ocular conditions that could warrant the use of these tests and assuming an age of 60 years, commercial preferred provider organization insurance, northeast region of residence, exclusive care by an ophthalmologist, high school education, and a $75 000 to $150 000 household net worth. The estimated odds of receiving each procedure in each year were then converted to probabilities.

For all analyses, P < .05 was considered statistically significant. The University of Michigan’s institutional review board determined this study was exempt from requiring its approval.

RESULTS

Table 1. Characteristics of Individuals With Open-Angle Glaucoma and Glaucoma Suspects

<table>
<thead>
<tr>
<th>No. (%)</th>
<th>Individuals With Open-Angle Glaucoma</th>
<th>Glaucoma Suspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total No.</td>
<td>149 018</td>
<td>360 380</td>
</tr>
<tr>
<td>Age, mean (SD), y</td>
<td>61.3 (11.8)</td>
<td>55.4 (10.9)</td>
</tr>
<tr>
<td>Time in plan, mean (SD), y</td>
<td>4.3 (2.2)</td>
<td>4.6 (2.3)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>68 904 (46.2)</td>
<td>152 188 (42.2)</td>
</tr>
<tr>
<td>Female</td>
<td>80 114 (53.8)</td>
<td>208 192 (57.8)</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>118 062 (79.2)</td>
<td>293 407 (81.4)</td>
</tr>
<tr>
<td>Black</td>
<td>15 905 (10.7)</td>
<td>25 699 (7.1)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>9376 (6.3)</td>
<td>24 736 (6.9)</td>
</tr>
<tr>
<td>Asian American</td>
<td>4350 (2.9)</td>
<td>12 892 (3.6)</td>
</tr>
<tr>
<td>Other</td>
<td>1325 (0.9)</td>
<td>3646 (1.0)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;High school</td>
<td>3060 (2.1)</td>
<td>5952 (1.7)</td>
</tr>
<tr>
<td>High school diploma</td>
<td>56 480 (38.8)</td>
<td>120 233 (34.1)</td>
</tr>
<tr>
<td>Some college</td>
<td>54 117 (37.2)</td>
<td>133 525 (37.9)</td>
</tr>
<tr>
<td>College diploma</td>
<td>31 599 (21.7)</td>
<td>91 497 (26.0)</td>
</tr>
<tr>
<td>Advanced degree</td>
<td>336 (0.2)</td>
<td>1119 (0.3)</td>
</tr>
<tr>
<td>Net worth, $</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;25 000</td>
<td>12 514 (9.0)</td>
<td>27 858 (8.2)</td>
</tr>
<tr>
<td>25 000–75 000</td>
<td>9841 (7.1)</td>
<td>21 517 (6.7)</td>
</tr>
<tr>
<td>75 000–150 000</td>
<td>18 804 (13.5)</td>
<td>43 173 (12.8)</td>
</tr>
<tr>
<td>150 000–500 000</td>
<td>62 353 (44.7)</td>
<td>150 946 (44.6)</td>
</tr>
<tr>
<td>&gt;500 000</td>
<td>36 069 (25.8)</td>
<td>93 619 (27.7)</td>
</tr>
<tr>
<td>Region of residence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>25 466 (17.1)</td>
<td>69 947 (19.4)</td>
</tr>
<tr>
<td>Southeast</td>
<td>65 005 (43.6)</td>
<td>146 075 (40.5)</td>
</tr>
<tr>
<td>Midwest</td>
<td>40 872 (27.4)</td>
<td>101 957 (28.3)</td>
</tr>
<tr>
<td>West</td>
<td>17 516 (11.8)</td>
<td>42 013 (11.7)</td>
</tr>
<tr>
<td>Other</td>
<td>137 (0.1)</td>
<td>350 (0.1)</td>
</tr>
<tr>
<td>Eye care provider</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optometrist only</td>
<td>13 411 (9.0)</td>
<td>70 748 (19.6)</td>
</tr>
<tr>
<td>Ophthalmologist only</td>
<td>106 639 (71.6)</td>
<td>227 941 (63.3)</td>
</tr>
<tr>
<td>Both provider types</td>
<td>28 317 (19.0)</td>
<td>59 523 (16.5)</td>
</tr>
</tbody>
</table>

and ranged from 4.1 to 4.6 years for the different races/ethnicities.

Of the 797 879 enrollees, 149 018 (18.7%) had 1 or more diagnoses of OAG and 360 380 (45.2%) had 1 or more diagnoses of glaucoma suspect. The average age of persons with OAG was 61.3 years and for glaucoma suspects was 55.4 years. Among those with OAG, there were 118 062 white, 15 905 black, 9376 Hispanic, and 4350 Asian American individuals. Table 1 shows the other sociodemographic characteristics of the enrollees with OAG and glaucoma suspects.

ANCILLARY GLAUCOMA TESTING IN THE FIRST 2 YEARS AFTER OAG DIAGNOSIS: 2003 VS 2007 COHORTS

The number of individuals with incident OAG with at least 24 months of follow-up in 2003 and 2007 were 4139 and 3803 persons, respectively. The proportions of white, black, Hispanic, and Asian American patients who underwent ancillary glaucoma testing within 24 months of...
their OAG diagnosis in 2003 were 74.5%, 73.8%, 65.5%, and 71.7% respectively for VF testing; 23.6%, 27.5%, 17.5%, and 20.0% respectively for FP; and 50.5%, 47.9%, 45.1%, and 48.3% respectively for OOI. By comparison, the proportions of white, black, Hispanic, and Asian American patients who underwent ancillary glaucoma testing within 24 months of their OAG diagnosis in 2007 were 75.8%, 73.7%, 72.8%, and 74.8% respectively for VF testing; 29.3%, 34.7%, 35.2%, and 35.8% respectively for FP; and 65.0%, 64.9%, 61.7%, and 66.2% respectively for OOI (Table 2 and Figures 2-4).

The proportion of white, black, Hispanic, and Asian American individuals with incident OAG diagnosed in 2003 who underwent no ancillary glaucoma testing (no VFs, FP, or OOI) within 24 months of diagnosis were 16%, 19%, 23%, and 21%, respectively. The proportion of white, black, Hispanic, and Asian American individuals with incident OAG diagnosed in 2007 who underwent no ancillary glaucoma testing (no VFs, FP, or OOI) within 24 months of diagnosis were 13%, 10%, 14%, and 15%, respectively (Figure 5). Table 3 shows the findings of similar analyses for glaucoma suspects.

TRENDS IN ANCILLARY GLAUCOMA TESTING OVER TIME FOR THE DIFFERENT RACES/ETHNICITIES

VF Testing

Among men and women of all races/ethnicities with OAG, the odds of undergoing VF testing declined from 2001 to 2007 for white, black, Hispanic, and Asian American men and women (Figure 2).
to 2005 and again from 2005 to 2009. Comparing the odds of undergoing VF testing in 2001 vs 2009, Asian American men demonstrated the lowest decline (36%) in odds of receiving VF testing (adjusted odds ratio [AOR], 0.64; 95% CI, 0.51-0.80), while Hispanic men (63%) and Hispanic women (57%) experienced the greatest decline (AOR, 0.37; 95% CI, 0.31-0.43 for Hispanic men and AOR, 0.43; 95% CI, 0.37-0.50 for Hispanic women) in odds of undergoing VF testing. Table 5 shows the findings for glaucoma suspects among the races/ethnicities.

### FP

No significant difference in the odds of undergoing FP were noted from 2001 to 2005 for most of the OAG groups with 2 exceptions: white women had 6% increased odds of FP and Asian American women had 72% increased odds of FP during that period. All of the groups beside Asian American women demonstrated increased odds of FP in 2009 relative to 2005. Overall, compared with 2001, these groups had significantly higher odds of FP in 2009: white men had 24% greater odds (AOR, 1.24; 95% CI, 1.16-1.32), white women had 15% greater odds (AOR, 1.15; 95% CI, 1.08-1.22), black women had 19% greater odds (AOR, 1.19; 95% CI, 1.03-1.38), Asian American men had 49% greater odds (AOR, 1.49; 95% CI, 1.09-2.03), and Asian American women had 86% greater odds (AOR, 1.86; 95% CI, 1.31-2.63) (Table 4). During that same time, the odds of FP for glaucoma suspects decreased for nearly all of the groups (Table 5).
The odds of undergoing OOI increased for men and women of each race with OAG from 2001 to 2005 and continued to increase for some of the groups from 2005 to 2009. Comparing the odds of OOI for OAG in 2001 vs 2009, the groups that demonstrated the greatest increase in odds of this procedure were black men (173%) and black women (173%), followed by Asian American women (157%), then white women (128%), Asian American men (127%), and white men (124%). Hispanic men (113%) and Hispanic women (77%) demonstrated the lowest increase in the odds of undergoing OOI in 2009 relative to 2001 (Table 4). Similar trends were observed for glaucoma suspects. In fact, unlike the other racial groups who demonstrated increased odds of OOI of 20% to 95% from 2001 to 2009, Hispanic men glaucoma suspects exhibited no significant difference in the odds of OOI in 2009 relative to 2001 (AOR, 1.12; 95% CI, 0.97-1.30) (Table 5).

### PROBABILITY OF UNDERGOING GLAUCOMA DIAGNOSTIC TESTING AND CHANGES OVER TIME FOR MEN AND WOMEN PATIENTS WITH OAG OF DIFFERENT RACES/ETHNICITIES

In 2001, after adjustment for ocular comorbidities and other factors, the probability of undergoing VF testing for OAG was 61% for white men, 61% for white women, 66% for black men, 67% for black women, 63% for Hispanic men, 62% for Hispanic women, 64% for Asian American men, and 64% for Asian American women. By comparison, in 2009, the probability of undergoing VF testing for OAG was 45% for white men, 45% for white women, 53% for black men, 54% for black women, 39% for Hispanic men, 41% for Hispanic women, 54% for Asian American men, and 49% for Asian American women. The magnitude of decline in the probability of undergoing VF testing for OAG from 2001 to 2009 was most for Hispanic men (−24%) and Hispanic women (−21%). By comparison, black men (−13%), black women (−13%), and Asian American men (−10%) experienced a much reduced decline in the probability of undergoing VF testing for OAG during the decade (Figure 6). The change in probability of undergoing FP for OAG from 2001 to 2009 was quite minimal for all of the groups (range, +1% to +5%) (Figure 7). In 2001, the probability of undergoing OOI testing for OAG was 23% for white men, 23% for white women, 24% for black men, 23% for black women, 19% for Hispanic men, 22% for Hispanic women, 23% for Asian American men, and 21% for Asian American women. By comparison, in 2009, the probability of receiving OOI testing for OAG was 39% for white men, 41% for white women, 47% for black men, 45% for black women, 34% for Hispanic men, 34% for Hispanic women, 40% for Asian American men, and 41% for Asian American women. The magnitude of increase in probability of undergoing OOI for OAG from 2001 to 2009 was greatest for black men (+23%) and black women (+22%) and least for Hispanic men (+15%) and Hispanic women (+12%) (Figure 8). The probabilities of undergoing each ancillary test for glaucoma suspects of the different races/ ethnicities are depicted in eFigures 1-3 (http://www.archophthalmol.com).
Using longitudinal data from 149,018 enrollees with OAG in a large nationwide US managed care network, we explored rates of ancillary glaucoma testing for men and women of different races/ethnicities to determine whether differences exist in the evaluation and monitoring of OAG among minorities. We found significant differences in ancillary glaucoma testing among the groups. In 2009, black men and women had the highest odds of undergoing VF testing and OOI. Black men and women also demonstrated the largest increase in the odds of OOI and the least decline in the odds of VF testing during the decade relative to other groups. By comparison, Hispanic men and women had the lowest odds of VF testing and OOI in 2009 and exhibited the largest decline in the odds of VF testing during the decade relative to other groups. By comparison, Hispanic men and women had the lowest odds of VF testing and OOI in 2009 and exhibited the largest decline in the odds of VF testing during the decade relative to other groups. Relatively similar trends were observed for glaucoma suspects.

During the past decade, Healthy People 2010 and several other initiatives have sought to reduce disparities in vision care provided to racial minorities in the United States. Prior to these initiatives, Coleman and colleagues7 noted that white individuals had a greater likelihood of undergoing VF testing in the year before surgery relative to black individuals and those of other races/ethnicities. In our analysis, we find that black individuals actually had the highest probability among all races/ethnicities, including white individuals, of undergoing VF testing in 2009. Furthermore, although the probability of undergoing VF testing has declined for all racial groups from 2001 through 2009, black men and women experienced less of a decline in the probability of undergoing these tests than did all other groups aside from Asian American men. It is encouraging to find that black individuals, a race known to have high rates of visual impairment and blindness from OAG, are undergoing ancillary glaucoma testing at higher rates relative to other racial groups than noted a decade earlier.

The specific factors contributing to higher probabilities of undergoing glaucoma testing among black individuals compared with white individuals noted in this study are unclear. Potential explanations for the greater use of ancillary glaucoma testing among black individuals include an increase in public service announcements educating the black population about OAG as well as improvements in the education of eye care providers about the increased risk for OAG and blindness from this disease among black individuals, which may impact practice patterns. Because disease severity can influence the frequency and intensity of glaucoma service use, the higher probabilities of undergoing testing among black individuals may be driven, in part, by the presence of more severe disease among black relative to white individuals on initial OAG diagnosis. Other studies have found evidence that black individuals tend to present to eye care providers with more severe OAG.3

Unfortunately, the current ICD-9-CM billing codes do not capture disease severity to study the influence of disease severity on patterns of ancillary glaucoma testing to determine whether this explains the differences in use we are noting, although in our analysis of glaucoma suspects, black men and women were also observed to have greater probabilities of ancillary glaucoma testing, suggesting that disease severity alone does not fully account for greater use among black individuals.

![Table 5. Odds of Undergoing Ancillary Testing for Men and Women Glaucoma Suspects of Different Races/Ethnicities](https://jamanetwork.com/)

<table>
<thead>
<tr>
<th>Patient Population</th>
<th>VF Testing</th>
<th>FP</th>
<th>OOI</th>
</tr>
</thead>
<tbody>
<tr>
<td>White men</td>
<td>0.44 (0.42-0.45)</td>
<td>0.69 (0.68-0.71)</td>
<td>0.30 (0.29-0.31)</td>
</tr>
<tr>
<td>White women</td>
<td>0.49 (0.47-0.50)</td>
<td>0.71 (0.69-0.72)</td>
<td>0.34 (0.32-0.36)</td>
</tr>
<tr>
<td>Black men</td>
<td>0.44 (0.38-0.50)</td>
<td>0.73 (0.66-0.80)</td>
<td>0.32 (0.29-0.36)</td>
</tr>
<tr>
<td>Black women</td>
<td>0.51 (0.46-0.56)</td>
<td>0.81 (0.75-0.86)</td>
<td>0.41 (0.37-0.45)</td>
</tr>
<tr>
<td>Hispanic men</td>
<td>0.42 (0.37-0.48)</td>
<td>0.63 (0.58-0.69)</td>
<td>0.27 (0.23-0.30)</td>
</tr>
<tr>
<td>Hispanic women</td>
<td>0.49 (0.44-0.55)</td>
<td>0.70 (0.65-0.75)</td>
<td>0.34 (0.30-0.38)</td>
</tr>
<tr>
<td>Asian American men</td>
<td>0.51 (0.43-0.61)</td>
<td>0.77 (0.69-0.86)</td>
<td>0.40 (0.33-0.47)</td>
</tr>
<tr>
<td>Asian American women</td>
<td>0.55 (0.46-0.65)</td>
<td>0.73 (0.65-0.82)</td>
<td>0.40 (0.34-0.47)</td>
</tr>
</tbody>
</table>

Abbreviations: AOR, adjusted odds ratio; FP, fundus photography; OOI, other ocular imaging; VF, visual field.

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visiting eye care providers less often than are other racial
groups, this is likely contributing to differences in the pro-
ability of undergoing glaucoma testing we observed. In the
study by Morales and colleagues,19 some of the factors they
found to be associated with a reduced likelihood of visiting
an eye care provider among Hispanic people included
younger age, male sex, less education, and lack of insur-
ance. In our analysis, despite our adjusting for sociodemo-
graphic factors including age, education level, and house-
hold net worth and despite the fact that all of the enrollees
had health insurance, we still observed lower probabili-
ties of ancillary glaucoma testing among Hispanic men
and women. Difficulty with the English language and lack of a
usual eye care provider or usual place of care are all fac-
tors that affected rates of eye care visits among partici-
pants in the Los Angeles Latino Eye Study and may also
be contributing to some of the trends we observed.19 Lan-
guage barriers may be particularly problematic when per-
forming VF testing on Hispanic individuals given the need
to instruct patients on how to properly take this test.

Although our analyses demonstrated that Hispanic indi-
viduals are lagging behind those of other races/ethnicities
with respect to monitoring for glaucoma, there is also some evidence that ancillary glaucoma testing
among Hispanic individuals is catching up with testing
for other races/ethnicities. The proportions of Hispanic
individuals with newly diagnosed OAG in 2003 who un-
derwent ancillary testing were much lower than each of
the other races/ethnicities. However, the proportions of
Hispanic people with newly diagnosed OAG in 2007 un-
dergoing ancillary testing were much more similar to those
of other races (Figures 2-5). Intensified efforts by groups
such as EyeCare America to better educate the Hispanic
population about the importance of regular eye care
may also be contributing to some of the trends we observed.19 Language barriers may be particularly problematic when performing VF testing on Hispanic individuals given the need to instruct patients on how to properly take this test.

The strengths of this study include its large sample
size, with adequate representation of each of the major
racial groups. Furthermore, unlike other studies that re-
view data collected at a specific academic medical cen-
ter or from the practices of glaucoma specialists, the data

While it is encouraging that black individuals are re-
ceiving similar or greater levels of monitoring of OAG rea-
tive to white individuals, it is disconcerting that there are
significant disparities in glaucoma testing among the His-
panic population, the fastest growing racial minority in the
United States.16 Our finding that Hispanic individuals have
lower probabilities of undergoing glaucoma testing rela-
tive to other races/ethnicities may be attributable, in part,
to differences in rates of eye care visits among Hispanic
people relative to other racial groups. Outside of the spe-
cialty of ophthalmology, studies have found that Hispanic
individuals have reduced access to health care services and
lower rates of use of medical services.17 Reduced fre-
cuency of visits and services among Hispanic individuals
has also been demonstrated within the field of ophthal-
mology.18,19 Using data from the Los Angeles Latino Eye
Study, Morales and colleagues19 found that only 36% of the
participants aged 40 years or older (all of whom were His-
panic) underwent an eye examination in the past 12 months
and only 57% admitted to ever receiving a dilated fundu-
scopic examination. If Hispanic individuals with OAG are

Figure 6. Probability of undergoing visual field testing for open-angle
  glaucoma from 2001-2009. AAM indicates Asian American men; AAW, Asian
  American women; BM, black men; BW, black women; HM, Hispanic men;
  HW, Hispanic women; WM, white men; and WW, white women.

Figure 7. Probability of undergoing fundus photography for open-angle
  glaucoma from 2001-2009. AAM indicates Asian American men; AAW, Asian
  American women; BM, black men; BW, black women; HM, Hispanic men;
  HW, Hispanic women; WM, white men; and WW, white women.

Figure 8. Probability of undergoing other ocular imaging for open-angle
  glaucoma from 2001-2009. AAM indicates Asian American men; AAW, Asian
  American women; BM, black men; BW, black women; HM, Hispanic men;
  HW, Hispanic women; WM, white men; and WW, white women.
for this analysis represents patients under the care of different eye care providers from communities throughout the United States. In addition, identification of enrollees with OAG and glaucoma suspects came from billing data from eye care providers, which may be more reliable than patient self-report.

There are several study limitations that need to be acknowledged. Because the study was conducted using claims data, there is no way of verifying whether all of the enrollees indeed had OAG. Some of the patients may have been misdiagnosed or miscoded. Second, it is important to recognize that the race/ethnicity of some of the enrollees may have been misclassified. While E-Tech (the company that produces the software that was used to assign race/ethnicity to each enrollee) touts a 96% level of correspondence between its software and information obtained from patient self-report, this accuracy level has not, to our knowledge, been confirmed in a peer-reviewed publication. Furthermore, the E-Tech software does not further characterize Hispanic individuals as white or black. In a multiethnic population such as that of the United States, some enrollees may have been misclassified. Differential misclassification of individuals of different races/ethnicities as possessing OAG could affect our study findings. Third, with claims data, we were also unable to consider glaucoma severity, which could impact the frequency and intensity of monitoring. Without clinical information, it is impossible to determine for specific patients whether levels of testing for OAG were inadequate, appropriate, or excessive. Fourth, all of the enrollees in this database had some form of health insurance. Caution should be taken when generalizing our findings to other groups such as those who are uninsured or underinsured. Given that others have demonstrated that possessing health insurance impacts use of eye care services and that racial minorities are known to have reduced access to health insurance, it is likely that we are underestimating disparities in ancillary testing for glaucoma among racial minorities in the overall US population. In fact, recent US Census report data found that 1 in every 3 Hispanic individuals had no health insurance.

It is encouraging that black individuals with OAG have higher rates of ancillary glaucoma testing compared with earlier studies. However, these findings need to be tempered by the fact that there are disproportionate numbers of black individuals and other racial minorities who are underinsured or uninsured and likely continue to have inadequate monitoring for OAG. Furthermore, we find disparities in monitoring for OAG among Hispanic men and women, even in this insured population. Future research must focus on identifying ways to reduce disparities in glaucoma care among racial minorities, especially the Hispanic population, the fastest growing racial minority in the United States.

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