

The Prevalence of Glaucoma in Chinese Residents of Singapore

A Cross-Sectional Population Survey of the Tanjong Pagar District

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Background: Data on prevalence of glaucoma in East Asia are scarce.

Objective: To determine the prevalence and clinical characteristics of glaucoma in adult Chinese Singaporeans.

Methods: A group of 2000 Chinese people, aged 40 to 79 years, were selected from the electoral register of Tanjong Pagar district in Singapore using a disproportionate, stratified, clustered, random-sampling procedure. Glaucoma was diagnosed in people with an excavated optic neuropathy and a reproducible visual field defect or on the basis of severe structural disc abnormality alone, if reliable field results could not be obtained. The diagnosis was also made in blind subjects with raised intraocular pressure or previous glaucoma surgery.

Results: Of 1717 eligible subjects, 1232 were examined, with a response rate of 71.8%. There were 45 cases of glaucoma: 27 were men and 18 were women. The main diagnoses were primary open-angle glaucoma (n=22 [49%]), primary angle-closure glaucoma (n=14 [31%]), and secondary glaucoma (n=7 [16%]). It was not possible to determine the mechanism in 2 (4%).

Conclusions: The age-standardized prevalence of glaucoma was 3.2% (95% confidence interval, 2.3-4.1) in the population 40 years and older. Glaucoma was the leading cause of blindness. Primary angle-closure glaucoma and secondary glaucoma were the most visually destructive forms of the disease. Our findings suggest current projections of glaucoma prevalence among ethnic Chinese are a substantial underestimate.

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GLAUCOMA IS believed to be the leading cause of surgically irremediable blindness worldwide.^{1,2} East Asians account for almost half of the world's estimated 67 million glaucoma sufferers.² However, this figure is based on results of a small number of studies, several of which have suffered from poor response rates or unsophisticated diagnostic methods.³ These factors have made reliable data on glaucoma prevalence in Asia a pressing priority in ophthalmic public health research.

It is believed that Sino-Mongolian people are more susceptible to primary angle-closure glaucoma (PACG) than primary open-angle glaucoma (POAG).⁴⁻⁶ However, comparison of POAG and PACG rates as indicators of visual morbidity in a population is confounded by differing diagnostic criteria. Decreased visual function has not been an absolute requirement for diagnosis of PACG, as it is for

POAG. This distinction is important for several reasons. First, POAG (and PACG causing optic neuropathy) rely on sophisticated psychophysical (visual field) testing to reach an unequivocal diagnosis. A substantial investment in infrastructure and staff training is therefore required to detect and treat early and moderately severe cases. Second, in early stages of the disease, treatment may differ significantly. It is believed that laser iridotomy will prevent the onset of PACG in many susceptible individuals⁷; POAG requires protracted medical therapy. Furthermore, data on the rate of glaucomatous visual loss are essential to assign priorities for community and hospital resources.

We therefore intended to estimate the prevalence of glaucoma causing visual loss, to enumerate those potentially at risk, and determine the predominant form of glaucoma in ethnic Chinese people aged 40 years and older resident in a district of Singapore.

SUBJECTS AND METHODS

STUDY POPULATION AND RECRUITMENT

This study was carried out in accordance with the World Medical Association's Declaration of Helsinki. Singapore has a population of 3.2 million, 78% of whom are ethnic Chinese, with ancestry in the provinces of Fujian and Guangdong. The 2000 subjects aged 40 to 79 years residing in the Tanjong Pagar district were selected from the electoral register (13% of 15082), using a disproportionate, stratified, clustered, random-sampling procedure. As electoral registration is a legal requirement in Singapore, the register provides a complete record of all citizens aged 21 years and older. The demographic and socioeconomic characteristics of Tanjong Pagar are similar to those of Singapore as a whole. Five hundred people were drawn from each of 4 age strata: 40 to 49, 50 to 59, 60 to 69, and 70 to 79 years. The percentage of men and women were determined by the sex ratio of that age group in the district. A small number of subjects reached an age greater than 79 years between selection of the sample and examination. These people, aged 80 and 81 years, are included in a separate age category, although of a small number. All subjects were offered an examination in a research clinic setting. If they did not accept this offer, an attempt was made to assess them in their homes.

OPHTHALMIC EXAMINATION

Examinations were carried out in a research clinic or at the subject's home between October 10, 1997, and August 14, 1998. The following examination was performed on subjects seen at the research clinic. A logMAR chart (The Light-house, Long Island, NY) was used to measure best-corrected visual acuity using a subjectively refined refractive correction. A 26-point static, threshold-related suprathreshold visual field screening test was carried out with near-refractive correction (Henson CFA 3200; Tinsley Medical, Newbury Berks, England). This was extended to a 66-point test, if the initial test was graded "suspect" or "defect" by the instrument's classification algorithm. A screening-mode frequency doubling technology test (model 710, software version 1.2; Welch Allyn, Skaneateles Falls, NY) was performed with the subject's own available distance refractive correction if worn, and without correction if glasses were not worn.

A slitlamp (model BQ 900; Haag-Streit, Bern, Switzerland) was used to examine the anterior segment for evidence of secondary glaucoma and to detect the ischemic sequelae of primary angle-closure. Intraocular pressure was estimated using an applanation tonometer (Goldmann model; Haag-Streit). The cornea was anesthetized using 0.5% amethocaine hydrochloride mixed with 1 drop of 2%

sodium fluorescein (both Minims; Chauvin Pharmaceuticals, Romford, England). Three readings were made, and the median taken as the pressure for that eye. Gonioscopy was carried out using a Goldmann-type 1-mirror lens (model 902; Haag-Streit) at $\times 25$ magnification with low-ambient illumination. Angles were graded occludable or not occludable (see "Diagnostic Definitions" section).

The pupils of all subjects were dilated with 1% tropicamide (Alcon-Couvruer, Puurs, Belgium) and 2.5% phenylephrine hydrochloride (Alcon Laboratories, Fort Worth, Tex) drops. The optic disc was examined at the slitlamp through a fundus contact lens at $\times 40$ magnification. The vertical dimensions of the disc and cup were measured using an eyepiece graticule etched in 0.1-mm units (Measuring Eyepiece; Haag-Streit, Bern). Measurements of vertical disc diameter excluded areas of peripapillary atrophy and Elschning ring. The margins of the cup were defined by stereoscopic examination as the point of maximum inflexion of contour. The height of the cup was measured as the vertical distance between the points of maximal centrifugal extension of the cup between the 11- to 1-o'clock and the 5- to 7-o'clock positions. The narrowest portion of the neuroretinal rim was measured. The intraocular pressure (IOP) of all subjects was remeasured using a Tonopen (Mentor, Norwell, Mass) before they left the clinic. Subjects judged to have an occludable drainage angle were routinely given acetazolamide (500 mg by mouth) (Apotex, Toronto, Ontario) 2 hours after leaving and again at bedtime. All these subjects were instructed to return the following day or contact the emergency ophthalmic service if they suffered adverse symptoms.

Five tests were used to determine provisional glaucoma suspect status of an eye. These were visual field screening (Henson CFA 3200 field screener; Tinsley Medical, Newbury Berks, England) (suspect or defect category); frequency doubling technology test (≥ 3 locations showing mild relative loss or worse); applanation tonometry (IOP > 19 mm Hg); gonioscopy (occludable angle); and examination of the optic disc (cup-disc ratio [CDR], ≥ 0.71 ; CDR asymmetry, ≥ 0.21 ; or narrowest neuroretinal rim, < 0.1 of CDR). If either eye of a subject met any of these criteria, or the subject was unable to satisfactorily complete 1 of the tests, he or she was asked to return for a threshold visual field test (30-2 program) (instrument model 750; Humphrey Instruments, San Leandro, Calif), unless another explanation for test failure was identified. Of the normal subjects, 10% were also invited for testing. Any tests on the Humphrey machine graded unreliable or compatible with glaucoma were repeated.

HOME EXAMINATIONS

Home examination was offered to subjects who did not attend for a clinic examination. Visual acuity in each eye was measured using a 3-m Snellen chart, with distance

RESULTS

From 2000 subjects selected, 46 died and 235 were not residents or had moved to addresses outside Tanjong Pagar before the study period. Two persons were considered unfit to undergo examination. Therefore, 1717 subjects were considered eligible for this study and 1090 were examined in the clinic. One hundred sixty subjects were

examined in their homes, from 300 addresses visited; 18 underwent further examination in the clinic (13 of 18 were "glaucoma suspects"). Therefore, the response to recruitment was 63.5% (1090 of 1717) for the clinic-based assessment and 8.3% (142 of 1717) for only a home examination, giving a total of 71.8% (1232 of 1717). **Table 1** summarizes age and sex distribution of the subjects selected and examined.

spectacles if worn. If the visual acuity was less than 20/40, it was remeasured using a pinhole. The anterior segment was examined using a portable slitlamp (model 904; Clement Clarke, Harlow, England). The depth of the anterior chamber at the temporal limbus was estimated, and if less than 25% of corneal thickness was present, gonioscopy was performed. Intraocular pressure was measured in each eye using a Tonopen. Optic discs were examined through dilated pupils using the slitlamp and a +78 diopter lens (Volk, Mentor, Ohio) to grade the CDR (with reference to standard photographs) and narrowest width of the neuroretinal rim. All subjects were offered a follow-up examination in the research clinic. If subjects were classified as glaucoma suspects (on the same basis as clinic subjects) they were offered follow-up investigation and treatment.

DIAGNOSTIC DEFINITIONS

A threshold examination of the central 30° of visual field (30-2 program) showing a glaucoma hemifield test (GHT) outside normal limits and a cluster of 4 contiguous points on the pattern-deviation plot ($P < .5\%$ of occurrence in age-matched normal subjects) not crossing the horizontal meridian were considered compatible with glaucoma. Test reliability was determined by the instrument's algorithm (fixation losses, $<20\%$; false positives, $<33\%$; and false negatives, $<33\%$). Test results compatible with glaucoma were repeated and considered definite if the GHT and the identical 4 points on the pattern-deviation plot were reproduced in reliable tests.

The distribution of CDR in the nonglaucomatous population was calculated using people who passed both the conventional field screening and the frequency doubling technology tests, or those who did not pass either test, but then completed a reliable 30-2 threshold field examination with a GHT within normal limits. This therefore represents a "hypernormal" population. Glaucoma was diagnosed as follows: (1) Category 1 diagnosis (structural and functional evidence): eyes with a CDR or CDR asymmetry at the 97.5th percentile or greater for the normal population, or a neuroretinal rim width reduced to 0.1 CDR or less (between 11- to 1-o'clock and 5- to 7-o'clock positions) that also showed a definite visual-field defect consistent with glaucoma. (2) Category 2 diagnosis (advanced structural damage): if the subject could not satisfactorily complete visual field testing but had a CDR or CDR asymmetry at the 99.5th percentile or greater for the normal population, glaucoma was diagnosed solely on the structural evidence. (3) Category 3 diagnosis (optic disc not seen): if it was not possible to examine the optic disc, glaucoma was diagnosed if the visual acuity was perception of light or worse and the IOP 21 mm Hg or more or the eye was classified as blind and showed evidence of glaucoma filtering surgery; or medical records were available confirming glaucomatous visual morbidity.

Glaucoma suspects were categorized as follows: (1) disc suspects (those who met category 1 [but not category 2] disc criteria, but were not proven to have definite field defects); (2) field suspects (those with definite field defects, but not meeting category 1 disc criteria); (3) those with optic disc margin hemorrhages; (4) those with an IOP of 22 mm Hg or greater; and (5) those with an occludable drainage angle (defined as one in which the pigmented/posterior trabecular meshwork could be seen for $<90^\circ$ of the angle circumference).

This diagnostic scheme is a prototype of that developed by the Working Group for Defining Glaucoma of the International Society of Geographical and Epidemiological Ophthalmology (R. Buhrmann, MD, MPH, P.J.F., G.J.J., and H. Quigley, MD, for the Working Group for Defining Glaucoma, unpublished data). The mechanism of glaucoma was determined by findings on gonioscopy and examination of the anterior segment. Subjects with an occludable drainage angle (defined above) and glaucoma (categories 1, 2, or 3) were classified as having PACG. People with evidence of secondary pathologic processes (eg, iris neovascularization) and glaucoma (categories 1, 2, or 3) were said to have secondary glaucoma. Those subjects with an open, normal drainage angle and no secondary pathologic processes were said to have POAG. Other cases, in which it was difficult to accurately assess the underlying cause of the glaucoma, were termed unclassifiable.

Blindness was defined as a best-corrected LogMAR visual acuity of worse than 1.3 or, for subjects seen during home visits, a Snellen visual acuity of less than 10/200 using a pinhole or the subject's own spectacles. Constriction of the visual field to less than 10° from fixation was also accepted as defining blindness.

STATISTICAL METHODS

Age-specific observed prevalence in men and women was calculated using the number of subjects meeting category 1, 2, or 3 case definitions as the numerator and the number of subjects examined as the denominator. Incomplete response for confirmatory visual field testing prejudiced the number of subjects meeting the category 1 criteria. Therefore, an adjusted prevalence was calculated on the assumption that subjects with discs meeting category 1 (but not category 2) criteria who did not attend for all confirmatory examinations had an identical rate of visual field defects. Confidence intervals (CIs) were calculated for age-specific prevalence figures assuming a Poisson distribution.⁸ Rates of glaucoma and blindness in subjects seen at the clinic and on home visits were compared using logistic regression, correcting for differences in age and sex between the groups.⁹ Population prevalence figures were calculated by direct age and sex standardization to the 1997 Chinese population of Singapore.

Table 2 gives details of the CDR parameters in right and left eyes with normal visual field used to allocate category 1 and 2 diagnoses. Among 91 people with category 1 discs, 54 (59%) completed all necessary field testing. From this number, 15 (28%) of 54 had a field defect. There were 37 clinic subjects and 10 subjects seen at their homes ($n=47$) who met category 1 disc criteria but did not complete field testing. An adjusted prevalence of glau-

coma was calculated, giving a 28% weighting to the cases after stratification by age and sex. This assumes that 13 (28%) of these 47 subjects would have produced visual field test results meeting category 1 specifications.

Forty-five individuals had glaucoma: 22 (49%) with POAG, 14 (31%) with PACG, 7 (15%) with secondary glaucoma (3 neovascular, 2 lens-related, 1 uveitic, and 1 posttraumatic), and 2, unclassifiable.

Table 1. Demographics of Subjects Selected and Examined

	Age, y								Total
	40-49		50-59		60-69		70-81		
	Men	Women	Men	Women	Men	Women	Men	Women	
Died*	1	0	3	2	5	8	17	10	46
Moved from area*	37	29	30	29	23	19	22	46	235
Unsuitable for examination*	0	0	0	0	1	0	1	0	2
Refused examination	27	31	19	33	16	31	18	34	209
Did not attend†	39	40	34	44	31	31	22	35	276
Examined									
Home	4	11	9	13	20	26	27	32	142
Home and clinic	0	1	2	1	2	3	5	4	18
Clinic	121	139	106	175	151	141	110	129	1072
Eligible subjects examined, %	65.4	68.0	68.8	71.0	78.6	73.3	78.0	70.5	71.8
Subtotal for sex	229	251	203	297	249	259	222	290	
Total for Age	480		500		508		512		2000

*Excluded from study.

†Agreed to examination when contacted by social worker or community volunteer, but did not attend the examination appointment.

Table 2. Cup-Disc Ratio in Subjects With Normal Visual Fields*

	Cup-Disc Ratios			Left to Right Asymmetry
	Right	Left	Right and Left	
Cup-disc ratio measurements, No.	840	843	1683	762
Satisfactory field test completed, No.	834	835	1669	755
Percentiles				
0.5th	0.01	0.11	0.08	-0.29
2.5th	0.19	0.23	0.21	-0.16
Median	0.46	0.48	0.47	0.01
97.5th	0.69	0.71	0.71	0.21
99.5th	0.80	0.83	0.81	0.32

*Defined as those either passing both the conventional and FDT Visual Field Instrument field screening test, or failing either test and then completing a reliable 30-2 threshold test, with a glaucoma hemifield test within normal limits.

Table 3. Mechanism of Glaucoma and Demographics of Cases*

Diagnosis	Sex Ratio, M:F	Median Age, y (Range)	Diagnostic Category			Blind in at Least 1 Eye, No. † (% of Total)	Previously Diagnosed, No. (%)
			1	2	3		
POAG	15:7	70 (45-81)	9	13	0	6 (27)‡	2 (9)
PACG	5:9	74.5 (51-81)	3	8	3	7 (50)	10 (71)
Secondary	6:1	72 (63-78)	1	2	4	5 (71)	4 (57)
Others	1:1	75.5 (74-77)	1	1	0	1 (50.0)	1 (50)
Total	27:18	74 (45-81)	14	24	7	19 (42)	17 (37.7)§

*M indicates male; F, female; POAG, primary open-angle glaucoma; and PACG, primary angle-closure glaucoma.

†Meeting diagnostic categories 3, 4, and 5 in the worst eye. Determined using International Classification of Diseases, Ninth Revision (ICD-9). From: World Health Organization. International Classification of Diseases, Ninth Revision (ICD-9). Geneva, Switzerland: World Health Organization; 1977.

‡One person with unilateral POAG was blind in the contralateral eye from diabetic retinopathy and was not included in this table.

§Percentage indicates total percentage of all subjects included in the study.

Ischemic sequelae of angle-closure were seen in 6 (43%) of 14 cases of PACG. All these people had been in contact with hospital ophthalmic services previously. Three were blind in both eyes, and 1 was unilaterally blind. Among the PACG patients without signs of iris ischemia, 5 of 8 cases had been previously diagnosed. Two of these people were blind in both eyes, and 1 was unilaterally blind. The difference in rates of

blindness in at least 1 eye between the ischemic and nonischemic cases of PACG was not significant (4 of 6 vs 3 of 8, respectively) ($P = .59$, Fisher exact test). **Table 3** gives the demographic characteristics of people with glaucoma and relative rates of blindness. The rate of unilateral blindness for those with PACG (50%) was approximately double that for those with POAG (27%).

Table 4. Prevalence of All Glaucoma by Age and Sex*

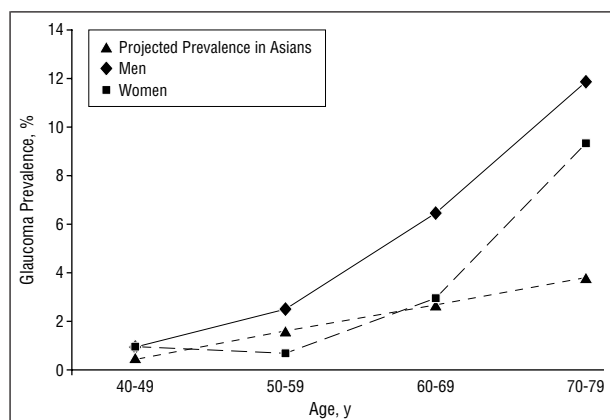
Age, y	Men					Women				
	Diagnostic Category			Rate per 100 (95% CI)†		Diagnostic Category			Rate per 100 (95% CI)†	
	1	2	3	Observed‡	Adjusted§	1	2	3	Observed‡	Adjusted§
40-49	0	1	0	0.8 (0.02-4.6)	1.0 (0.02-4.5)	0	0	0	0 (0.0-2.4)	1.1 (0.2-4.8)
50-59	2	0	0	1.7 (0.2-6.2)	2.7 (0.5-7.5)	1	0	0	0.5 (0.01-2.9)	0.8 (0.1-3.8)
60-69	3	4	2	5.2 (2.4-9.9)	6.6 (3.6-12.1)	2	0	1	1.8 (0.4-5.2)	3.1 (1.0-6.9)
70-79	3	9	3	11.5 (6.4-18.9)	12.0 (7.0-19.8)	3	8	1	7.8 (4.0-13.6)	9.5 (5.5-16.1)
≥80	0	0	0	0 (0.00-33.5)	10.6 (0.2-50.7)	0	2	0	18.2 (2.2-65.7)	18.2 (2.2-65.7)
Total	8	14	5			6	10	2		

*CI indicates confidence interval.

†The 95% CIs were calculated assuming a Poisson distribution.

‡Observed rate calculated as the number of cases detected per number of cases examined.

§Adjusted rate assumes 28% of category 1 disc subjects with incomplete field testing had glaucoma.



The prevalence of glaucoma in Chinese Singaporeans in 4 decades. The estimated glaucoma prevalence in Asians was derived from the statistical model of Quigley.²

Table 4 summarizes the number and diagnostic category of glaucoma cases, giving age- and sex-specific rates of disease. The observed prevalence of glaucoma was calculated as 2.2% (95% CI, 1.4-2.9). Adjusting for those who did not complete field testing gave a prevalence of 3.2% (95% CI, 2.3-4.1). The **Figure** shows the increasing prevalence of glaucoma with age in men and women. The observed prevalence of POAG was 1.2% (95% CI, 0.6-1.8); adjusted prevalence, 2.4% (95% CI, 1.6-3.2).

The overall rate of glaucoma and suspect glaucoma, including cases diagnosed as category 3 cases, was 18.3% (95% CI, 15.8-20.7). **Table 5** gives age- and sex-specific rates of the abnormal features of examination associated with glaucoma. There were 56 people who were blind in at least 1 eye; 10 were blind in both eyes. Glaucoma was the leading cause of unilateral and bilateral blindness, affecting 19 (34%) and 6 (60%) people, respectively. The causes of blindness are detailed in **Table 6**. The age-standardized prevalence of unilateral blindness in the population was 2.6% (95% CI, 1.9-3.4); bilateral blindness, 0.41% (95% CI, 0.15-0.67).

The 160 subjects initially examined on home visits (including the 18 people later seen in the clinic) were significantly older ($P < .001$) than the 1072 clinic-only examinees. There was no significant difference in sex be-

tween the 2 groups ($P = .44$). After allowing for age differences, the people seen at home were more likely to be blind in at least 1 eye ($P = .008$) and more likely to be diagnosed as having glaucoma ($P = .002$). Two hundred sixty-five people (21.5%) had heard of glaucoma: 245 (22%) among the clinic subjects and 20 (15%) of subjects seen at home. Significantly less subjects seen at home had heard of glaucoma, compared with the people attending the clinic examination ($P = .03$).

COMMENT

Hospital data from Singapore in the 1960s found that PACG cases in an eye clinic outnumbered POAG cases by a ratio of 4.5:1.¹⁰ A later report gave similar findings, and determined that glaucoma was the leading cause of registered blindness between 1953 and 1966.¹¹ Although the prevalence of bilateral blindness in our study population was low (0.4%), we too found that glaucoma was the leading cause of blindness (60%). Primary open-angle glaucoma was associated with a lower rate of unilateral blindness (27%) than was PACG (50%) and secondary glaucoma was the most visually destructive form of glaucoma (71% were blind in at least 1 eye).

The observed prevalence of glaucoma of 2.2% in the population 40 years and older does not seem particularly high. However, the marked increase in prevalence with age suggests glaucoma is a major problem in elderly persons. We believe the observed prevalence rate represents a minimum estimate. The adjusted prevalence of 3.2% is probably not an overestimate. This view is supported by the finding that the subjects seen at home (initially defaulting recruitment) had a higher rate of disease than clinic respondents. It also underlines the fact that those who did not take up the offer of free eye care services were those more likely to have glaucoma.

The age- and sex-specific population-based data on the prevalence of all forms of glaucoma among persons of European,¹² East Asian,¹³ and African^{12,14} descent are summarized in **Table 7**. After adjustment for age and sex (using the Chinese population of Singapore as the standard), the lowest prevalence was found among the

Table 5. Observed Prevalence of Glaucoma and Suspected Glaucoma by Age and Sex*

Age, y	Abnormal Feature, Rate per 100								Total¶ (95% CI)	
	Disc†		Field‡		IOP§		Gonioscopy			
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
40-49	4.0	4.7	1.6	2.0	2.4	1.3	1.6	2.0	8.8 (3.7-13.8)	9.2 (4.6-13.9)
50-59	11.1	5.8	4.3	2.1	4.3	3.7	6.0	10.0	20.5 (13.2-27.8)	19.0 (13.4-24.7)
60-69	12.2	10.1	11.6	4.1	6.4	3.6	10.4	13.6	32.3 (25.4-39.3)	26.6 (20.3-33.0)
70-79	20.0	13.5	5.3	5.2	6.9	7.7	9.2	16.8	35.4 (27.1-43.6)	32.9 (25.5-40.3)
≥80	8.3	45.5	0	0	0	9.1	8.3	18.2	16.7 (0-40.1)	54.5 (21.5-87.6)

*IOP indicates intraocular pressure; CI, confidence interval.

†Vertical cup-disc ratio ≥97.5th percentile, or asymmetry of cup-disc ratio ≥97.5th percentile, of persons with normal visual fields.

‡A glaucoma hemifield test result outside normal limits, with a 4-point hemifield cluster defect reproduced at least twice in reliable 30-2 threshold field tests.

§An IOP greater than 21 mm Hg in the eye with the highest pressure estimate.

||Persons with occludable drainage angles detected on gonioscopic examination, including treated cases (laser or surgical peripheral iridotomy).

¶All persons with suspected glaucoma or glaucoma.

Table 6. Causes of Blindness

	One or Both Eyes, No. (%)	Both Eyes No. (%)
Glaucoma	19 (34)	6 (60)
Cataract (unoperated)	11 (20)	1 (10)
Age-related macular degeneration	7 (12)	2 (20)
Cataract (operated)	5 (9)	1 (10)
Degenerative myopia	5 (9)	0 (0)
Other retinal causes	3 (5)	0 (0)
Others	6 (11)	0 (0)
Total	56 (100)	10 (100)

Table 7. Age-Specific Prevalence of Glaucoma in Selected Population-Based Studies

Study Population Age, y	Baltimore* (Whites) ¹²		Mongolia ⁶		Japan ¹³ †		Singapore‡		Baltimore* (Blacks) ¹²		Barbados§ (Blacks) ⁵	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
40-49	0.4	0.0	0.0	0.8	1.5	1.0	1.0	1.1	2.6	1.2	2.3	1.2
50-59	0.7	0.9	1.7	1.9	2.5	2.8	2.7	0.8	4.6	5.0	4.7	4.0
60-69	1.6	2.2	7.4	4.8	5.0	4.9	6.6	3.1	9.5	5.7	11.2	5.7
70-79	4.1	3.6	12.5	0.0	8.0	8.2	12.0	9.5	10.0	11.5	20.1	14.7
≥80	5.6	3.6	0.0	16.7	13.1	9.1	10.6	18.2	23.5	7.5	25.8	23.9
Age-standardized prevalence	1.1	1.1	2.5	2.2	3.1	3.2	3.4	2.9	5.1	4.2	6.1	4.6
Age- and sex-standardized prevalence	1.1		2.4		3.1		3.2		4.7		5.3	

*Additional unpublished data from J. M. Tielsch, PhD, 1999.

†Additional unpublished data from Y. Shiose, MD, 1999.

‡Adjusted for nonresponse to complete visual field testing.

§Additional unpublished data from M. C. Leske, MD, MPH, 1999.

||Direct standardization to the Chinese population of Singapore, ending June 1997.

European-derived population of East Baltimore,¹² at 1.1% among the population 40 years and older. East Asians in Japan,¹³ Mongolia,⁶ and Singapore have a prevalence 2.5 to 3 times higher. The highest prevalence occurs among people of African origin.^{12,14}

Quigley² used population-based data to construct mathematical models of glaucoma prevalence in African, Asian, and European people. East, Southeast, and South Asians were considered as a single group because of the lack of specific data on each. However, the model assumes a linear increase in prevalence with age; our study

shows the increase to be nonlinear. The prevalence of glaucoma at age 55 years is correctly predicted, but there was a substantial underestimate at age 75 years (actual, 11.2%; projected, 4.0%). We believe current figures underestimate glaucoma morbidity in East Asians, as illustrated in the Figure. The increasing longevity in the region that is likely to accompany current economic development will only serve to exacerbate this.

Our finding that glaucoma is the major cause of blindness among Chinese Singaporeans aged 40 years and older suggests that this condition should be the focus of

public health initiatives. Primary open-angle glaucoma is the predominant form of the disease; PACG and secondary glaucoma were less frequent but accounted for most glaucoma blindness. Population screening for POAG is not currently considered a viable proposition; however, screening for PACG shows more promise.¹⁵⁻¹⁷ As only one fifth of the population has heard of glaucoma, raising public awareness of the risk of blindness from the disease, particularly that associated with PACG, is a major priority in Singapore. However, intensive follow-up of the large number of glaucoma suspects would probably swamp health care services. Therefore, further data on the natural history of glaucoma in East Asians are urgently needed to accurately target resources on those at greatest risk.

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