WORLD VIEW

The number of people with glaucoma worldwide in 2010 and 2020

H A Quigley, A T Broman

Br J Ophthalmol 2006;**90**:262–267. doi: 10.1136/bjo.2005.081224

See end of article for authors' affiliations

Correspondence to: Harry Quigley, Wilmer 122, Johns Hopkins Hospital, 600 N Wolfe Street, Baltimore, MD 21287, USA; hquigley@jhmi.edu

Accepted for publication 2 October 2005

Aim: To estimate the number of people with open angle (OAG) and angle closure glaucoma (ACG) in 2010 and 2020.

Methods: A review of published data with use of prevalence models. Data from population based studies of age specific prevalence of OAG and ACG that satisfied standard definitions were used to construct prevalence models for OAG and ACG by age, sex, and ethnicity, weighting data proportional to sample size of each study. Models were combined with UN world population projections for 2010 and 2020 to derive the estimated number with glaucoma.

Results: There will be 60.5 million people with OAG and ACG in 2010, increasing to 79.6 million by 2020, and of these, 74% will have OAG. Women will comprise 55% of OAG, 70% of ACG, and 59% of all glaucoma in 2010. Asians will represent 47% of those with glaucoma and 87% of those with ACG. Bilateral blindness will be present in 4.5 million people with OAG and 3.9 million people with ACG in 2010, rising to 5.9 and 5.3 million people in 2020, respectively.

Conclusions: Glaucoma is the second leading cause of blindness worldwide, disproportionately affecting women and Asians.

Public health planning requires accurate estimation of disease burden for major disorders. We previously estimated the number with open angle glaucoma (OAG) and angle closure glaucoma (ACG),[1] but since then, further surveys have appeared.[2–25] In addition, a standardised definitional structure of OAG and ACG was proposed to compare prevalence in glaucoma studies.[26] We estimate the number with OAG and ACG for 2010 and 2020 using prevalence models constructed by age, sex, and ethnicity.

METHODS

Age and sex specific population projections by 5 year grouping of adults over age 40 years were obtained (http://esa.un.org). We selected the dominant ethnic group for each of eight regions: (1) Middle East/North Africa group (Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iraq, Jordan, Kuwait, Lebanon, Palestine, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen, Algeria, Egypt, Libya, Morocco, Sudan, Tunisia, Western Sahara); (2) European derived group (Europe including Russian Federation and Ukraine, Bermuda, Canada, Greenland, United States, Australia, New Zealand, Israel); (3) Latin American group (Mexico, Central and South America); (4) African group (countries south of the Sahara, excluding North African states included in Middle East/North Africa, but including the Caribbean States); (5) South East Asia group (Oceania, Brunei, Cambodia, Indonesia, Laos, Malaysia, Burma, Philippines, Singapore, Thailand, Vietnam); (6) Indian group (Afghanistan, Bangladesh, Bhutan, India, Iran, Kazakhstan, Kyrgyzstan, Maldives, Nepal, Pakistan, Sri Lanka, Tajikistan, Turkmenistan, Uzbekistan); (7) China group (China, Hong Kong, Macao, North Korea, South Korea, Mongolia); and (8) Japan.

The literature search yielded 2158 items, including 111 reports identified before 1995.[1] Included studies satisfied the following criteria: (1) random population based sampling; (2) >50% examination rate; (3) >50% had visual field testing; (4) disc evaluation by an ophthalmologist; (5) definition of OAG independent of intraocular pressure (IOP); (6) definition of ACG compatible with Foster *et al*[26]; and (7) definition of glaucoma included both optic disc and visual field damage. Thirty four studies satisfied the criteria (new studies since 1995.[2–25] and 11 studies included in previous report[27–37]).

Ten studies included previously[1] were excluded, owing to: (1) no population based sample[38–40]; (2) majority not visual field tested[41–44]; or (3) IOP level used to define OAG.[45–47] Normal tension glaucoma and exfoliation syndrome were included as OAG. We included "definite" and "probable" cases as OAG.

The age specific prevalence for the eight population groups was derived by regional models separately for OAG and ACG. The reports used were: Europe OAG,[2 3 7 12 15 24 27 28 30 31 32 34 35] Europe ACG,[5 7 27 28 30 32 35] Africa OAG,[6 19 20 29 33 35] Africa ACG (Europe estimate used), India OAG,[8 14 17 18 22] India ACG,[9 14 17 23] China and South East Asia OAG,[4 10 11] China and South East Asia ACG,[4 10 11 37] Japan OAG,[13 25 36] Japan ACG,[36] Latin America OAG,[16 21] Latin America ACG (Europe estimate used), and Middle East/North Africa OAG and ACG (Europe estimates used).

We assessed age specific prevalence with generalised estimating equations (GEE), assuming a binomial probability distribution to model prevalence, and exchangeable correlation structure,[48] accounting for different number of people among studies. For the Japan ACG group with only one study, a logistic regression model was used. The logit estimate from the GEE or logistic regression models was used to estimate age specific prevalence rates and upper and lower 95% confidence intervals. Prevalence was set to zero at age 35.

The age specific prevalence by region was multiplied by the number of people estimated in each 5 year age group to give the total number with OAG and ACG. For OAG, there was no preponderance of evidence that prevalence was related to sex.

Abbreviations: ACG, angle closure glaucoma; GEE, generalised estimating equations; IOP, intraocular pressure; LCL, lower confidence limit; OAG, open angle glaucoma; UCL, upper confidence limit

For ACG, women were more often affected and the sex adjustment for ACG cases varied regionally (male/female ratio) as follows: Africa = 7/17, Europe = 3/15 (used for Latin America and Middle East), China = 11/17 (used for South East Asia and Japan), and India = 1/3.

The ACG prevalence model for European people was constructed from seven available studies. This model was also applied to Latin America, Africa, and Middle East.

Glaucoma blindness was estimated from proportions suggested by Foster *et al*[49]—that is, 10% of those with OAG and 25% of those with ACG were assumed to be bilaterally blind.

RESULTS

The average percentage of people examined among those in the selected sample was 80.9% (10.3%) (mean (SD); 32 studies). The percentage known to have glaucoma before survey was 26.0% (21.5%) for OAG (n = 25 studies) and 28.6% (38.4%) for ACG (n = 7). The OAG previous diagnosis rate in developed countries was 34%, while in developing countries it was 8%. The previous ACG diagnosis rate was 67% in developed countries and 0.1% in developing countries.

OAG was most prevalent among African derived people (fig 1). In both Latin American and Chinese regions, prevalence approached that of African people in the oldest age groups. OAG prevalence for Indian, European, and Japanese people was lower and similar to each other. ACG prevalence was highest among Chinese people, intermediate in Japanese, and lower in Europeans and Indians (fig 2). The model confidence limits were relatively narrow for the Africa OAG group (fig 3), while India ACG confidence limits were wider (fig 4).

The estimated number with both OAG and ACG was 60.5 million for 2010 (95% CI: 44.4, 85.4 million; table 1). The largest absolute number with OAG and ACG was in China, followed by Europe and India. Africa had the highest ratio of glaucoma to adult population, followed by Japan and Latin America. Regions with many affected by glaucoma had either higher prevalence (Africa, Japan), proportionately more older people (Europe), or both (China, India).

The absolute number with OAG in 2010 was highest among European derived people (table 2). The European group represented 23.9% of those with OAG worldwide, while Asian regions had 47% of OAG people.

The greatest number with ACG in 2010 were in China (47.5% of the total), and 86.5% of those affected by ACG were in Asia (table 3). In 2010, 74.0% of those with glaucoma had OAG and 26.0% had ACG (95% CI OAG: 70.4% to 76.4% and ACG: 23.6% to 29.6%).

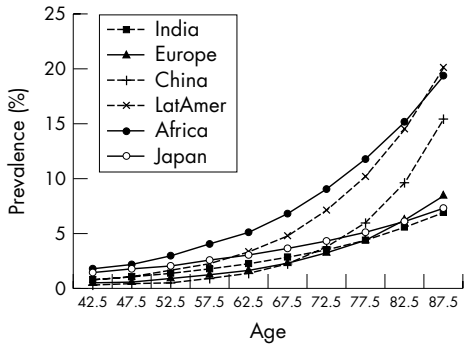

Figure 1 The prevalence model data showing age specific prevalence of open angle glaucoma (OAG) for the six major ethnic groups (as defined in Methods) among whom qualifying studies have been performed. Prevalence is highest among the African and Latin American groups.

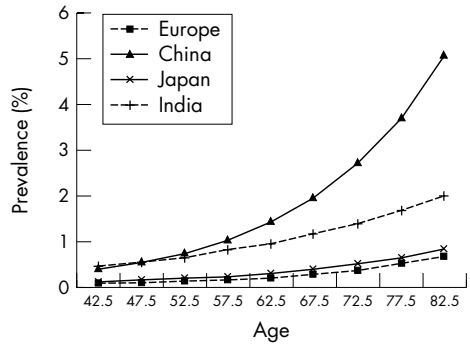

Figure 2 Prevalence model data for the age specific prevalence of angle closure glaucoma (ACG), highest in the China group, second highest among Japanese, and lowest in European and Indian groups (as defined in Methods).

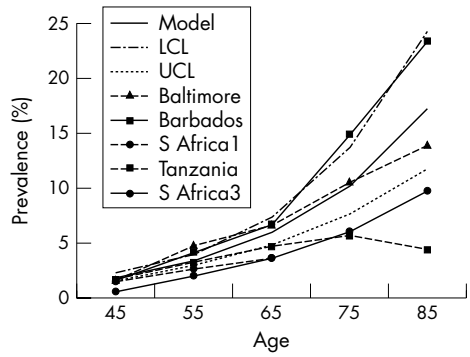

Figure 3 Prevalence model for Africa group: open angle glaucoma (OAG) data are relatively closely grouped among the studies in age specific prevalence. This, combined with the relatively large number of studies of this ethnicity, results in narrow confidence limits for the prevalence estimates (only five of six qualifying studies are shown). (LCL, UCL = lower and upper 95% confidence limit of model estimate, respectively).

We found that the mean prevalence for OAG worldwide in 2010 was 1.96%, while that for ACG was 0.69% (table 4). Women were disproportionately affected by glaucoma, representing 59.1% of all people with glaucoma (95% CI: 59.0% to 59.2%), substantially more than the 51.5% of the world population over age 40 that will be female in 2010. For

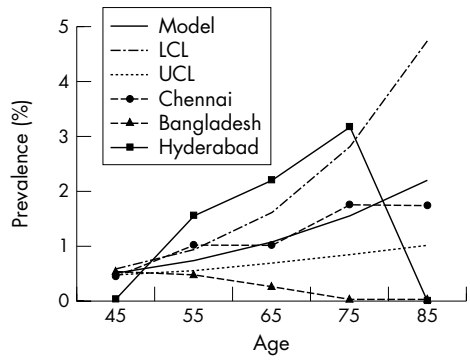

Figure 4 Data for India group and its prevalence model: angle closure glaucoma (ACG) prevalence shows large differences among the three studies shown, with consequently wide confidence limits for the model prevalence estimate. (LCL, UCL = lower and upper 95% confidence limit of model estimate, respectively).

Table 1 Number of people with OAG and ACG combined, 2010

World region	Total glaucoma	Lower CL	Upper CL	Total population >40	Ratio glaucoma to population >40	Lower CL	Upper CL
China	15,782,196	11,114,702	23,640,340	593,278,000	2.66%	1.87%	3.98%
Europe	12,064,740	8,910,048	16,475,405	541,993,000	2.23%	1.64%	3.04%
India	11,944,896	9,443,597	15,447,556	468,426,000	2.55%	2.02%	3.30%
Africa	6,458,023	5,227,245	7,979,655	149,408,000	4.32%	3.50%	5.34%
Latin America	5,677,158	3,252,201	10,035,372	169,215,000	3.35%	1.92%	5.93%
SE Asia	4,257,620	2,990,848	6,432,503	178,899,000	2.38%	1.67%	3.60%
Japan	2,662,446	2,278,345	3,154,376	72,007,000	3.70%	3.16%	4.38%
Middle East	1,618,718	1,171,439	2,268,907	110,094,000	1.47%	1.06%	2.06%
World	60,465,796	44,388,425	85,434,114	2,283,320,000	2.65%	1.94%	3.74%

Table 2 Number of people with OAG, 2010

	Total OAG	Lower CL	Upper CL	% World OAG
Europe	10,693,335	7,599,188	15,040,703	23.9
China	8,309,001	6,695,433	10,423,439	18.6
India	8,211,276	6,812,711	9,937,413	18.4
Africa	6,212,179	4,992,103	7,722,626	13.9
Latin America	5,354,354	2,943,534	9,697,792	12.0
Japan	2,383,802	2,106,534	2,697,623	5.3
SE Asia	2,116,036	1,744,523	2,580,354	4.7
Middle East	1,440,849	1,001,315	2,082,944	3.2
World	44,720,832	33,895,340	60,182,894	

Table 3 Number of people with ACG, 2010

	Total ACG	Lower CL	Upper CL	% World ACG
China	7,473,195	4,419,269	13,216,902	47.5
India	3,733,620	2,630,886	5,510,142	23.7
SE Asia	2,141,584	1,246,325	3,852,149	13.6
Europe	1,371,405	1,310,861	1,434,702	8.7
Latin America	322,804	308,667	337,581	2.1
Japan	278,643	171,811	456,753	1.8
Africa	245,844	235,143	257,029	1.6
Middle East	177,869	170,124	185,964	1.1
World	15,744,965	10,493,085	25,251,221	

Table 4 Percentage >40 years of age by region with OAG and ACG, 2010

OAG		ACG	
Africa	4.16%	China	1.26%
Japan	3.31%	SE Asia	1.20%
Latin America	3.16%	India	0.80%
Europe	1.97%	Japan	0.39%
India	1.75%	Europe	0.25%
China	1.40%	Latin America	0.19%
Middle East	1.31%	Africa	0.16%
SE Asia	1.18%	Middle East	0.16%
World	1.96%	World	0.69%

OAG, the greater number of women affected derived from their greater longevity. For ACG, both higher prevalence and greater longevity contribute to sex disproportion. Women comprised 55.4% of OAG (95% CI: 55.3% to 55.5%) and 69.5% of ACG (95% CI: 67.8% to 71.2%).

The bilateral blindness rate from all eye diseases including the glaucomas was 1.5% (1.8%) (n = 11 studies). In developed countries, 0.37% of adults over age 40 were blind (n = 6), compared to 4.2% in three African countries. The number estimated blind from OAG in 2010 was 4,472,083 (95% CI: 3,389,534 to 6,018,289) and from ACG 3,936,241 (95% CI: 2,623,271, to 6,312,805), for a combined total of 8,408,324 (95% CI: 6,012,805 to 12,331,095). While only 24% of those with primary glaucoma have ACG, the number of ACG blind is nearly equal to that of OAG because of the greater estimated morbidity of this disease.

Table 5 Number of people with OAG and ACG combined, 2020

World region	Total glaucoma	Lower CL	Upper CL	Total population >40	Ratio glaucoma to population >40	Lower CL	Upper CL
China	21,824,015	15,564,052	32,008,501	714,911,000	3.05%	1.64%	1.41%
India	16,088,243	12,661,836	20,921,034	610,439,000	2.64%	1.81%	0.82%
Europe	13,971,113	10,338,552	19,017,776	583,088,000	2.40%	2.13%	0.27%
Africa	8,359,451	6,744,779	10,360,282	190,366,000	4.39%	4.22%	0.17%
Latin America	8,011,575	4,625,900	14,035,093	222,238,000	3.60%	3.40%	0.20%
SE Asia	6,005,711	4,242,094	8,976,978	234,717,000	2.56%	1.29%	1.26%
Japan	3,084,669	2,620,687	3,686,374	77,968,000	3.96%	3.53%	0.43%
Middle East	2,295,407	1,663,614	3,210,499	151,907,000	1.51%	1.35%	0.17%
World	79,640,184	58,461,515	112,216,536	2,785,634,000	2.86%	2.11%	0.75%

Table 6 Number with OAG in 2020

	Total OAG	Lower CL	Upper CL	% World OAG
Europe	12,397,352	8,834,379	17,371,262	21.1
China	11,733,463	9,478,881	14,637,523	20.0
India	11,076,123	9,169,246	13,437,368	18.9
Africa	8,040,780	6,439,995	10,027,097	13.7
Latin America	7,559,113	4,193,288	13,561,883	12.9
SE Asia	3,039,376	2,497,186	3,715,897	5.2
Japan	2,749,598	2,417,389	3,127,327	4.7
Middle East	2,043,721	1,422,895	2,947,352	3.5
World	58,639,527	44,453,258	78,825,708	

For 2020, the model calculations show that OAG and ACG will increase by 20 million people over the decade (table 5).

By 2020, India will become second overall in number with glaucoma, surpassing Europe. There will be six million more Chinese people with glaucoma. In 2020, the Europe region will still contain the greatest number of people with OAG (table 6), and the proportion of all those with ACG that live in Asian regions will increase further to 87.6%. The total with OAG will be 58.6 million, while the number with ACG will rise to 21.0 million (table 7). The number estimated to be bilaterally blind from glaucoma in 2020 will increase to 11,114,117 (95% CI: 7,947,390 to 16,230,278), comprising 5,863,953 blind from OAG and 5,250,164 blind from ACG.

DISCUSSION

The present analysis more precisely estimates the number with glaucoma worldwide. By 2010, 60 million people will have OAG and ACG, and glaucoma will be the second leading cause of world blindness. These estimates could be improved with surveys from regions such as North Africa and the Middle East. OAG was estimated to affect 2.22 million people in the United States in 2002.[50] Our model predicts that there will be 2.79 million people with OAG in the United States in 2010. The difference may be explained by increases in the number of older people in the 8 year period and by differences in the models. Likewise, it was predicted that 9.4 million Chinese people had OAG and ACG in 2001.[49] Our models predict for 2010 that 9.2 million will have either OAG or ACG in China. We used only population based studies, defined OAG without regard to IOP level,[26] required both disc and field tests to define glaucoma, and compared the definitions reported to a standard definitional structure. Wolfs *et al* evaluated this definition for OAG,[51] determining that it was likely to specify those with definite disease. Failure to test the field can miss up to one third of those with OAG.[52] Disc examination alone is not specific enough and studies that use ''expert'' subjective assessment of disc and field may not be reproducible.[53–57] To permit comparison among studies, those who prefer expert assessment might report data by a standard method to place their work in perspective.

We divided the world into regions whose specific groupings could be criticised as arbitrary. The designation of a region as representing people derived from Africa understates the

Table 7 Number with ACG in 2020

	Total ACG	Lower CL	Upper CL	% World ACG
China	10,090,552	6,085,171	17,370,978	48.0
India	5,012,120	3,492,590	7,483,666	23.9
SE Asia	2,966,334	1,744,908	5,261,080	14.1
Europe	1,573,761	1,504,174	1,646,514	7.5
Latin America	452,462	432,612	473,211	2.2
Japan	335,071	203,299	559,047	1.6
Africa	318,671	304,784	333,185	1.5
Middle East	251,686	240,720	263,147	1.2
World	21,000,657	14,008,258	33,390,828	

variety of ethnicities making up each African nation state. Designations such as ''Hispanic'' may be sociocultural designations rather than definable entities. We did not subdivide populations within individual countries by ethnicity, since sensitivity analyses showed that world estimates would be affected little (data not shown).

Over 80% of those with ACG live in Asia, while OAG disproportionately affects those of African derivation. Women are more affected by glaucoma because of their greater prevalence of ACG, as well as their relatively greater longevity. Since women are estimated to have twice as much visual impairment and blindness overall compared to men,[58] more attention should be placed on the delivery of eye care services to women. From 2010 to 2020, the most detectable change in glaucoma worldwide will be its increase in India. As the proportion of those over age 40 increases, the proportional increase in glaucoma will challenge our resources and ingenuity.

Over 8.4 million people will be bilaterally blind from primary glaucoma in 2010, rising to 11.1 million by 2020. Previous estimates based on blindness prevalence surveys[58] suggested that 12% of world blindness (4.4 million people) was caused by glaucoma. The two estimates differ because of methodological issues. Blindness prevalence surveys often assign the most ''treatable'' disease as the primary cause of blindness. It is often assumed that cataract is more treatable than glaucoma. This leads to underestimation of glaucoma blindness.

In summary, glaucoma is second only to cataract among visual disorders. There are glaucoma treatments available in the developed world that reduce glaucoma disability. It is important to improve diagnostic and therapeutic approaches to OAG and ACG that can be applied worldwide.

ACKNOWLEDGEMENTS

The authors thank Karen Bandeen-Roche, PhD, for biostatistical consultation, and are appreciative of data shared by Paul Foster, Rupert Bourne, and L Vijaya.

Authors' affiliations

H A Quigley, A T Broman, The Glaucoma Service and the Dana Center for Preventive Ophthalmology, Wilmer Ophthalmological Institute, Baltimore, MD, USA

Supported in part by PHS Research Grants 02120 (Dr Quigley), 01765 (Core Facility Grant, Wilmer Institute), and the Leonard Wagner Trust, New York.

Competing interest: none declared

REFERENCES

1 **Quigley HA**. The number of persons with glaucoma worldwide. *Br J Ophthalmol* 1996;**80**:389–93.
2 **Anton A**, Andrada MT, Mujica V, *et al*. Prevalence of primary open-angle glaucoma in a Spanish population. The Segovia Study. *J Glaucoma* 2004;**13**:371–6.
3 **Bonomi L**, Marchini G, Marraffa M, *et al*. Prevalence of glaucoma and intraocular pressure distribution in a defined population. The Egna-Neumarkt Study. *Ophthalmology* 1998;**105**:209–15.
4 **Bourne RRA**, Sukudom P, Foster PJ, *et al*. Prevalence of glaucoma in Thailand: a population based survey in Rom Klao District, Bangkok. *Br J Ophthalmol* 2003;**87**:1069–74.
5 **Bonomi L**, Marchini G, Marraffa M, *et al*. Epidemiology of angle-closure glaucoma. Prevalence, clinical types, and association with peripheral anterior chamber depth in the Egna-Neumarkt glaucoma study. *Ophthalmology* 2000;**107**:998–1003.
6 **Buhrmann RR**, Quigley HA, Barron Y, *et al*. The prevalence of glaucoma in a rural east African population. *Invest Ophthalmol Vis Sci* 2000;**41**:40–8.
7 **Cedrone C**, Culasso F, Cesareo M, *et al*. Prevalence of glaucoma in Ponza, Italy: a comparison with other studies. *Ophthalmic Epidemiology* 1997;**4**:59–72.
8 **Dandona L**, Dandona R, Srinivas M. Open-angle glaucoma in an urban population in southern India. *Ophthalmology* 2000;**107**:1702–9.
9 **Dandona L**, Dandona R, Mandal P, *et al*. Angle-closure glaucoma in an urban population in Southern India. The Andra Pradesh Eye Disease Survey. *Ophthalmology* 2000;**107**:1710–16.
10 **Foster PJ**, Baasanhu J, lsbirk PH, *et al*. Glaucoma in Mongolia. A population-based survey in HÖvsgÖl Province, Northern Mongolia. *Arch Ophthalmol* 1996;**114**:1235–41.
11 **Foster PJ**, Oen FTS, Machin D, *et al*. The prevalence of glaucoma in Chinese residents of Singapore. A cross-sectional population survey of the Tanjong Pagar District. *Arch Ophthalmol* 2000;**118**:1105–11.
12 **Giuffre G**, Giammanco R, Dardanoni, *et al*. Prevalence of glaucoma and distribution of intraocular pressure in a population. The Casteldaccia Eye Study. *Acta Ophthalmol Scand* 1995;**73**:222–5.
13 **Iwase A**, Suzuki Y, Araie M, *et al*. The prevalence of primary open-angle glaucoma in Japanese. The Tajimi Study. *Ophthalmology* 2004;**111**:1641–8.
14 **Jacob A**, Thomas R, Koshi SP, *et al*. Prevalence of primary glaucoma in an urban South Indian population. *Indian J Ophthalmol* 1998;**46**:81–6.
15 **Mitchell P**, Smith w, Attebo K, *et al*. Prevalence of open-angle glaucoma in Australia. The Blue Mountains Eye Study. *Ophthalmology* 1996;**103**:1661–9.
16 **Quigley HA**, West SK, Rodriguez J, *et al*. The prevalence of glaucoma in a population-based study of Hispanic subjects. *Arch Ophthalmol* 2001;**119**:1819–26.
17 **Rahman MM**, Rahman N, Foster PJ, *et al*. The prevalence of glaucoma in Bangladesh: a population based survey in Dhaka division. *Br J Ophthalmol* 2004;**88**:1493–7.
18 **Ramakrishnan R**, Nirmalan RK, Krishnadas R, *et al*. Glaucoma in a rural population of southern India. *Ophthalmology* 2003;**10**:1484–90.
19 **Rotchford AP**, Kirwan JF, Muller MA, *et al*. Temba Glaucoma Study: a population-based cross-sectional survey in urban South Africa. *Ophthalmology* 2003;**110**:376–82.
20 **Rotchford AP**, Johnson GJ. Glaucoma in Zulus. A population-based cross-sectional survey in a rural district in South Africa. *Arch Ophthalmol* 2002;**120**:471–8.
21 **Varma R**, Ying-Lai M, Francis BA, *et al*. Prevalence of open-angle glaucoma and ocular hypertension in Latinos. The Los Angeles Latino Eye Study. *Ophthalmology* 2004;**111**:1439–48.
22 **Vijaya L**, *et al*. Prevalence of open-angle glaucoma in a rural South Indian population. (in preparation).
23 **Vijaya L**, *et al*. Prevalence of angle-closure glaucoma in a rural South Indian population. (in preparation).
24 **Wensor MD**, McCarty CA, Stanislavsky YL, *et al*. The prevalence of glaucoma in the Melbourne Visual Impairment Project. *Ophthalmology* 1998;**105**:733–9.
25 **Yoshida M**, Okada E, Mizuki N, *et al*. Age-specific prevalence of open-angle glaucoma and its relationship to refraction among more than 60,000 asymptomatic Japanese subjects. *J Clin Epidemiol* 2001;**54**:1151–8.
26 **Foster PJ**, Buhrmann R, Quigley HA, *et al*. The definition and classification of glaucoma in prevalence surveys. *Br J Ophthalmol* 2002;**86**:238–42.
27 **Bengtsson B**. The prevalence of glaucoma. *Br J Ophthalmol* 1981;**65**:46–9.
28 **Coffey M**, Reidy A, Wormald R, *et al*. Prevalence of glaucoma in the west of Ireland. *Br J Ophthalmol* 1993;**77**:17–21.
29 **David R**, Duval DON, Luntz MH. The prevalence and management of glaucoma in an African population. *S Afr Arch Ophthalmol* 1984;**10**:55–62.
30 **Dielemans I**, Vingerling JR, Wolfs RCW, *et al*. The prevalence of primary open-angle glaucoma in a population-based study in The Netherlands. *Ophthalmology* 1994;**11**:1851–5.
31 **Leibowitz HM**, Kreuger DE, Maunder LR, *et al*. The Framingham Eye Study Monograph. *Surv Ophthalmol* 1980;**24**(suppl):335–610.
32 **Klein BE**, Klein R, Sponsel WE, *et al*. Prevalence of glaucoma. The Beaver Dam Eye Study. *Ophthalmology* 1992;**99**:1499–1504.
33 **Leske MC**, Connell AMS, Schachat AP, *et al*. The Barbados Eye Study. Prevalence of open angle glaucoma. *Arch Ophthalmol* 1994;**112**:821–9.
34 **Ringvold A**, Blika S, Elsas T, *et al*. The Middle-Norway eye-screening study. II. Prevalence of simple and capsular glaucoma. *Acta Ophthalmol* 1991;**69**:273–80.
35 **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.
36 **Shiose Y**, Kitazawa Y, Tsukahara S, *et al*. Epidemiology of glaucoma in Japan—a nationwide glaucoma survey. *Jap J Ophthalmol* 1991;**35**:133–55.
37 **Congdon NG**, Quigley HA, Hung PT, *et al*. The impact of age, various forms of cataract and visual acuity on whole-field scotopic sensitivity screening for glaucoma in rural Taiwan. *Arch Ophthalmol* 1995;**113**:1138–43.
38 **Lindblom B**, Thorburn W. Prevalence of visual field defects due to capsular and simple glaucoma in Halsingland, Sweden. *Acta Ophthalmol* 1982;**60**:353–61.
39 **Gibson JM**, Rosenthal AR, Lavery J. A study of the prevalence of eye disease in the elderly in an English community. *Trans Opthalmol Soc UK* 1985;**104**:196–203.
40 **Bankes JLK**, Perkins ES, Tsolakis S, *et al*. Bedford Glaucoma Survey. *BMJ* 1968;**1**:791–6.
41 **Rouhiainen H**, Terasvirta M. Kuopio Eye Survey (KEYS). *Acta Ophthalmol* 1990;**68**:554–8.
42 **Mason RP**, Kosoko O, Wilson MR, *et al*. National survey of the prevalence and risk factors of glaucoma in St Lucia, West Indies. *Ophthalmology* 1989;**96**:1363–8.
43 **Hyams SW**, Keroub C, Pokotilo E. The computer in clinical research. Prevalence of glaucoma. *Doc Ophthalmol* 1977;**43**:17–21.
44 **Hollows FC**, Graham PA. Intra-ocular pressure, glaucoma, and glaucoma suspects in a defined population. *Br J Ophthalmol* 1966;**50**:570–86.
45 **Wallace J**, Lovell HG. Glaucoma and intraocular pressure in Jamaica. *Am J Ophthalmol* 1969;**67**:93–100.
46 **Neumann E**, Zauberman H. Glaucoma survey in Liberia. *Am J Ophthalmol* 1965;**59**:8–12.

47 **Martinez GS**, Campbell AJ, Reinken J, *et al*. Prevalence of ocular disease in a population study of subjects 65 years old and older. *Am J Ophthalmol* 1982;**94**:181–9.
48 **Katz J**, Zeger S, Liang KY. Appropriate statistical methods to account for similarities in binary outcomes between fellow eyes. *Invest Ophthalmol Vis Sci* 1994;**35**:2461–5.
49 **Foster PJ**, Johnson GJ. Glaucoma in China: how big is the problem? *Br J Ophthalmol* 2001;**85**:1277–82.
50 **Friedman DS**, Wolfs RC, O'Colmain BJ, *et al*. Prevalence of open-angle glaucoma among adults in the United States. *Arch Ophthalmol* 2004;**122**:532–8.
51 **Wolfs RC**, Borger PH, Ramrattan RS, *et al*. Changing views on open-angle glaucoma: definitions and prevalences—the Rotterdam Study. *Invest Ophthalmol Vis Sci* 2000;**41**:3309–21.
52 **Tielsch JM**, Katz J, Singh K, *et al*. A population-based evaluation of glaucoma screening: the Baltimore Eye Survey. *Am J Epidemiol* 1991;**134**:1102–10.
53 **Klein BEK**, Magli YL, Richie KA, *et al*. Quantitation of optic disc cupping. *Ophthalmology* 1985;**92**:1654–6.
54 **Tielsch JM**, Katz J, Quigley HA, *et al*. Intraobserver and interobserver agreement in measurement of optic disc characteristics. *Ophthalmology* 1988;**95**:350–6.
55 **Varma R**, Steinmann WC, Scott I. Expert agreement in evaluating the optic disc in glaucoma. *Ophthalmology* 1992;**99**:215–21.
56 **Gaasterland DE**, Blackwell B, Dally LG, *et al*. The Advanced Glaucoma Intervention Study (AGIS): 10. Variability among academic glaucoma subspecialists in assessing optic disc notching. *Trans Am Ophthamol Soc* 2001;**99**:177–84.
57 **Ervin JC**, Lemij HG, Mills RP, *et al*. Clinician change detection viewing longitudinal stereophotographs compared to confocal scanning laser tomography in the LSU Experimental Glaucoma (LEG) Study. *Ophthalmology* 2002;**109**:467–81.
58 **Resnikofff S**, Pascolini D, Etya'ale D, *et al*. Global data on visual impairment in the year 2002. *Bull World Health Organ* 2004;**82**:844–51.