ORIGINAL ARTICLES – Clinical science

Number of people with glaucoma worldwide

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Abstract

***Aim*—To estimate the prevalence of glaucoma among people worldwide.**

***Methods*—Available published data on glaucoma prevalence were reviewed to determine the relation of open angle and angle closure glaucoma with age in people of European, African, and Asian origin. A comparison was made with estimated world population data for the year 2000.**

***Results*—The number of people with primary glaucoma in the world by the year 2000 is estimated at nearly 66·8 million, with 6·7 million suffering from bilateral blindness. In developed countries, fewer than 50% of those with glaucoma are aware of their disease. In the developing world, the rate of known disease is even lower.**

***Conclusions*—Glaucoma is the second leading cause of vision loss in the world. Improved methods of screening and therapy for glaucoma are urgently needed.**

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Glaucoma is a common visual disorder whose frequency among people of the world has not been analysed comprehensively. Open angle glaucoma (OAG) is a slowly progressive atrophy of the optic nerve, characterised by loss of peripheral visual function and an excavated appearance of the optic disc by ophthalmoscopy.[1] The causes of OAG are not clear, though the intraocular pressure (IOP) is a risk factor. An abnormally high IOP level is not an effective diagnostic criterion for OAG, since some of those affected have IOP within the normal range.[2] The high cost of present methods for glaucoma screening are a barrier to the identification of people at high risk for glaucoma blindness.

While an acute form of primary angle closure glaucoma (ACG) produces pain and decreased vision, ACG is often an asymptomatic disorder. ACG eyes are smaller than normal in length and anterior chamber depth,[3] features that have been suggested for diagnostic screening.

This report examines all published reports of the prevalence of glaucoma in populations from many countries. Its specific aims are to estimate the prevalence of OAG and ACG among people of the major ethnic groups of the world and to account for its variation by age. These estimates are used to enumerate those expected to have glaucoma by the year 2000.

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Methods

In 111 published reports on the prevalence of glaucoma,[4] I evaluated whether each study had the following desirable design features: random selection among the subject population, a high rate of examination of the sample, and a clear definition of glaucoma (including either optic disc examination or a visual field test). These three desirable features were required for a study to be included in this analysis. Studies were not included if elevated IOP or low visual acuity at screening were the sole criteria for definitive examination.

United States Census Bureau estimates for world population in the year 2000 were used, divided by 5 year age groups and by sex. The countries of the world were placed in regional groups that were expected to be similar in glaucoma prevalence. These were named: China (People's Republic of China, Taiwan, Hong Kong, Macau), India (India, Pakistan, Bangladesh, Afghanistan, Iran, Nepal), South Asia (Asian states not in China or India groups, Oceania), Near East (African states not in Africa group, Arab states), Africa (African states south of 20° N latitude, Caribbean nations with majority of African derivation, African Americans), Latin America (Mexico, Central and South American states, Caribbean states not in Africa group), and European derived (United States, Canada, Europe, former Soviet states, Australia, New Zealand).

In each region, data were evaluated from surveys that cited age specific OAG and ACG prevalences. For groups with insufficient population based prevalence data, estimates from hospital based data were used. The equation representing the best fit for existing estimates of glaucoma prevalence from individual surveys was used to generate a model of age specific and ethnic group specific prevalence estimates for the purposes of estimating global numbers of people with glaucoma.

Results

EUROPEAN DERIVED PEOPLE

In the detailed analysis of studies among European derived people, the best fit of OAG prevalence[5–23] related to age is an exponential

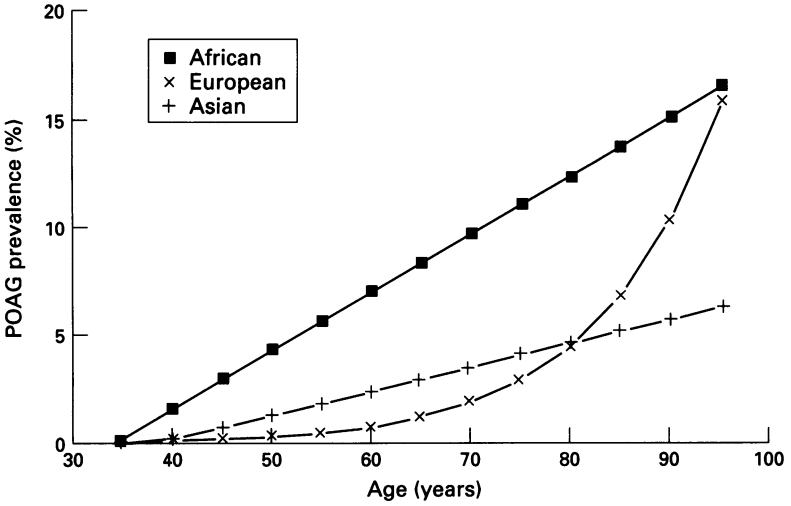

Figure 1 The prevalence of open angle glaucoma in European, African, and Asian people by age.

function: prevalence (%)=0·0059×$e^{0·08*age}$ (adjusted r^2=0·70) (Fig 1). In this modelling, weights were assigned to data points to take account of the variance in prevalence, indicated by the number of cases and the total population. The mean age adjusted prevalence for adult European derived people (over age 40) was 2·42% (SD 2·10%). In this estimate, the data from surveys of people of European derivation[5–23] were applied to the population data of those defined here as European derived. OAG here includes those with normal and elevated levels of IOP. The diagnosis required evidence that either functional visual loss or structural damage to the optic disc was present. The ratio of males to females suggested no consistent sex difference (mean male/female ratio=1·1 (SD 0·7) (n=13).[6–8 10 12 14–17 19 21–23]

The age adjusted prevalence for ACG in nine studies[5–7 10–12 19 21 23] averaged 0·20% (SD 0·20%) in those over 40 years. This is 11·4 times lower than the OAG prevalence in the same reports. Since the data were insufficient to estimate an age prevalence relation, it was assumed that ACG has the same exponential age relation as OAG, but 11·4 times lower. Males and females were presumed to be equally affected, as the stratification by sex produces groups too small for analysis.

AFRICAN DERIVED PEOPLE

The analysis of surveys[21 24–29] of OAG among African derived people was provided previously.[4] The prevalence/age relation is linear: prevalence=0·27 (age)−0·22 (r^2=0·52) (Fig 1). ACG is rare in those of African descent, both in survey and clinic based data.[30] The conclusion used here is that Africans have one half the European rate of ACG.

ASIAN PEOPLE

Population based studies of glaucoma prevalence in Asia include one report in 9000 Japanese people,[31] a study in Beijing, China,[32] a study of Chinese in Taiwan,[33 34] and a study of a South African group with both Asian and African heritage.[35] The age specific data suggest a linear relation of OAG to age in Asians: prevalence=0·11 (age)−4·22 (r^2=0·75) (Fig 1). This was applied to the China, India, and South Asia groups, though there are no available data on the latter two regions.

In available survey data, in blindness prevalence data, and in clinical reports from Asia,[36–40] ACG appears more common among Chinese people than any other ethnic group. Their ratio of ACG to OAG approaches 3:1.[33 34] The estimates assume the same slope of ACG with age as that for OAG, but with a rate three times higher among the China group. For India and South Asia groups, the slope and prevalence for ACG and OAG are assumed to be equal. Despite reports that ACG may be more common in women than in men, there are few survey data to support this conclusion; no sex difference is assumed. The practical consequence of this assumption is minimal, since in Asia, Latin America, and the Near East, the numbers of adult men and women are similar.

LATIN AMERICA, NEAR EAST

The estimation of glaucoma prevalence in Latin America and the Near East is conjectural, with no reason to assume that OAG is more or less common than among Europeans.[41–44] Therefore, the European rate is assigned. Among both groups, clinical reports and hospital based data suggest that ACG may be more common than among Europeans. For example, in Saudi Arabia, clinical records of consecutive glaucoma patients were categorised by subspecialty trained ophthalmologists. OAG was diagnosed in 60% (122/203) and ACG in 31% (63/203) (personal communication). For this analysis, the rate of ACG in these groups was estimated at five times the rate of ACG in the European derived group.

SECONDARY AND CHILDHOOD GLAUCOMA

Few studies describe secondary glaucoma as a separate entity and some investigators do not provide the criteria used in its definition. Those with pigmentary and exfoliation (or capsular) glaucoma are included here as primary OAG. The mean prevalence for secondary glaucoma in eight studies (including European, African, and Asian people)[7 10 11 19 21 24 27 29 31] is 0·44% (SD 0·36%), or 18% of the mean OAG prevalence in Europeans. The number of children with glaucoma is apparently quite small relative to that in adults, with little population based data to provide estimates. They are not included in this presentation, though it is recognised that the number of years during which blind children might live gives disproportionate importance to their visual disability.

DIAGNOSED VERSUS UNKNOWN GLAUCOMA

The number of those with glaucoma who were previously diagnosed before each survey was compared with the number with newly

Table 1 Estimate of number of people affected by glaucoma worldwide

Group	*Open angle*	*Angle closure*	*Total population*
China	7 444 663	22 333 990	1 288 704 314
India	5 591 042	5 591 042	1 435 699 181
South Asia	4 224 819	4 224 819	769 979 570
Europe	6 945 870	609 287	1 116 845 880
Africa	7 026 081	46 285	723 834 244
Latin America	1 278 751	560 856	506 533 880
Near East	640 040	280 719	323 624 981
Total	33 151 266	33 646 997	6 165 222 154
Total primary glaucoma	66 798 263		

discovered disease. This varied from no known cases to 79% previously diagnosed, with a mean of 45% (SD 25%) known cases (n=14 surveys[6–14 17 19 21–23]). Since most data were from studies in European derived people, it is likely that the number of known cases is fewer in developing countries.

NUMBER OF PEOPLE WITH GLAUCOMA WORLDWIDE

The age data for seven world regions by 5 year group for the year 2000 were applied to the prevalence figures described above (Table 1). This suggests that 66·8 million people have OAG and ACG in nearly equal numbers. An additional 6·0 million people are estimated to have secondary glaucoma. The majority of ACG is in Asia, while OAG is more equally distributed.

It is important to estimate the number of those expected to be blind from glaucoma (disability/case ratio). In surveys from the European derived group, the rates of acuity of 20/200 or worse in the better eye as a result of glaucoma were: 2·5% (Wisconsin, USA, B Klein, personal communication), 4·4% (Baltimore, USA),[21] and 6·2% (Roscommon, Ireland).[7] Unfortunately, some studies provide only data with blindness indicated at the 20/200 level, rather than including the World Health Organisation standard of <20/400 (3/60). For African Americans, blindness occurred in 7·9% (≤20/200 (3/300)).[21] At a value of 10% blindness per case, 6·7 million people are estimated to be blind from glaucoma worldwide.

The comparison of glaucoma by age among regions reveals interesting differences. The total populations in the Africa and Europe groups are similar (723 million and 1·1 billion, respectively) and their OAG total numbers are similar (7 million and 6·9 million). However, owing to the earlier development of disease, the higher prevalence at younger ages, and differing demographic profiles, the distribution of disease by age is dramatically different in the two groups (Fig 2). The burden of disease is substantially higher among younger people in the Africa group.

Discussion

There are few earlier estimates of the number with glaucoma among the various ethnic groups in the world.[45 46] Estimates of glaucoma prevalence that are based in part on blindness surveys[46] might understate glaucoma prevalence, since both OAG and ACG affect visual acuity only at the last stage of their damage. Thylefors and Negrel[46] estimated a global glaucoma blindness figure of 5·2 million people. Their estimate of the number affected by glaucoma (about 20 million) was substantially lower than the estimate in this report. It is not possible to determine the differences between the models in the two reports, as the detailed values for prevalence by ethnic group and region are not given in their brief report. They assumed a bilateral blindness/case proportion of 23%. However, among disease prevalence studies in European derived people, bilateral blindness rates per case vary from 2·5% to 8%. Blindness registry data from Denmark suggest a glaucoma blindness rate of 5% per case.[47] Glaucoma blindness rates in developing countries are probably higher than in Europe and the United States, assuming that in developed countries more of those affected are under therapy and that treatment is somewhat effective. Thus, the worldwide estimate for blindness/case is likely to be higher than the 8% rate among African Americans. If 10% of those with glaucoma in the world are blind and if the prevalence estimates here are accurate, the resultant estimate is 6·7 million blind by the year 2000. Thus, while some of our assumptions differ, the other recent report and this one

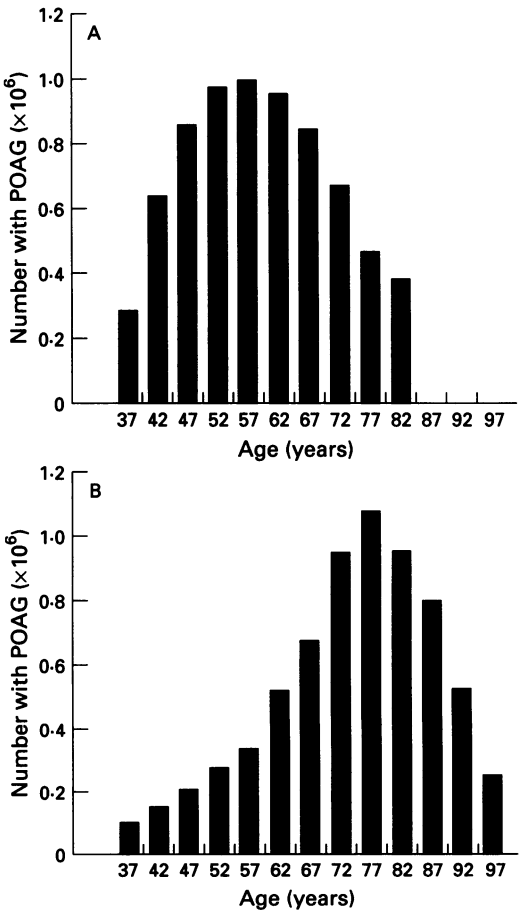

Figure 2 Comparison of primary open angle glaucoma (POAG) distribution among African (A) and European derived (B) groups of people. All those over age 80 in the African data are grouped in one age stratum, while in the European data, the proportion of those over 80 years of age justified four additional 5 year groupings.

come to similar conclusions about the magnitude of the glaucoma blindness problem. By these estimates, glaucoma is, or soon will be, the second largest cause of bilateral blindness in the world after cataract.[48] In addition, typical blindness statistics do not include the significant functional loss in glaucoma before bilateral blindness, often including monocular blindness and loss of mid peripheral visual field function and stereopsis.

Among people with glaucoma in developed countries only half are likely to be known to the health care system. In developing countries, the number is surely less. Because OAG is asymptomatic before blindness, patients are often unaware of their disease. Acute attacks of ACG are more likely to lead to presentation for care; hence, statistics based on clinic based data tend to overestimate the proportion of ACG compared with OAG. This bias was avoided here for much of the world by using survey based data. Lay people may assume that it is satisfactory to wait until blindness occurs, believing that it can be reversed as is true of cataract blindness. Since glaucoma blindness is irreversible, educational efforts in blindness prevention must target high risk populations with this information. In part, the low rate of glaucoma detection also results from the frustration of health care providers with impractical screening methods and the perceived inability to offer effective therapy for glaucoma.

Screening for glaucoma requires either the informed assessment of optic disc appearance or a functional test of peripheral visual function. It is inherently more difficult[49] than the identification of cataract or trachoma, two other important causes of visual loss. Furthermore, there is no general agreement on criteria for glaucoma diagnosis. Despite a diversity of definitions, prevalence studies among European derived people come to relatively similar conclusions regarding its importance as a cause of vision loss. The recognition that glaucoma is the second most important cause of blindness worldwide should stimulate interest in better case detection. It is not necessary (and perhaps not even desirable) in many regions of the world to identify the earliest cases of glaucoma in order to have an impact. Given the relatively low disability/case ratio, the recognition of those at greatest risk of blindness would be a prudent approach. Initially at least, methods should be used that are sensitive enough to find those with moderate to severe glaucoma damage. This approach will have better specificity, decreasing the burden of examination of those improperly identified at screening. Furthermore, those already damaged may be more likely to agree to undergo therapy.

The therapy for glaucoma is less attractive to patients than cataract surgery, since vision can be retained, but not restored. Eyedrop treatment to lower IOP has been the initial therapy in developed countries, but its effectiveness and efficacy are being questioned. Daily medical treatment is expensive and subject to poor patient compliance. Initial surgery may be more effective at IOP lowering[50] and is being compared with initial eyedrops in a US clinical trial. Antifibrotic agents as adjuncts to surgery[51 52] may produce acceptable rates of trabeculectomy success, especially if complications such as transient low IOP can be managed by releasable suture techniques.[53 54] Coordination of glaucoma surgery with cataract surgery programmes would take advantage of economies of scale.

These prevalence estimates are based on a relatively small number of people detected in surveys, and are subject to the assumptions presented. Hopefully, others will generate additional data and improve the intuitive approach. Further studies of glaucoma prevalence are urgently needed in the groups of countries included here – China, India, South Asia, Latin America, and the Near East. Screening for ACG, which may represent half of worldwide glaucoma, is hampered by inadequate methods and lack of standardised diagnostic criteria.

Among the regions of the world, there are striking differences in the number of people affected by glaucoma owing to variation in age distributions. The appropriate age at which screening begins to be most effective in African people is 30 years, because of the earlier onset of disease and the high proportion of young people in this population. For the European derived, it seems most efficient to screen those over 50 years of age. Expected changes in world population will continue to increase the number and proportion of older people. The concomitant increases in those with cataract and glaucoma will expand the need for diagnostic and therapeutic services.

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