

Prevalence of Open-Angle Glaucoma and Ocular Hypertension in Latinos

The Los Angeles Latino Eye Study

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Objective: To estimate age- and gender-specific prevalences of ocular hypertension and open-angle glaucoma (OAG) in adult Latinos.

Design: Population-based, cross-sectional study.

Participants: Six thousand three hundred fifty-seven Latinos 40 years and older from 6 census tracts in Los Angeles, California.

Methods: The study cohort consisted of all self-identified Latinos of primarily Mexican ancestry 40 years and older residing in 6 census tracts in La Puente, California. All participants underwent a complete ophthalmologic examination, including measurement of intraocular pressure (IOP), visual field (VF) testing using an automated field analyzer, and simultaneous stereoscopic fundus photography of the optic disc. Ocular hypertension was defined as IOP of >21 mmHg and the absence of optic disc damage or abnormal VF test results. Open-angle glaucoma was defined as the presence of an open angle and various criteria that included a glaucomatous VF abnormality and/or evidence of glaucomatous optic disc damage in at least one eye.

Main Outcome Measures: Prevalence of open-angle glaucoma and ocular hypertension.

Results: For the 6142 participants who underwent a complete ophthalmologic examination at the clinical center, the prevalence of OAG was 4.74% (95% confidence interval [CI], 4.22%–5.30%). The prevalence of ocular hypertension was 3.56% (95% CI, 3.12%–4.06%). The prevalences of OAG and ocular hypertension were higher in older Latinos than in younger Latinos ($P < 0.0001$). No gender-related differences in prevalences of OAG and ocular hypertension were present. The mean IOP, mean deviation, and mean vertical cup–disc ratio in persons with OAG were 17 mmHg, –9.6 decibels, and 0.6, respectively. Seventy-five percent of Latinos with OAG and 75% of Latinos with ocular hypertension were previously undiagnosed. Further, 17% of Latinos with OAG and 23% of Latinos with ocular hypertension had received treatment for “glaucoma.”

Conclusion: Our data suggest that the prevalence of OAG is high among Latinos of Mexican ancestry. The higher prevalence of OAG in older Latinos emphasizes the public health importance of providing eye care services for the early diagnosis and management of this condition in Latinos. *Ophthalmology* 2004;111:1439–1448 © 2004 by the American Academy of Ophthalmology.

It is estimated that 66.8 million people in the world have open-angle glaucoma (OAG).¹ Glaucoma is the second leading cause of blindness worldwide, with approximately 6.7 million people blind from glaucoma.^{1,2} It is also the leading cause of blindness in United States blacks. However, large differences exist in the prevalence of glaucoma

among different racial and ethnic groups. Overall, there appears to be a 4-fold higher prevalence of OAG in US blacks relative to non-Hispanic whites in the US.^{2,3} Further, the prevalence of OAG is even higher in non-US blacks relative to US blacks.⁴ Although many population-based studies have documented the prevalence of glaucoma in

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blacks and non-Hispanic whites in the US and worldwide, few studies have focused on Latinos, the fastest-growing segment of the US population and the largest and fastest growing minority in the US.⁵ Census 2000 data reveal that 12.5% of the residents in the US are Latino or Hispanic (35 million people), as compared with 8.8% in the 1990 census.⁶ Census projections estimate that, by 2050, 25% of the US population will be of Hispanic origin.⁷

The Los Angeles Latino Eye Study (LALES) was designed to address this lack of data by estimating the prevalence of glaucoma and other eye diseases among Latinos in Los Angeles County, California.

This article specifically addresses age- and gender-specific prevalences of OAG and ocular hypertension in the LALES. We further describe the clinical characteristics of a population-based sample of Latinos with OAG and ocular hypertension. Forthcoming reports will present data on the risk factors associated with OAG and ocular hypertension.

Materials and Methods

Study Design

The study population consisted of self-identified Latinos, 40 years or older, living in La Puente, California. Details of the study design, sampling plan, and baseline data are reported elsewhere.⁸ In brief, after all dwelling units within 6 census tracts in La Puente were identified and enumerated, a door-to-door census of all residents was conducted. All residents who were eligible (self-identified Latinos 40 years or older at the time of the census) were informed of the study and invited to participate in both a home interview and a clinic examination. Demographic and socioeconomic characteristics of Latinos in the 6 census tracts of La Puente were similar to those of the Latino population in Los Angeles County, California and the US.⁸ Institutional review board approval was obtained from the Los Angeles County/University of Southern California Medical Center Institutional Review Board. All study procedures adhered to the principles outlined in the Declaration of Helsinki for research involving human subjects.

Study Sociodemographic and Clinical Data

After informed consent was obtained, a detailed in-home interview was conducted. Details of the in-home interview, along with how Mexican American and Native American ancestry was attributed to a participant, are presented elsewhere.⁸ All eligible individuals then were invited and scheduled for a detailed eye examination, which was performed in a standardized manner at the LALES local eye examination center.⁸ Data from the in-home interview and near visual acuity (VA) were used to evaluate selection bias in those individuals who did not have a complete eye examination.

Visual Field Evaluation

The LALES participants' peripheral vision was tested using the Humphrey Automated Field Analyzer II (Carl Zeiss Meditec, Dublin, CA). A Swedish Interactive Threshold Algorithm (SITA) Standard C24 was first performed, and if the results for the visual field (VF) were normal, no further testing was done. However, if the results were unreliable or abnormal, a repeat SITA Standard C24 or a full threshold 24-2 test was performed. The repeat test at the initiation of the study was a full threshold test and was changed to a repeat SITA Standard C24 test to decrease participant testing

time. Sixty-four percent of second tests were SITA Standard C24, and 36% of second tests were a full threshold 24-2. No VF tests were performed on eyes that presented with a VA of light perception (LP) or no LP. An abnormal SITA Standard VF was defined by any one of the following criteria: glaucoma hemifield tests (GHTs) borderline, GHTs outside normal limits, GHTs with generalized reduction in sensitivity, or ≥ 2 adjacent points depressed $P < 0.5\%$ (determined by the technician). An unreliable test included false positives of greater than 33%, false negatives of greater than 33%, or fixation losses of greater than 50%. Next, 2 glaucoma specialists evaluated the field loss pattern and the congruence among the ≥ 2 VF tests. The glaucoma specialists described the field loss pattern as any one of or any combination of the following criteria: nasal step, arcuate, paracentral, altitudinal, central island, temporal island, diffuse depression, or central scotomas. Congruence of field loss among the VF tests was defined as excellent ($> 75\%$), fair and compatible with overlap (25%–75%), poor, questionable ($< 25\%$), or noninterpretable/not applicable. Finally, based on optic disc evaluation, clinical examination data, and evaluation of fundus photographs, the glaucoma specialists determined if the field loss was characteristic of glaucoma, compatible with glaucoma, due to other neurologic/nonglaucomatous cause or artifact, or not determinable/not applicable. Visual field defects characteristic of glaucoma were defined as defects corresponding to the nerve fiber bundle pattern, which included nasal steps (either superior or inferior, but not both), paracentral defect, arcuate defect, central island, temporal island, and absolute defect. Visual field defects compatible with glaucoma were defined as defects that conform to nerve fiber bundle loss but have deviated in some manner from the characteristic defects, including altitudinal loss, both superior and inferior nasal steps, and defects with fair congruence, including a VF defect present in one field test but not in the second field test (defects in the nasal, arcuate, or paracentral regions).

Optic Nerve Evaluation

Optic nerve findings were evaluated from the simultaneous stereoscopic optic disc photographs using a stereoscopic viewer (Asahi viewer, Pentax, Englewood, CO). The 2 glaucoma specialists first determined whether the disc photographs were of good quality and gradable. If the photograph was gradable, the appearance of the optic disc was characterized in terms of vertical and horizontal cup-disc ratios, cup-disc ratio asymmetry between the 2 eyes, disc and peripapillary nerve fiber layer hemorrhage, peripapillary atrophy, diffuse thinning of the neural rim (remaining neural rim < 0.1), and notching of the neural rim (remaining neural rim in a localized area < 0.1). Finally, the optic disc was classified as either compatible with or characteristic of glaucoma, abnormal but non-glaucomatous, normal, or unsure. The optic nerve appearance was classified as compatible if it met 1 of the following criteria and characteristic if it met ≥ 2 of the following: horizontal or vertical cup-disc ratio ≥ 0.8 , notching of the neural rim, localized or diffuse loss of the neural rim with a maximum remaining neural rim of < 0.1 , or a nerve fiber layer defect in the arcuate bundles. In the absence of clear, high-quality photographs, data from the direct binocular ophthalmoscopic examination of the optic nerve were used.

Diagnosis of Glaucoma

A 3-step process was used to determine the diagnosis of OAG. First, 2 glaucoma specialists (BAF, BB-TN) evaluated all clinical history, including any history of glaucoma, treatment of glaucoma, family history of glaucoma; history of treatment and management for other ocular diseases, including cataract, diabetic retinopathy,

and age-related maculopathy; and examination data, including VA, Van Herrick test results, gonioscopy results, evaluation of the anterior and posterior segments of the eye, clinical optic disc evaluation, clinical fundus evaluation, optic disc photographs, and VFs. Second, the 2 glaucoma specialists determined the presence or absence of OAG using specified guidelines. The 2 specialists graded both optic disc photographs and VFs, independently and masked to the gradings of the other glaucoma specialist. In determining the diagnosis of glaucoma, the specialists classified each eye of each person with particular consideration to the Humphrey VF test results and evaluation of the optic disc photographs. If the 2 glaucoma specialists agreed on the diagnosis, that diagnosis was assigned to each specific eye of each person. Third, in the event of disagreement, a third glaucoma specialist assessed the data. An agreement between 2 of the 3 glaucoma specialists was used to assign the diagnosis for each eye of each participant. Additionally, the principal investigator (RV) performed a confirmatory review of all cases of OAG.

Open-angle glaucoma was defined in several ways:

1. The primary definition required the presence of an open-angle, congruent, characteristic, or compatible glaucomatous VF abnormality, and evidence of characteristic/compatible glaucomatous optic disc damage in at least one eye after ophthalmologic exclusion of other possible causes. Specifically, OAG was diagnosed if an open angle; at least 2 reliable, congruent VF tests (Humphrey C24 SITA Standard and/or full threshold C24-2); and optic disc damage characteristic of glaucoma were present, or if an open angle, at least 1 abnormal VF test, and optic disc damage characteristic or compatible with glaucoma were present.
2. Open-angle glaucoma was also diagnosed if there was an open angle and 1 of the following 4 criteria: (1) end-stage disease with VA of $\leq 20/200$ and a cup-disc ratio of 1.0, an open angle, and absence of VF data; (2) at least 1 abnormal VF test with characteristic/compatible glaucomatous VF defects and no evidence of optic disc damage; (3) characteristic/compatible glaucomatous optic disc damage with no evidence of VF abnormality; and (4) other combinations of VF (lack of perfect congruence between the 2 or 3 VFs) and optic disc abnormalities that are both compatible with glaucoma. The definition of OAG did not include intraocular pressure (IOP).

Ocular hypertension was diagnosed in individuals with an IOP of >21 mmHg (or ≤ 21 mmHg if the person was using ocular hypotensive medication(s) or had undergone laser or incisional surgery to lower IOP in that eye), and the absence of both optic disc damage and abnormal VF test results.

Statistical Analyses

Prevalence of OAG was calculated as the ratio of the number of individuals with OAG graded by both glaucoma specialists (or 2 of 3 glaucoma specialists) to the total number of individuals in that stratum. If a person had glaucoma in both eyes, that person was defined as having glaucoma, and data from the eye with the higher mean deviation were selected for that person. If one eye had glaucoma and the contralateral eye was either ocular hypertensive or normal, that person was defined as having glaucoma, and data from the glaucomatous eye were selected for that person. If both eyes were ocular hypertensive, the person was defined as having ocular hypertension, and the data from the eye with the higher IOP were considered representative of that person. If one eye had ocular hypertension and the contralateral eye was normal, that person was defined as having ocular hypertension, and data from the ocular hypertensive eye were considered representative for that

person. The relationship of demographic characteristics to participation status utilized chi-square test procedures. Analysis of variance was used to compare the difference in demographic and clinical characteristics between LALES participants with OAG and those with ocular hypertension. All analyses were conducted at the 0.05 significance level and utilized SAS.⁹

Results

Participants and Participation Rate

Of the 7789 persons who were identified as eligible for the LALES, 6357 (82%) completed the clinical examination.⁸ Three groups of persons refused to participate: those who refused the interview only ($n = 11$), those who refused the clinical examination only ($n = 524$), and those who refused both the interview and clinical examination ($n = 908$). To ascertain the bias in recruitment of our sample, we have compared the age and gender distributions of those eligible who completed an in-home interview ($n = 6870$) with the distributions of those who did not ($n = 919$) elsewhere.¹⁰ Those eligible who completed the in-home interview were on average younger (mean age, 54.9 ± 11.0 years) and more likely to be female (58%) than those who did not complete an interview (mean age, 56.8 ± 11.0 years; 47% female) ($P < 0.001$). To further assess participation bias, we compared those 6357 study participants who completed the home questionnaire and had a clinical examination with the 524 participants who completed only the home questionnaire.¹⁰ Participants who completed only the in-home questionnaire were more likely to be older, born in the US, more acculturated, and more educated; to have higher incomes and health insurance; to report a history of cataract surgery; to rate their vision as good to excellent; and to have better than 20/40 binocular near vision using the in-home VA test than participants who completed both the in-home interview and a clinical examination ($P < 0.05$). However, there was no difference between these 2 groups in terms of gender distribution, employment and marital status, history of hypertension, diabetes, cataract, and glaucoma ($P > 0.05$).

Of the 6357 participants who had a complete clinical examination, 6142 completed the in-clinic examination, and 215 completed the in-home examination. Because the examination protocol conducted at home was not identical to that in the clinic, the analyses for OAG and ocular hypertension presented here are based on the 6142 participants who completed the in-clinic examination. The mean age of those included in these analyses was 54.9 (± 11) years, with 58% of participants being female and 95% having Mexican ancestry.

Completion and Reproducibility of Data Collection for Glaucoma Classification

Of the 291 participants with OAG, 286 (98%) had a clinical optic disc examination, 273 (94%) had gradable optic disc photographs, and 5 (2%) had no optic disc data. Two or more VF tests were performed on 242 (83%) participants, 41 (14%) had 1 VF test, and 8 (3%) had no VF data (Table 1). The agreement between the 2 glaucoma specialists in estimating the vertical cup-disc ratio was substantial (average weighted κ for right and left eye, 0.67 [95% confidence interval (CI), 0.62–0.69]). The agreement between the 2 glaucoma specialists in estimating the horizontal cup-disc ratio was substantial (average weighted κ for right and left eye, 0.64 [95% CI, 0.60–0.68]). The agreement between the 2 glaucoma specialists when determining abnormal VF tests was substantial (average weighted κ for right and left eye, 0.82 [95% CI, 0.81–0.83]).

Table 1. Completeness of Data for Glaucoma Classification for Participants with Open-Angle Glaucoma in the Los Angeles Latino Eye Study (n = 291)

	Gradable Disc Photographs* [n (%)]	Clinical Disc Examination Data Only [n (%)]	No Disc Data [n (%)]	Total [n (%)]
≥2 visual fields [†]	226 (77.6%)	11 (3.8%)	5 (1.7%)	242 (83.2%)
1 visual field [†]	40 (13.7%)	1 (0.3%)	—	41 (14.1%)
No visual field	7 (2.4%)	1 (0.3%)	—	8 (2.7%)
Total	273 (93.8%)	13 (4.5%)	5 (1.7%)	291 (100%)

*Simultaneous stereoscopic optic disc photographs.

[†]Humphrey C24 Swedish Interactive Threshold Algorithm Standard and/or full threshold C24-2.

Prevalence of Open-Angle Glaucoma and Ocular Hypertension

Of the 6142 participants who received eye examinations, 291 (4.74%; 95% CI, 4.22%–5.30%) were diagnosed as having OAG. The prevalence of OAG was higher in older Latinos (Table 2; $P < 0.0001$). The prevalence of OAG was 16-fold higher in the oldest age group (≥80 years) relative to the youngest age group (40–49 years; 21.76% vs. 1.32%; $P < 0.0001$). After adjusting for nonparticipation in the examination, the overall prevalence of OAG was 4.89%, similar to the 4.74% before adjustment. There were no gender-related differences in the prevalence of OAG ($P = 0.03$).

Ocular hypertension was present in 219 (3.56%; 95% CI, 3.12–4.06) of the 6142 participants examined (Table 3). The prevalence of ocular hypertension was significantly lower in Latinos ≤49 years old than in those ≥50 years old ($P < 0.0001$). Also, there is an age-specific increase in the prevalence of ocular hypertension. Older Latinos (≥80 years old) have a prevalence of ocular hypertension 3-fold higher than that of younger Latinos (40–49 years). The prevalence of ocular hypertension was 3.00% (95% CI, 2.38–3.76; n = 77) in males and 3.96% (95% CI, 3.35–4.65; n = 142) in females. These differences were not statistically different. After adjusting for nonparticipation in the examination, the overall prevalence of ocular hypertension was 3.57%, similar to the 3.56% before adjustment.

Criteria for Diagnosis of Open-Angle Glaucoma

Table 4 details the criteria used to diagnose OAG. Seventy-five percent of the participants with OAG (n = 218) had at least one

eye with both VF loss and optic disc damage, irrespective of the IOP. In the remaining persons diagnosed with OAG, at least one eye had either VF loss (n = 16 [5.5%]) or optic disc damage (n = 56 [19.2%]) that was characteristic of or compatible with glaucoma or a combination of VF loss and optic disc damage that was compatible with glaucoma (n = 16 [5.5%]), irrespective of the IOP. Finally, one person was considered to have OAG because this participant had one eye with a VA worse than 20/200 and a cup–disc ratio of 1.0. This participant's glaucoma was managed with multiple surgical glaucoma interventions in this eye at the Doheny Eye Institute, before the initiation of this study.

Bilaterality of Open-Angle Glaucoma and Ocular Hypertension

Of the 291 persons with OAG in either eye, 137 (47%) had bilateral OAG and 154 (53%) had unilateral OAG. Of these 154 persons, 29 (10%) had OAG in one eye and ocular hypertension in the other eye, and 125 (43%) had OAG in one eye and no OAG or ocular hypertension in the other eye. Of the 219 persons with ocular hypertension in either eye, 92 (42%) had bilateral ocular hypertension, and 127 (58%) had ocular hypertension in one eye and no OAG or ocular hypertension in the other eye.

Characteristics of Open-Angle Glaucoma and Ocular Hypertension Cases

Details of the clinical characteristics of all LALES participants with OAG and ocular hypertension are presented in Tables 5 to 7. Overall, participants with OAG (mean age, 65 years) were older than participants with ocular hypertension (60 years). Among

Table 2. Age- and Gender-Specific Distribution of Prevalence of Open-Angle Glaucoma in Los Angeles Latino Eye Study Participants

Age Group (yrs)	No. Who Received on Examination	Prevalence					
		Males		Females		Total	
		n (%)	95% CI	n (%)	95% CI	n (%)	95% CI
40–49	2363	18 (1.82)	1.08–2.88	13 (0.94)	0.50–1.62	31 (1.32)	0.90–1.86
50–59	1853	28 (3.62)	2.42–5.24	26 (2.40)	1.58–3.52	54 (2.92)	2.18–3.80
60–69	1195	40 (8.20)	5.86–11.16	48 (6.78)	5.00–9.00	88 (7.36)	5.90–9.08
70–79	584	40 (15.32)	10.96–20.86	46 (14.24)	10.42–19.00	86 (14.72)	11.78–18.18
≥80	147	13 (24.52)	13.06–41.94	19 (20.22)	12.18–31.56	32 (21.76)	14.90–30.72
Total	6142	139 (5.44)	4.59–6.38	152 (4.35)	3.61–4.95	291 (4.74)	4.22–5.30

CI = confidence interval.

*Utilizes a Poisson distribution for number of cases ≤ 100; otherwise, utilizes the binomial distribution.

Table 3. Age- and Gender-Specific Prevalence of Ocular Hypertension in Los Angeles Latino Eye Study Participants

Age Group (yrs)	No. Who Received on Examination	Prevalence					
		Males		Females		Total	
		n (%)	95% CI	n (%)	95% CI	n (%)	95% CI
40–49	2363	20 (2.04)	1.24–3.14	20 (1.46)	0.88–2.24	40 (1.70)	1.20–2.30
50–59	1853	22 (2.84)	1.78–4.32	57 (5.28)	4.00–6.84	79 (4.26)	3.38–5.32
60–69	1195	18 (3.68)	2.18–5.82	39 (5.52)	3.92–7.54	57 (4.76)	3.62–6.18
70–79	584	13 (4.98)	2.66–8.52	19 (5.88)	3.54–9.18	32 (5.48)	3.74–7.74
≥80	147	4 (7.54)	2.06–19.32	7 (7.44)	2.98–15.34	11 (7.48)	3.74–13.38
Total	6142	77 (3.00)	2.38–3.76	142 (3.96)	3.35–4.65	219 (3.56)	3.12–4.06

CI = confidence interval.

*Utilizes a Poisson distribution for cases ≤ 100; otherwise, utilizes a binomial distribution.

participants with OAG, the mean IOP was 17.3 mmHg, with 82% having an IOP of ≤21 mmHg (Table 5). Also, there was no significant difference in IOP between persons with a history of OAG (mean, 18.3 mmHg) and those whose OAG was previously undiagnosed (mean, 17.0 mmHg). Further, only 15% of persons with previously undiagnosed OAG and 25% of those with a history of OAG had IOPs of >21 mmHg. Nineteen percent of ocular hypertensive persons had an IOP of ≤21 mmHg because they were either on ocular hypotensive medications or had undergone previous laser or incisional glaucoma surgery.

When evaluating the VF characteristics of persons with OAG, the mean defect (deviation: median mean defect OAG, −6.6 decibels;

median mean defect ocular hypertension, −2.1 decibels; $P<0.0001$) and the pattern standard deviation (median PSD OAG, 5.1; median PSD ocular hypertension, 2.1; $P<0.0001$) were worse in persons with OAG than in those with ocular hypertension. The field defects in all persons with ocular hypertension were considered (by both glaucoma specialists) to be due to a lid/lens artifact or nonglaucomatous retinal/optic nerve disease. Finally, the central corneal thickness (CCT) among persons with OAG was less than that of those with ocular hypertension (OAG, 545 μm ; ocular hypertension, 568 μm ; $P<0.0001$). More detailed analyses of CCT among Latinos and the relationship of CCT with IOP have been presented elsewhere.¹¹

On average, cup–disc ratios, both horizontal and vertical, were larger in persons with OAG than in those with ocular hypertension (Table 6). Of the participants with OAG, 42% to 51% had horizontal and vertical cup–disc ratios greater than 0.7 (the 97.5th percentile for all Latinos), compared with one participant (0.5%)

Table 4. Frequency of Specific Diagnostic Criteria for Defining Open-Angle Glaucoma in Los Angeles Latino Eye Study Participants (n = 291)

Diagnostic Criteria	Frequency (n = 291)	
	n	%
A. Evidence of visual field* and optic disc damage		
1. Open angle, ≥2 reliable, abnormal visual field tests with excellent congruence and optic disc damage both characteristic of glaucoma	123	42.4
2. Open angle, ≥1 abnormal visual field test(s) and optic disc damage both characteristic of or compatible with glaucoma	79	27.1
3. End-stage disease with visual acuity ≤20/200 and a cup–disc ratio of 1.0 and absence of visual field data	1	0.3
4. Combinations of visual field and optic disc abnormalities with fair congruence between fields that are both compatible with glaucoma	16	5.5
B. Evidence of either visual field* or optic disc damage		
5. ≥1 abnormal visual field test(s) that are characteristic of or compatible with glaucoma and no evidence of optic disc damage	16	5.5
6. Characteristic or compatible glaucomatous optic disc damage with no evidence of visual field abnormality	56	19.2

*Humphrey C24 Swedish Interactive Threshold Algorithm Standard and/or full threshold C24-2.

Table 5. Clinical Characteristics of Persons with Open-Angle Glaucoma (OAG) and Ocular Hypertension in the Los Angeles Latino Eye Study

	OAG (n = 291)	Ocular Hypertension (n = 219)	P
Age (yrs)			
Mean ± SD	65.4±11.8	59.7±11.4	<0.0001
Median	67	58	
IOP (mmHg)			
Mean ± SD	17.3±5.4	22.8±8.1	<0.0001
Median	16	22	
% IOP > 21 mmHg	18	81*	<0.0001
Mean defect (dB)			
Mean ± SD	−9.8±9.1	−4.2±6.0	<0.0001
Median	−6.6	−2.1	
Pattern standard deviation (dB)			
Mean ± SD	5.7±3.5	3.3±2.6	<0.0001
Median	5.1	2.1	
CCT (μm)			
Mean ± SD	545±38	568±42	<0.0001
Median	547	568	

CCT = central corneal thickness; dB = decibels; IOP = intraocular pressure; SD = standard deviation.

*19% of these participants were considered ocular hypertensive because they did not have evidence of OAG, had an IOP of ≤21 mmHg, and were on ocular hypotensive medication.

Table 6. Optic Disc Characteristics of Persons with Open-Angle Glaucoma (OAG) and Ocular Hypertension (OHT) in the Los Angeles Latino Eye Study

	OAG* (n = 291)	OHT* (n = 219)	P
HCDR [†]			
Mean ± SD	0.7±0.1	0.4±0.1	<0.0001
Median	0.6	0.3	
VCDR [†]			
Mean ± SD	0.7±0.1	0.4±0.1	<0.0001
Median	0.6	0.3	
HCDR>0.7 [†] [n (%)]	115 (42.1)	1 (0.5)	<0.0001
VCDR>0.7 [†] [n (%)]	138 (50.6)	1 (0.5)	<0.0001
Cup–disc ratio asymmetry of ≥0.3 [‡] [n (%)]	49 (18.5)	1 (0.5)	<0.0001
Disc/NFL hemorrhage [‡] [n (%)]	21 (7.2)	0	<0.0001
Peripapillary atrophy [‡] [n (%)]	241 (82.8)	93 (42.5)	<0.0001
Diffuse thinning of neural rim to disc margin [‡] [n (%)]	133 (45.7)	0	<0.0001
Notching of neural rim [‡] [n (%)]	174 (59.8)	0	<0.0001

HCDR = horizontal cup–disc ratio; NFL = nerve fiber layer; SD = standard deviation; VCDR = vertical cup–disc ratio.

*Person-specific: if only one eye of a person had diagnosed OAG or OHT data from that eye were included; if both eyes had OAG, data from the eye with the largest mean defect were included.

[†]Highest HCDR or VCDR in the eye with OAG. The average value of 2 reviewers was included. The 97.5th percentiles for the population for VCDR and cup–disc ratio asymmetry were 0.7 and 0.3, respectively.

[‡]Optic disc characteristic considered to be present only if both reviewers agreed it was present; otherwise, categorized as not present.

with ocular hypertension ($P<0.0001$). Cup–disc ratio asymmetry of ≥ 0.3 (the 97.5th percentile for all Latinos) was present in 18.5% of participants with OAG. One of the participants with ocular hypertension had a cup–disc ratio asymmetry of ≥ 0.3 . Peripapillary atrophy was present in 83% of participants with OAG and 43% of participants with ocular hypertension. By definition, diffuse thinning of the neural rim to the disc margin and notching of the neural rim were only present in persons with OAG. Disc/nerve fiber layer hemorrhages were present only in patients with OAG ($n = 21$ [7.2%]). None of the participants with ocular hypertension had a disc/nerve fiber layer hemorrhage. The most common VF defects present in Latinos with OAG were arcuate scotomas (61%), nasal steps (25%), paracentral scotomas (6.5%), and altitudinal defects (5%).

Prevalences of visual impairment in persons with and without OAG were 6.6% and 1.07%, respectively ($P<0.0001$). Prevalences of legal blindness in persons with and without OAG were 1.04% and 0.37%, respectively. Although this represents a 2.5-fold difference, it is not statistically significant because of the small numbers of persons in the entire cohort who were blind ($n = 26$).

Table 7. Self-Reported History of Glaucoma and Glaucoma Treatment History in Los Angeles Latino Eye Study Participants with Open-Angle Glaucoma (OAG) and Ocular Hypertension (OHT)

	OAG (n = 291)	OHT (n = 219)
History of glaucoma	71 (24.2)	54 (24.8)
No treatment	19 (6.5)	3 (1.4)
Treatment of glaucoma*	52 (17.8)	51 (23.4)
Current ocular hypotensive medication	50 (17.1)	49 (22.5)
Previous glaucoma laser surgery	16 (5.5)	11 (5.1)
Previous incisional glaucoma surgery	9 (3.1)	10 (4.6)

Data are n (%).

*Subjects may have a history of more than one treatment of glaucoma.

Prevalences of Previously Undiagnosed and Previously Treated Glaucoma

A majority of persons with OAG and ocular hypertension were previously undiagnosed. Over 75% ($n = 220$) of the 291 persons with OAG had no history of glaucoma or treatment for glaucoma. Similarly, over 75% ($n = 165$) of those diagnosed with ocular hypertension were previously undiagnosed. For those who had been previously diagnosed with OAG and ocular hypertension, the distribution of the self-reported history of treatment for glaucoma and elevated IOP is presented in Table 7. The most common current treatment was use of ocular hypotensive medications. Approximately 17% of all persons with OAG and ocular hypertension were being treated with ocular hypotensive medications. In addition to ocular hypotensive medications, 5.5% and 3.1% of participants with OAG had had previous laser surgery and previous incisional surgery, respectively. Surprisingly, of those persons with ocular hypertension, 5.1% had had previous laser surgery and 4.6% had had previous incisional glaucoma surgery.

Discussion

The LALES is the largest population-based study of eye disease in any racial/ethnic group in the US. Our sample of Latinos primarily of Mexican ancestry reflects the largest Latino group in the US.⁷ Of the 7789 eligible persons, 6357 participated in both the interview and the clinical examination, providing a participation rate of 82%, which is comparable to other population-based studies. A strength of our study is the use of standardized protocols for determining glaucoma, for obtaining simultaneous stereoscopic photographs of the optic disc, and for performing VF testing (particularly for the confirmation of VF defects) with ≥ 2 threshold VFs in the majority of cases. Grading of the photographs and VFs and the diagnosis of glaucoma were performed independently by 2 glaucoma specialists, with a

Table 8. Prevalence of Definite Open-Angle Glaucoma as Reported in Other Studies

Study	Racial/Ethnic Group	Age-Specific Prevalence Age Groups (yrs)					Total
		40–49	50–59	60–69	70–79	≥80	
Baltimore Eye Study*	Blacks	1.27	4.15	6.19	8.88	12.87	4.97
Barbados Eye Study†	Blacks	1.4	4.1	6.7	14.8	23.2	6.8
LALES	Latinos	1.32	2.92	7.36	14.72	21.76	4.74
Proyecto VER‡	Latinos	0.50	0.59	1.73	5.66	12.63	1.97
Baltimore Eye Study*	NHW	0.18	0.32	1.53	3.33	1.94	1.44
Blue Mountains Eye Study§	NHW		0.4	1.3	4.7	11.4	3.0
Visual Impairment Project¶	NHW	0.5	1.5	4.5	8.6	9.9	3.4
Roscommon#	NHW		0.72	1.76	3.2	3.05	1.88

LALES = Los Angeles Latino Eye Study; NHW = non-Hispanic white.

*Tielsch JM, Sommer A, Katz J, et al. Racial variations in the prevalence of primary open-angle glaucoma. The Baltimore Eye Survey. JAMA 1991;266:369–74.

†Leske MC, Connell AM, Schachat AP, Hyman L. The Barbados Eye Study. Prevalence of open angle glaucoma. Arch Ophthalmol 1994;112:821–9.

‡Quigley HA, West S, Rodriguez J, et al. The prevalence of glaucoma in a population-based study of Hispanic subjects: Proyecto VER. Arch Ophthalmol 2001;119:1819–26.

§Mitchell P, Smith W, Attebo K, Healey PR. Prevalence of open-angle glaucoma in Australia. The Blue Mountains Eye Study. Ophthalmology 1996;103:1661–9.

||The study combined ages 40–59 into one group.

¶Wensor MD, McCarty CA, Stanislavsky YL, et al. The prevalence of glaucoma in the Melbourne Visual Impairment Project. Ophthalmology 1998;105:733–9.

#Coffey M, Reidy A, Wormald R, et al. Prevalence of glaucoma in the west of Ireland. Br J Ophthalmol 1993;77:17–21.

third glaucoma specialist adjudicating discrepancies. We believe that these methods have allowed us to obtain accurate estimates of the frequency of OAG and ocular hypertension in our Latino population. These estimates can assist health care providers in developing screening programs for the early detection of OAG, particularly among elderly Latinos.

As mentioned previously, population-based studies on OAG in the US have been in largely black and non-Hispanic white populations, with only one previous study in a Latino population—Proyecto VER (Table 8). In Proyecto VER, the age-specific prevalence of OAG ranged from 0.50% in the youngest age group (40–49 years) to 12.63% in the oldest group (≥80 years). These rates are significantly lower than the prevalence in our study (Table 2, Fig 1). These differences are further emphasized by the fact that the mean age and mean IOP of participants in our study were lower than those of participants in Proyecto VER. In Proyecto VER, the mean age and mean IOP of those with OAG were 70.9 (±12.5) years and 18.5 (±8.7) mmHg, respectively, whereas in our study the mean age and mean IOP of those with OAG were 65.4 (±11.8) years and 17.3 (±5.4) mmHg. There are numerous possible explanations for the difference in the prevalence between the 2 studies. The difference may

be due to the difference in genetic admixture of the 2 populations—a high proportion of Proyecto VER's study population had some Native American ancestry (approximately 40%), whereas only 5.3% of participants in the LALES had some Native American ancestry¹²—or it may be due to the difference in examination methods and the definitions used for the diagnosis of glaucoma. In Proyecto VER, the testing performed to detect glaucoma included a single SITA Fast test and nonsimultaneous stereoscopic optic disc photography. Of those participants with glaucoma in Proyecto VER, 95% (90/94) had a single VF test in either eye and 62% (58/94) had nonsimultaneous stereoscopic optic disc photographs to document the presence of OAG. Further, in Proyecto VER, a single glaucoma specialist evaluated a selected group of participants to determine the presence of glaucoma. In contrast, in the LALES we performed 2 SITA Standard field tests and simultaneous stereoscopic optic disc photography. Of those participants with glaucoma, 97% (283/291) had at least a single VF test, 83% (242/291) had ≥2 VFs in either eye, and 94% (273/291) had simultaneous stereoscopic optic disc photographs to document the presence of OAG. Finally, in the LALES, 2 glaucoma specialists evaluated all participants to determine

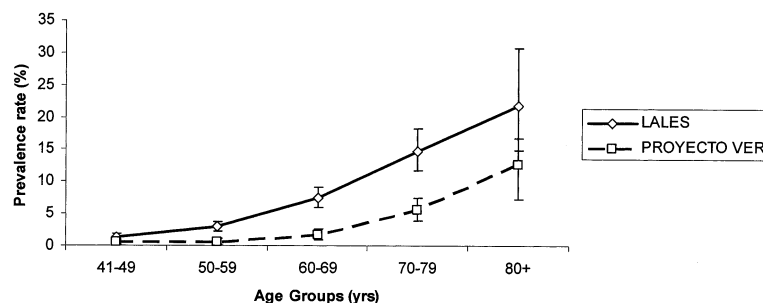


Figure 1. Comparison of age-specific prevalence of open-angle glaucoma in the Los Angeles Latino Eye Study (LALES) and Proyecto VER.

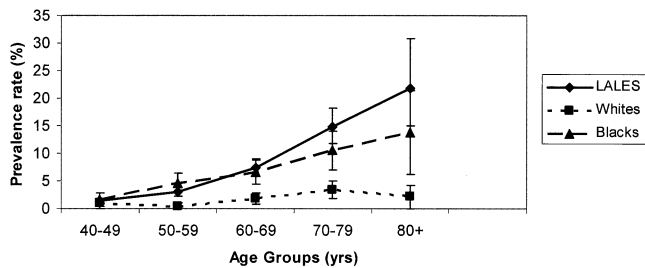


Figure 2. Comparison of age-specific prevalence of open-angle glaucoma in the Los Angeles Latino Eye Study (LALES) and the Baltimore Eye Study (blacks and non-Hispanic whites).

the presence of glaucoma, and a third glaucoma specialist confirmed the diagnosis of OAG.

The age-specific prevalence of OAG in Latinos in our study is higher than that seen in non-Hispanic whites and similar to that seen in blacks in the US (Fig 2).^{3,13} However, when compared with prevalence in studies conducted outside the US, the prevalence in Latinos was lower than that in Barbadian Afro-Caribbeans and higher than those in non-Hispanic whites in Australia, Ireland, and the Netherlands and in Singaporean Chinese.^{4,14–23} Although there is no clear explanation for these differences, possible explanations include genetic differences and differences in the methods of detecting and defining OAG.

In our study, the prevalence of OAG was higher in older Latinos. The prevalence of OAG in Latinos 80 years or older was 16 times higher (22%) than that in Latinos 40 to 49 years old (1.3%). Our data, which reflect an age-related increase in prevalence of OAG, support similar observations that have been reported previously in other prevalence studies^{3,4,13–15,18–23} (Table 8). Furthermore, the absence of any gender-related differences in our study is also similar to the lack of gender-related differences found in other studies.^{3,5,13,15}

To the best of our knowledge, our study is one of the first population-based prevalence studies to provide data on the age- and gender-specific prevalences of ocular hypertension in Latinos. Previously, the Beaver Dam Eye²⁴ and Blue Mountains Eye¹⁴ studies have presented data on age-specific prevalence of ocular hypertension in non-Hispanic whites. Their age-specific prevalences, ranging from 2.3% in persons 43 to 49 years old and 7.7% in persons 75 to 79 years and older, are similar to ours (1.7%–7.48%). Although the Blue Mountains Eye Study found no age-related increase in the prevalence of ocular hypertension, our results are similar to those of the Beaver Dam Eye Study and other studies in which an age-related increase in the prevalence of ocular hypertension was noted.^{24–28} Further, the lack of gender-specific differences observed in our study is supported by similar observations in the Beaver Dam Eye and Blue Mountains Eye studies.^{14,24} The overall prevalences of ocular hypertension in non-Hispanic Barbadian whites (4.6%)²⁸; Roscommon, Ireland (3.6%)¹⁹; Beaver Dam (4.5%)²⁴; and Blue Mountains, Australia (3.7%)¹⁴ are similar to those in our study. However, the prevalence of ocular hypertension in Indians in Andhra Pradesh (0.42%),²² non-Hispanic whites in Melbourne (1.6%),¹⁵ non-Hispanic

whites in Northern Italy (2.1%),²⁰ and Barbadian blacks (18.4%)⁴ significantly differs from that in our study. One possible explanation is the younger ages of participants in the Andhra Pradesh study and older participants in the Barbadian study. Another possible explanation for these differences is the genetic dissimilarity between these groups.

The demographic and clinical characteristics of patients with OAG and ocular hypertension provide information on these characteristics in a population-based sample (Tables 5, 6). The most common clinical signs of glaucomatous optic neuropathy we noted included cup–disc ratio > 0.7, notching of the neural rim, diffuse thinning of the neural rim and cup–disc ratio asymmetry of ≥ 0.3 , arcuate scotomas and nasal steps, and a thin central cornea. These common optic disc and VF signs should be considered when diagnosing glaucomatous optic neuropathy. Also, though OAG is considered to be a bilateral disease, in our study, over half of all persons with OAG had only unilateral glaucomatous optic nerve damage at the time of examination. Given the asymmetric nature of OAG, its diagnosis should be considered in the differential diagnosis list of patients with signs of unilateral optic nerve damage.

The IOP in Latinos with OAG was significantly lower than that in those with ocular hypertension (Table 5). Another contributor to this difference may be the mean CCT in persons with OAG being thinner (545 μm) than in those with ocular hypertension (568 μm).¹¹ However, the low IOP in persons with OAG (particularly those who were previously undiagnosed) and the low prevalence of IOPs of >21 mmHg (18%) highlight the poor value of IOP for the screening and diagnosis of glaucoma. These observations are comparable to similar rates found in Northern Italy (13%),²⁰ Arizona (20%),⁵ and Blue Mountains (25%)¹⁴ and lower than those in Melbourne (39%),¹⁵ Baltimore (45%),³ and Rotterdam (61%).²³ Furthermore, although the average vertical cup–disc ratios in persons with OAG are larger than in those with ocular hypertension, the wide range of cup–disc ratios even in persons with OAG suggests that cup–disc ratios alone are also unlikely to be valuable in screening for OAG. This is further reinforced by the significant overlap of cup–disc ratios between those persons with OAG and those with ocular hypertension. This wide range of cup–disc ratios in persons with OAG has also been observed in other population-based studies and supports the fact that cup–disc ratios are not useful in diagnosing OAG.

Over 75% of our participants with OAG and 75% with ocular hypertension were undiagnosed previously. These rates are comparable to those in Northern Italy (78%)²⁰ and higher than those found in other population-based studies in Melbourne (50%),¹⁵ Blue Mountains (51%),¹⁴ Baltimore (58% in blacks and 50% in non-Hispanic whites),³ Roscommon (49%),¹⁹ Rotterdam (53%),¹⁶ Barbados (51%),⁴ and Arizona (62%).⁵ Such high prevalences of underdiagnosis highlight the need to develop and assess early detection and treatment programs directed at Latinos. These programs are likely to be increasingly important as the Latino population ages. In addition to the underdiagnosis and undertreatment, 59 participants (equivalent to 27% of persons with OAG) reported having a history of glaucoma; however, they had no evidence of OAG based on the LALES examination.

This overdiagnosis of OAG further emphasizes the need for better methods for the diagnosis of OAG.

The LALES is one of the largest and most comprehensive studies of OAG and ocular hypertension in a Latino population and the only study, to our knowledge, with a majority of Mexican-born Latinos. With a high participation rate of 82% and a study population composition of demographics similar to those seen in other large Latino populations, the results of the LALES are generalizable to the adult Latino population in Los Angeles and may be generalizable to other regions in the country with large Latino populations of primarily Mexican ancestry. One potential limitation of our study is a bias in the prevalence estimates because of a higher recruitment of women and older Latinos. Such a differential participation rate would likely lead to a bias in the overall prevalence for OAG and ocular hypertension. However, after adjusting for age- and gender-specific participation rates, there was no significant change in the overall prevalence of OAG and ocular hypertension. Additionally, these differential participation rates are unlikely to impact age- and gender-specific prevalences. Finally, because our analysis assumes independence between participants from the same household, the possibility of a design effect does exist. However, there was no impact of familial clustering on the prevalence of OAG or ocular hypertension.

In summary, Latinos with a predominantly Mexican ancestry in Los Angeles have rates of OAG comparable to those of US blacks and significantly higher than those seen in non-Hispanic whites. In addition, Latinos have a comparably high prevalence of ocular hypertension. If our data are generalizable to all Latinos in the US, it is estimated that over 410 000 Latinos may have OAG and over 301 000 may have ocular hypertension in one or both eyes. Of those 410 000 Latinos, an estimated 310 780 will have undiagnosed OAG. Further, given that Latinos are the fastest-growing segment of the US population and given the expected increase in the life expectancy and aging of the Latino population, it is likely that there will be an increase in the number of Latinos with OAG. Finally, the high rate of undiagnosed OAG in Latinos suggests that the role of early screening, diagnosis, and management should be further examined.

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