The Prevalence of Glaucoma in a Population-Based Study of Hispanic Subjects

Proyecto VER

Harry A. Quigley, MD; Sheila K. West, MD; Jorge Rodriguez, MD; Beatriz Munoz, MD; Ronald Klein, MD; Robert Snyder, MD

Objective: To determine the prevalence of glaucoma in a population-based sample of Hispanic adults older than 40 years.

Methods: Using 1990 census data for Arizona, groups of persons living in sections of the city in Nogales and Tucson were randomly selected with a probability proportional to the Hispanic population older than 40 years. We tried to recruit all eligible adults in homes with 1 self-described Hispanic adult. Detailed ocular examinations at a local clinic included visual acuity testing, applanation tonometry, gonioscopy, an optic disc evaluation, and a threshold visual field test. Open-angle glaucoma (OAG) was defined using a proposed international system for prevalence surveys, including threshold visual field defect and optic disc damage. Angle-closure glaucoma was defined as bilateral appositional angle closure, combined with optic nerve damage (judged by field and disc as for OAG).

Results: Examinations were conducted in 72% (4774/6658) of eligible persons, with a 1.97% prevalence (95% confidence interval, 1.58%-2.36%) of OAG (94 persons). The age-specific OAG prevalence increased nonlinearly from 0.50% in those aged 41 to 49 years to 12.63% in those 80 years and older. Angle-closure glaucoma was detected in 5 persons (0.10%). Sex, blood pressure, and cigarette smoking were not significant OAG risk factors. Only 36 (38%) of the 94 persons with OAG were aware of their OAG before the study. Screening results with an intraocular pressure higher than 22 mm Hg (in the eye with a higher pressure) would miss 80% of the OAG cases.

Conclusions: The prevalence of OAG in Hispanic persons was intermediate between reported values for white and black persons. The prevalence increased more quickly with increasing age than in other ethnic groups. Glaucoma was the leading cause of bilateral blindness.


Glaucoma is the second leading cause of world blindness,1 equalling the visual disability caused by trachoma and exceeded only by cataract. A group of recent population-based studies2-13 has detailed its impact on European- and African-derived persons in the United States, Europe, Australia, the Caribbean, Tanzania, and Mongolia. There are substantial differences in the prevalence and incidence of glaucoma between European- and African-derived persons12 that appear to be genetically based. Present data on glaucoma do not include large well-designed studies of the many important ethnic groups in the world. In particular, to our knowledge, there are no population-based studies of glaucoma in Hispanic persons.

Latin America is estimated to have a population of more than 500 million persons. If the prevalence of glaucoma is similar to rates among European-derived groups, there would be nearly 2 million Hispanic persons affected by open-angle glaucoma (OAG) or angle-closure glaucoma (ACG) throughout North and South America. This estimate would be more accurate if it were based on true population-based measures of prevalence. Furthermore, 2000 census data (available at: http://www.census.gov) indicate that 12.5% of US citizens identify themselves as Hispanic or Latino and that this proportion will increase dramatically with greater longevity, immigration, and relatively higher birth rates.

The present survey was designed to estimate the prevalence of blindness and visual impairment from the major ocular diseases, including glaucoma, among a representative sample of Hispanic persons in the southwestern United States.
PARTICIPANTS AND METHODS

Proyecto VER (Spanish for “to see”) was a population-based survey of ocular disease prevalence, visual impairment, and blindness among noninstitutionalized Hispanic persons older than 40 years living in the Pima and Santa Cruz counties of southern Arizona. Most of the population in these 2 counties is concentrated in 2 cities, Nogales and Tucson. Using 1990 census data, groups of persons living in sections of the city (also called “block groups”) in Nogales and Tucson were randomly selected with a probability proportional to the size of the Hispanic population older than 40 years. From the selected block groups, every other household in Nogales and 2 of 3 households in Tucson were contacted, and eligibility was determined. If at least 1 self-described Hispanic person older than 40 years was a resident, participation of all eligible adults in that home was sought. After informed consent was obtained, an extensive home interview was administered and an appointment was made for an ocular examination at a nearby clinic. For those who did not consent to come to the examination site, a short version of the questionnaire was administered. The short questionnaire asked for overall health status, preferred spoken language, whether the subject had difficulty seeing with and without glasses, and whether the subject had been diagnosed as having diabetes.

Eighty percent of the home interviews were conducted in Spanish, consisting of questions on education, socioeconomic status, health status, health and eye care use, and history of vision problems and treatment. The interview included a short version of the National Eye Institute Visual Function Questionnaire and a series of questions designed to determine the degree of acculturation of the subject to non-Hispanic society and the degree to which older relatives of the subject were native Americans.

At the clinic site, an ocular examination consisted of visual acuity measurement with initial correction and best refraction using the Early Treatment Diabetic Retinopathy Study chart. Legal blindness for this report is defined as 20/200 or worse in the better eye. Visual field testing was performed in every eye that had a 20/200 or better visual acuity with a threshold testing program (SITA Fast, 24-2 protocol of the HFA II instrument; Zeiss-Humphrey Systems, Dublin, Calif). When an initial test using the visual field instrument indicated a lack of acceptable reliability, the test was restarted after repositioning the patient in test performance. Only 1 threshold visual field test was completed on each eye of eligible persons. Each person underwent applanation tonometry, a slitlamp examination, and a dilated fundus examination. As part of the slitlamp examination, the narrowness of the anterior chamber was determined by estimating the space between the peripheral corneal endothelial surface and the anterior iris stroma (the van Herick technique). When this estimate showed a space of less than 20% of the corneal thickness, gonioscopy was performed. Angles were considered closed when the investigator (J.R.) could not see most of the trabecular meshwork that is typically pigmented in the absence of forward dynamic pressure with the goniolens.

All subjects underwent stereophotography of the optic disc with a camera (model FF4; Carl Zeiss Co, Jena, Germany) and nerve fiber layer imaging with an analyzer (Nerve Fiber Analyser, Laser Diagnostic Technologies, Inc, San Diego, Calif). Participants had their blood pressure measured and had a hemoglobin A1c level determined. We defined diabetes as present if persons were told by a physician that they had diabetes or if the level of hemoglobin A1c at examination was 7.0% or greater. Hypertension was defined as present when a participant was receiving blood pressure–lowering medication or had a measured systolic pressure of 160 mm Hg or higher or a diastolic pressure of 90 mm Hg or higher. The difference between the diastolic blood pressure and the intraocular pressure (IOP) in the eye with a higher pressure was calculated as the perfusion pressure. Examinations were conducted from April 1, 1997, to September 1, 1999.

To identify possible cases of glaucoma, a glaucoma specialist (H.A.Q.) reviewed all study data on persons with any of the following features: a self-reported history of glaucoma, an IOP of 22 mm Hg or higher in either eye, a shallow anterior chamber, a visual field defect in either eye (definition given later), a cup-disc ratio graded as 0.7 or greater during the clinical examination, or vision loss attributed to glaucoma during the clinical examination. The examining ophthalmologist at the study visit also indicated all participants who, in his opinion, would qualify as possibly having glaucoma. These were reviewed

RESULTS

Among 20622 dwelling units, 4255 had 6658 eligible adult residents. Of these persons, 4774 (72%) had complete examinations. In addition, 953 eligible persons (14%) underwent the home interview only, 229 (3%) answered a short version of the questionnaire, and 701 (11%) gave only their age and sex. Participants were the 4774 persons who underwent the home and the clinical examination. Nonparticipants differed from participants in their age distribution (Table 1). The youngest and the oldest members of the eligible population were less likely to have participated. Nonparticipants had proportionately more men and described themselves as having better health, less diabetes, and fewer vision problems (Table 1). Similar response rates were found in the 2 locations for the study (72% in Nogales and 71% in Tucson).

The applanation IOP for healthy persons (those not diagnosed as having primary or secondary glaucoma) was 15.6±3.2 mm Hg (n=9302 eyes, using both eyes for each subject and correcting for interocular correlation with the generalized estimating equation approach19). The 97.5 percentile value for IOP among healthy subjects was 22 mm Hg, with 109 persons (of 4661) having an IOP greater than this value in the eye with a higher pressure. The vertical cup-disc ratio, as judged by the ophthalmologist (J.R.) for all subjects without glaucoma, was compared by regression to the IOP of each eye and the age of the subject. With older age and with a higher IOP, subjects without glaucoma had a significantly larger cup-disc ratio. For each decade of age, the cup-disc ratio increased by 0.019 (95% CI, 0.015-0.022). For each millimeter of mercury of IOP, the cup-disc ratio increased by 0.004 (95% CI, 0.003-0.006).
by the specialist who made the diagnostic determination, even if they failed to meet any of the previously listed criteria for evaluation.

Optic disc findings were graded by a glaucoma specialist (H.A.Q.) from the stereophotographs, using a micrometer overlay to measure the vertical diameter of the disc and the cup to yield a vertical cup-disc ratio. The narrowest remaining width of the rim was also measured by micrometer (calculated as a ratio to disc diameter) between the 11- and 1-o’clock positions and between the 5- and 7-o’clock positions. In eyes in which the stereophotographs were too poor in quality or were not obtained, the vertical cup-disc and narrowest rim measurements were made with a ruler from images provided from the analyzer (Nerve Fiber Analyser) (see the “Results” section). When photographs and images of the disc were not obtained, the cup-disc ratio was estimated by the clinician (J.R.) using a handheld indirect lens and the slitlamp. This clinician had been trained to grade the cup-disc ratio in a similar fashion to the glaucoma specialist (H.A.Q.) during training sessions with patients.

The criteria for OAG were those to be published soon by an international group that considered a definitional structure at the 1998 meeting of the International Society for Geographic and Epidemiologic Ophthalmology, June 14, 1998, Leeuwenhorst, the Netherlands. A visual field defect was defined from the results of a threshold 24-2 test (Zeiss-Humphrey) as a glaucoma hemifield test graded “outside normal limits” and a cluster of 3 contiguous points at the 5% level or worse on the pattern deviation plot in the same eye. Optic disc structural damage sufficient for the diagnosis of glaucoma was a vertical cup-disc ratio or asymmetry of the vertical cup-disc ratio between the 2 eyes that equals or exceeds the 97.5 percentile value for the overall population being examined. For the population examined, these values were a vertical cup-disc ratio of 0.7 or greater and asymmetry of 0.2 or greater (these are similar to those found in several populations). In addition, disc damage could be considered sufficient for a glaucoma diagnosis if there was a narrowest rim width less than 0.1 by ratio to the disc diameter in a position matching the visual field defect in the opposite quadrant.

For the diagnosis of OAG, a person had to have 1 of the following sets of findings in at least 1 eye and had to have been judged to have an open angle by gonioscopy: (1) diagnostic category 1 (structural and functional evidence), 1 eye with optic disc damage (as previously defined) and a visual field defect (as previously defined) in the same eye; (2) diagnostic category 2 (advanced structural damage with unproved field loss), at least 1 eye in a subject who could not satisfactorily complete the visual field testing had a cup-disc ratio that equals or exceeds the 99.5 percentile value for this population (herein, this is 0.85); and (3) diagnostic category 3 (disc not seen and field test impossible), a subject who could not complete visual field testing in whom the optic disc was not visible by clinical examination or photography, the visual acuity was in the legal blindness category, and the IOP was greater than the 99.5 percentile value for the population (27 mm Hg in this population).

In all diagnostic categories, there could not be an alternative explanation for the disc finding or the visual field defect other than glaucoma.

Angle-closure glaucoma was defined as bilateral closed angles on gonioscopic evaluation, combined with the definitions previously given for optic nerve damage (category 1, 2, or 3).

We calculated the prevalence and 95% confidence intervals (CIs) for OAG, stratified by age. We compared the prevalence of OAG from 2 other representative studies with that in Proyecto VER by applying the age-specific rates from the other studies to our population structure. Linear regression models were used to compare the IOP of eyes of healthy subjects and of subjects with glaucoma and to examine the relationship between the cup-disc ratio and the IOP. Generalized estimating equations were used to estimate the SEs and to account for the correlation between eyes. The χ² test and the Fisher exact test were used to compare proportions. Logistic regression models were used to examine the relationship between the presence of OAG and selected characteristics, adjusting for age. Odds ratios and 95% CIs are provided from these calculations.

The study was approved by the Joint Committee of Clinical Investigation of The Johns Hopkins University School of Medicine, Baltimore, Md, and abided by the tenets of the Declaration of Helsinki.

Data are given as mean±SD unless otherwise indicated.

With the OAG definition given (in the “Participants and Methods” section), 94 persons (1.97%) were defined as having OAG (95% CI, 1.58%-2.36%). The age of those with OAG was 70.9±12.5 years, significantly older than those participants who did not have glaucoma (56.6±11.6 years) (t test, P<.001). The age-specific prevalence of OAG increased substantially in the older decades (Figure 1, Figure 2, and Table 2). The proportion of men and women affected did not differ significantly (Table 3). Among those affected by OAG, 63% (61/94) were women, compared with 61% (2838/4674) of those without glaucoma (χ²=0.54, P=.50). Of those diagnosed as having OAG, 90 of 94 were categorized using an examination of the disc and the threshold field test (Table 4). Of these 94 persons, 58 (62%) had color stereophotographs to document the disc finding.

At the clinic examination, 63 persons reported a history of glaucoma. Only 36 of these persons met our criteria for OAG (57% of those reporting a history of glaucoma). Thus, of our 94 subjects with OAG, 58 (62%) were unaware of their diagnosis before the survey.

The IOP for eyes with glaucoma was 18.5±8.7 mm Hg, significantly higher than that of the healthy subjects (n=187 eyes, including both eyes of each subject, with the generalized estimating equation method, P<.001). The IOP in the eye with a higher pressure for those with OAG was 20.5±9.1 mm Hg. Compared with the normal range of IOPs, only 14% (27/187) of the eyes with OAG and 20% (19/94) of the subjects with OAG had an IOP higher than 22 mm Hg. The IOP distribution of those with OAG was compared with that of those who did not have any form of glaucoma (Figure 3).
The subjects with OAG had a vertical cup-disc ratio of 0.71 ± 0.23 (n = 178 eyes) compared with 0.35 ± 0.14 for those without glaucoma (n = 9244 eyes).

Five persons were found to have ACG, for an overall prevalence of 0.10% (95% CI, 0.03%-0.24%). Those with ACG were aged 76.0 ± 9.2 years, and 3 of the 5 were women. One person (0.02%), a woman, was diagnosed as having secondary glaucoma (95% CI, 0.00%-0.11%). The subject with secondary glaucoma and 4 of the 5 subjects with ACG had an IOP higher than 22 mm Hg. The IOP in the eye with a higher pressure for the subjects with ACG was 31.6 ± 11.5 mm Hg.

Visual function was poorer among those with OAG than among the population without glaucoma. The best-corrected visual acuity in the better eye of subjects with OAG was at or below the US standard for legal blindness (20/200 or worse) in 3 (3%) of the 94 persons. The visual acuity in the better eye reached the level of impairment (worse than 20/60) in 6 (6%) of the 94 persons (including the 3 persons who were legally blind).

Among the 4667 subjects without glaucoma, the comparable figures for legal blindness and impairment were 10 (0.21%) and 48 (1.03%), respectively. The threshold visual field results for participants with OAG showed substantial visual field loss in many eyes. One fourth of the eyes among subjects with OAG had mean deviation indexes for 86 right eyes and 83 left eyes, and in at least 1 eye of 90 subjects. The deviation in right eyes was −8.8 ± 7.5; in left eyes, −10.3 ± 9.3. The pattern SD in right eyes was 6.8 ± 4.2; in left eyes, 6.1 ± 3.9. The total points

---

**Table 1. Characteristics of the Sample by Participation Status***

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Participants</th>
<th>Nonparticipants</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age group, y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41-49</td>
<td>1594 (33.4)</td>
<td>565 (37.3)</td>
<td></td>
</tr>
<tr>
<td>50-59</td>
<td>1362 (28.5)</td>
<td>391 (25.8)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>60-69</td>
<td>984 (20.6)</td>
<td>270 (17.8)</td>
<td></td>
</tr>
<tr>
<td>70-79</td>
<td>636 (13.3)</td>
<td>184 (12.2)</td>
<td></td>
</tr>
<tr>
<td>≥ 80</td>
<td>197 (4.1)</td>
<td>104 (6.9)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>1</td>
<td>371</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1851 (38.8)</td>
<td>796 (46.3)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Female</td>
<td>2923 (61.2)</td>
<td>925 (53.7)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>0</td>
<td>164</td>
<td></td>
</tr>
<tr>
<td>Self-reported general health</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>392 (8.2)</td>
<td>112 (9.5)</td>
<td></td>
</tr>
<tr>
<td>Very good</td>
<td>633 (13.3)</td>
<td>198 (16.7)</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>1594 (33.4)</td>
<td>407 (34.4)</td>
<td>&lt;.002</td>
</tr>
<tr>
<td>Fair</td>
<td>1810 (37.9)</td>
<td>386 (32.9)</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>341 (7.1)</td>
<td>81 (6.8)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>4</td>
<td>701</td>
<td></td>
</tr>
<tr>
<td>Self-reported diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>885 (18.6)</td>
<td>170 (14.5)</td>
<td>&lt;.005†</td>
</tr>
<tr>
<td>No</td>
<td>3873 (81.4)</td>
<td>1005 (85.5)</td>
<td></td>
</tr>
<tr>
<td>Self-reported vision problem</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1546 (32.5)</td>
<td>283 (24.0)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>3217 (67.5)</td>
<td>897 (76.0)</td>
<td></td>
</tr>
</tbody>
</table>

*Data are given as number (percentage) of participants unless otherwise indicated. Percentages are based on the totals within each section (excluding the number in the "missing" category) and may not total 100 because of rounding.
†Values are from x² testing and were age adjusted.

---

**Table 2. Age-Specific Prevalence of OAG in Proyecto VER***

<table>
<thead>
<tr>
<th>Age Group, y</th>
<th>Total</th>
<th>Prevalence (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>41-49</td>
<td>1594</td>
<td>0.50 (0.21-0.99)</td>
</tr>
<tr>
<td>50-59</td>
<td>1362</td>
<td>0.59 (0.25-1.16)</td>
</tr>
<tr>
<td>60-69</td>
<td>984</td>
<td>1.73 (0.91-2.54)</td>
</tr>
<tr>
<td>70-79</td>
<td>636</td>
<td>5.66 (3.86-7.46)</td>
</tr>
<tr>
<td>80-89</td>
<td>183</td>
<td>12.02 (7.35-16.80)</td>
</tr>
<tr>
<td>≥ 90</td>
<td>15</td>
<td>20.90 (4.13-58.50)</td>
</tr>
<tr>
<td>Total</td>
<td>4774</td>
<td></td>
</tr>
</tbody>
</table>

*OAG indicates open-angle glaucoma; CI, confidence interval; and ellipses, data not applicable.
abnormal (P<.005) in right eyes were 14.5±12.4; in left eyes, 12.9±12.2. Some persons may have such severe visual field loss that they should be considered blind by this criterion alone, even with an acuity that is better than the 20/200 standard. We chose to consider blindness by field loss alone as those eyes in which the pattern deviation probability was 0.5% for 42 or more of the 54 points in the field. This would ensure that all of the field outside the central 10° was severely defective or that the central 10° and most of the remainder of the field were gone. Two persons had 1 eye meeting this standard, but none had field loss to this degree in both eyes with an acuity better than 20/200. Of the 2 eyes of the 2 persons with 42 or more severely abnormal points, the acuity was 20/20 and 20/25 in the other eye. Hence, at least with the standard used, there were no persons who were bilaterally blind by visual field criteria with preserved central acuity.

We evaluated the association of various risk factors with OAG by univariate analysis and adjusted for age in multivariate analysis (Table 3). In comparing OAG with non-OAG in this analysis, we excluded the 6 persons with either ACG or secondary glaucoma. Age was significantly associated with the presence of OAG, but diabetes, hypertension, body mass index, and cigarette smoking did not confer statistically significant risk when adjusted for age. Among all participants, 22% (1043/4756) were diabetic, with a prevalence of OAG of 2.9% (30/1043) among diabetic persons compared with 1.7% (64/3713) among nondiabetic persons. This difference was not significant when adjusted for age (P=.35). Diabetic persons did have a significantly higher IOP than nondiabetic persons. The mean IOP of the 2 eyes equaled 15.9 mm Hg in diabetic persons compared with 15.6 mm Hg in nondiabetic persons (2078 eyes of 1042
The number of persons with each level of intraocular pressure (IOP) in the eye with a higher pressure among those without glaucoma and those with open-angle glaucoma (OAG), on a logarithmic scale. While the mean IOP is higher among those with OAG, the distributions are not dramatically different. Those with an IOP of 31 mm Hg or higher are grouped together, and only in this group do subjects with OAG predominate.

diabetic persons compared with 7399 eyes of 3707 non-diabetic persons; significantly different after age adjustment, by regression analysis, \( P < .01 \). After age adjustment, diabetic persons similarly had a significantly higher IOP in the eye with a higher pressure compared with non-diabetic persons \( (P = .01) \).

Overall, 44\% (2090/4764) of the participants were classified as having hypertension, and when the simple relationship of OAG to hypertension was assessed, the prevalence of OAG was 2.4\% (51/2090) in hypertensive subjects compared with 1.6\% (43/2674) in nonhypertensive subjects \( (\chi^2 = 4.2, P = .04) \). However, after age adjustment in a logistic model, the odds ratio for OAG among hypertensive subjects was 0.97 (95\% CI, 0.63–1.48) for systolic and 1.00 for diastolic blood pressure. Likewise, when OAG prevalence was examined with participants stratified by age and presence of hypertension, there was no clear association (Table 5).

Yet, there was an association of blood pressure with OAG when the difference between the diastolic pressure and the IOP (mean of the IOPs in the 2 eyes), or the per-fusion pressure, was calculated (Figure 4). The lower the perfusion pressure, the more likely the subject was to have OAG \( (\chi^2 = 28.8, P = .001, \text{test for trend}; \text{age-adjusted odds ratio in the logistic model}, 0.96 \ (95\% \ CI, 0.94–0.99)) \).

In a univariate analysis (Table 3), some risk factors were associated with OAG, including lower level of schooling attained, father identified as Mexican, and living in No-gales. However, when these factors were adjusted for age, none had a significant relationship to OAG. For example, we asked participants to describe themselves as 1 of the following: Mexican; Hispanic, Latin American, or other Spanish origin; Mexican American; Native American; American; or Anglo American. The largest group was 59\% (2778/4722) who stated that they were Mexican. Their OAG prevalence was 2.12\% (59/2778) compared with 1.59\% (31/2044) among persons who used all of the other self-descriptions of ethnicity \( (\chi^2 = 1.71, P = .19) \). When participants were asked to describe their father by one of these same terms of ethnic identification, 75\% (351/4652) used the term Mexican vs all the other terms. The OAG prevalence among these participants was 2.22\% (78/351) compared with 1.14\% (13/1141) among the remaining persons \( (\chi^2 = 5.26, P = .02) \). However, these ethnic descriptors were not significantly related to OAG when adjusted for age.

\[ \chi^2 = 0.00005x^2 - 0.0078x + 0.3118, R^2 = 0.98. \]
The age-specific prevalence of OAG among Hispanic persons is intermediate between reported rates for white and black persons in past surveys, with a steeper slope against age than that of either black (eg, the Baltimore Eye Survey) or white (eg, the Roscommon Glaucoma Study) persons. In fact, the 95% CI for OAG prevalence among Hispanic persons overlapped that of white persons in the younger age groups and increased to overlap that of black persons in the older age groups. Applying the rates of the Baltimore and Roscommon study data to the Proyecto VER population structure allows the calculation of overall age-adjusted rates for black Baltimoreans of 3.44% and for white Irish subjects of 1.11%. The former is above and the latter is below the 95% CI for the overall rate of 1.97% for Hispanic persons in the present study. Because the age-specific prevalence of OAG increases more rapidly in Hispanic persons, according to our data, than in either the white or black population, it is probable that the incidence of OAG in Hispanic persons has a steeper increase than that modeled from published data.12

The present population of Hispanic persons in the border area between Arizona and Mexico comes from Asians who migrated over the former land bridge to North America and from those who arrived from Europe. As such, they would be expected to have somewhat different characteristics from strictly European-derived persons. Our findings suggest that the shift to a higher proportion of older persons in the population of Mexico that is occurring will be associated with an even greater increase in OAG prevalence than the same shifts in population age will cause in European and African groups. We do not know if this Hispanic group will be representative of other Hispanic groups from different regions of Latin America. Because glaucoma is already the most frequent cause of bilateral legal blindness in the Hispanic group that we studied, it merits serious attention in public health planning for early detection and treatment.

Several factors may cause the impact of glaucoma to be greater among Hispanic Americans, whatever its prevalence. In the Baltimore Eye Survey, blindness from glaucoma was inversely related to socioeconomic status and educational level. Hispanic Americans are more likely to have a lower economic status and are less likely to have health insurance.17 The cost of care and the distrust of the majority culture are potential barriers for this group to access preventive health services. This is probably a contributing factor in the 62% undiagnosed rate for OAG among the Hispanic persons in this study, which is even higher than the 50% undiagnosed rate for white and black persons in the United States and other developed countries.1

The IOP of Hispanic persons in this study is similar to that reported in white and black populations in previous surveys, but is higher than that in Asians, as recently confirmed in a Mongolian population.13 The use of IOP as a method of screening for glaucoma would clearly fail, as has been repeatedly recognized. The 97.5 percentile value for IOP herein in the eye with a higher pressure is 22 mm Hg; however, only a few of those with OAG would be identified by an IOP higher than this criterion in the eye with a higher pressure. The low rate of already diagnosed glaucoma in this population may, in part, be a reflection of continued physician reliance on the IOP measurement instead of on optic disc and visual field examinations. The IOP of those with OAG may be somewhat influenced by treatment among the 36 (38%) of the 94 persons who reported that they were aware of their diagnosis. This factor cannot be evaluated with any certainty in this or in other prevalence surveys in which some subjects with OAG are undergoing treatment. While we know the rate at which subjects report knowledge of their OAG, we do not believe that self-reported use of eyedrops would have allowed us to interpret the IOP data better. It is known that cooperation with medical therapy is not ideal. Thus, we cannot determine if the IOP was affected in the few subjects with OAG who reported prior knowledge of their disease and may have been using some therapy. At most, this would have affected fewer than one third of those diagnosed as having OAG herein.

Another finding in our data that has been previously described is the association between the cup-disc ratio and the IOP level in healthy eyes.18,19 Varma and colleagues found that the higher the IOP, the larger the cup-disc ratio. It is possible that this finding derives from simple backward forces associated with the IOP, causing the disc surface to be positioned in a way that artificially enlarges the cup at a higher IOP. However, this explanation is not compatible with experimental results on disc elasticity.20 We favor the concept that the prevailing IOP causes attrition of retinal ganglion cells and their axons. In this hypothesis, there would be greater loss at a higher IOP, even in the normal range, and not only in those with clinical glaucoma. In most persons, this effect would be undetected and functionally insignificant. In the most susceptible eyes, this effect combines with many other risk factors to produce OAG damage.

While the absolute number of persons blind from glaucoma among Hispanic persons and other world populations is large, the proportion of those with OAG who become legally blind is relatively modest, 3.2% of the subjects in this study. One medical record review study among white persons suggests that 9% (95% CI, 5%-14%) of patients with OAG become bilaterally blind during the course of their treatment. Because this is higher than the data reported in several population-based studies of European-derived persons, there may be methodological differences that explain the discrepancy. The clinic-based data are persons diagnosed as having OAG, who represent only 50% of subjects with OAG and are more likely to be detected by being more severely affected. Furthermore, the population of Minnesota, where these data were collected, has a greater longevity than the general US population and probably a higher rate of exfoliation-related OAG. Both of these factors would lead to a greater probability of more severe damage and blindness, from longer exposure and from a higher IOP than more representative populations.

In prior population-based studies, the relationship of diabetes mellitus to OAG was unclear. Neither of the studies among African-derived individuals in whom this relationship was investigated has shown a positive association, while among studies of European-derived persons, there are studies showing no association, one showing an association only among subjects with OAG with a higher
IOG, and some demonstrating an OAG risk that is nearly twice as high among those with diabetes. In this Hispanic population, we found no evidence for an association. It may be that the variation in association among the studies in white persons derives from differences in the definition of OAG and diabetes. Or, genetic differences among the populations may be playing a role. Each of the studies, including our study of Hispanic persons, found that those with diabetes have a higher IOP, making the relationship plausible. However, it is interesting that longitudinal studies do not confirm diabetes as a risk factor for incident glaucomatous visual field loss.

While there has been a presumed association between hypertension and glaucoma, several studies have indicated that there is no clear overall association among persons in population-based surveys. Indeed, stratified analysis shows a more interesting picture, with the present study and 3 others detecting no association between hypertension and OAG, but suggesting a strong relationship between the perfusion pressure (blood pressure – IOP) and OAG prevalence. Those with a perfusion pressure lower than 50 mm Hg had a 4 times greater risk of OAG than those with a perfusion pressure of 80 mm Hg. Naturally, perfusion pressure is directly related to IOP, because the latter is part of its calculation; thus, some part of the increase in OAG is due purely to a higher IOP. Yet, the range of the IOP in a population is relatively narrow (largely, 15-30 mm Hg). Hence, these perfusion differences of 40 to 50 mm Hg must be influenced at least as much, if not more, by variation among subjects in blood pressure levels. It will be important to determine if the progressive worsening in OAG is also associated with a low perfusion pressure. This would mandate use of perfusion pressure as a second monitoring tool in OAG management.

The prevalence of ACG in this Hispanic population was similar to that observed in other studies of European-derived groups. For example, in Ireland, the ACG prevalence was 0.01%, and a recent Australian population-based study reported 0.1% of affected adults. It has been speculated that angle closure might be more common among Hispanic persons in the Western Hemisphere because of their linked heritage to migrants from Asia after the last Ice Age. Angle closure is substantially more common among Mongolian and Chinese persons. It will be interesting to have further studies of this issue among other populations in Latin America, particularly those including more persons whose families were residents before the European immigration.

In conclusion, OAG in Hispanic adults was more prevalent than among European-derived persons in other population-based surveys, with a tendency toward a higher prevalence in older age groups that suggests a different relationship of incidence to age than in other ethnic groups.

Accepted for publication August 22, 2001.

This study was supported in part by Public Health Service research grant EY11283 (Dr West) and by core facility grant EY01765 (Wilmer Institute, Baltimore, Md) from the National Eye Institute, National Institutes of Health, Bethesda, Md. Dr West is a Research to Prevent Blindness Inc Senior Scientific Investigator.

Corresponding author: Harry A. Quigley, MD, Wilmer 122, The Johns Hopkins Hospital, 600 N Wolfe St, Baltimore, MD 21287 (e-mail: hquigley@jhmi.edu).

REFERENCES