# Prevalence of Open-Angle Glaucoma Among Adults in the United States

*The Eye Diseases Prevalence Research Group**

**Objective:** To estimate the prevalence and distribution of open-angle glaucoma (OAG) in the United States by age, race/ethnicity, and gender.

**Methods:** Summary prevalence estimates of OAG were prepared separately for black, Hispanic, and white subjects in 5-year age intervals starting at 40 years. The estimated rates were based on a meta-analysis of recent population-based studies in the United States, Australia, and Europe. These rates were applied to 2000 US census data and to projected US population figures for 2020 to estimate the number of the US population with OAG.

**Results:** The overall prevalence of OAG in the US population 40 years and older is estimated to be 1.86% (95% confidence interval, 1.75%-1.96%), with 1.57 million white and 398 000 black persons affected. After applying race-, age-, and gender-specific rates to the US population as determined in the 2000 US census, we estimated that OAG affects 2.22 million US citizens. Owing to the rapidly aging population, the number with OAG will increase by 50% to 3.36 million in 2020. Black subjects had almost 3 times the age-adjusted prevalence of glaucoma than white subjects.

**Conclusions:** Open-angle glaucoma affects more than 2 million individuals in the United States. Owing to the rapid aging of the US population, this number will increase to more than 3 million by 2020.

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THE MOST RECENT ESTIMATES of the burden of open-angle glaucoma (OAG) in the United States relied on limited data.[1] One obstacle to obtaining accurate estimates is the lengthy examination procedures needed to identify individuals with glaucoma. Detecting glaucoma in eye disease prevalence surveys requires detailed evaluation of both the optic nerve head and the visual field. Fortunately, several recent major population-based surveys have determined the prevalence of glaucoma using rigorous study designs.[2-14]

The aim of this research was to use pooled data from these large, worldwide population-based studies to determine more precisely the magnitude of the problem in the United States and to project how the numbers will change in the coming decades.

## METHODS

Principal investigators from the following studies provided data on the prevalence of OAG: the Baltimore Eye Survey,[2] the Barbados Eye Study,[4] the Beaver Dam Eye Study,[3] the Blue Mountains Eye Study,[5] the Kongwa Eye Project,[15] Proyecto Vision Evaluation Research,[8] the Rotterdam Study,[10] and the Melbourne Visual Impairment Project.[6] **Table 1** provides the baseline demographics of subjects in each of the studies contributing data for the present research. The Barbados and Tanzania data were excluded from the main estimates of US prevalence, but included in alternative analyses.

The Baltimore Eye Survey (1985-1988) enrolled 5308 black and white subjects (75% of the intended population); the Beaver Dam Eye Study (1988-1990) in Beaver Dam, Wis, enrolled 4926 subjects (83% of the intended population); the Blue Mountains Eye Study (1992-1994) in Sydney, Australia, examined 3654 white subjects (82% of the eligible population); the Rotterdam Study (1990-1993) enrolled 6774 subjects (67% of the intended population); Proyecto Vision Evaluation Research enrolled 4774 subjects (72% of the eligible population); and the Melbourne Visual Impairment Project (1991-1998) enrolled 4744 persons (86% response rate). The investigators from each of those studies provided us with the number of individuals able to undergo evaluation for OAG and the number with definite OAG stratified by gender and race for groups aged 40 to 44, 45 to 49, 50 to 54, 55 to 59, 60 to 64, 65 to 69, 70 to 74, 75 to 79, and 80 to 84 years and 85 years or older.

There is no single standard for defining OAG in population-based research. Researchers have instead relied on a wide range of approaches, including consensus meetings,[6] review of all suspected cases by a single expert,[2] and statistical approaches using cutoffs for cup-

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*A complete list of the members of the Eye Diseases Prevalence Research Group appears on page 538.*

**Table 1. Studies Included in Estimates of Glaucoma Prevalence**

| | BES | Barbados* | BDES | BMES | Proyecto VER | RS† | KEP* | Melbourne VIP |
|---|---|---|---|---|---|---|---|---|
| Years study conducted | 1985-1988 | 1988-1992 | 1988-1990 | 1992-1994 | 1999-2000 | 1990-1993 | 1996 | 1991-1998 |
| No. of participants‡ | 5308 | 4314 | 4585 | 3632 | 4773 | 6774 | 3261 | 4652 |
| Age group, y%§ | | | | | | | | |
| 40-49 | 22.1 | 29.1 | 17.7 | NA | 33.4 | NA | 41.5 | 26.9 |
| 50-54 | 11.9 | 12.0 | 14.5 | 12.7 | 16.3 | NA | 17.9 | 14.6 |
| 55-59 | 12.9 | 12.5 | 13.6 | 14.7 | 12.3 | 18.5 | 13.3 | 13.6 |
| 60-64 | 14.3 | 11.9 | 14.1 | 17.6 | 10.9 | 22.3 | 11.1 | 13.4 |
| 65-69 | 14.5 | 11.3 | 14.3 | 18.5 | 9.8 | 20.3 | 5.5 | 11.5 |
| 70-74 | 11.2 | 10.9 | 11.7 | 14.8 | 8.2 | 17.6 | 5.2 | 9.4 |
| 75-79 | 7.2 | 7.4 | 8.4 | 11.6 | 5.1 | 12.7 | 2.8 | 5.4 |
| ≥80 | 5.8 | 4.9 | 5.8 | 10.0 | 4.1 | 8.6 | 2.7 | 5.1 |
| Gender, % | | | | | | | | |
| Women | 60.3 | 57.3 | 55.8 | 56.7 | 61.2 | 58.2 | 56.0 | 53.3 |
| Men | 39.7 | 42.7 | 44.2 | 43.3 | 38.8 | 41.8 | 44.0 | 46.7 |
| Race, % | | | | | | | | |
| Black | 45.1 | 100.0 | 0 | 0 | 0 | 0 | 100.0 | 0 |
| Hispanic | 0 | 0 | 0 | 0 | 100.0 | 0 | 0 | 0 |
| White | 54.9 | 0 | 100.0 | 100.0 | 0 | 100.0 | 0 | 100.0 |
| Crude prevalence of definite POAG, % | 2.49 | 7.00 | 2.07 | 2.97 | 1.97 | 0.80 | 3.01 | 1.83 |

Abbreviations: Barbados, Barbados Eye Study,[4] Barbados, West Indies; BDES, Beaver Dam Eye Study,[3] Beaver Dam, Wis; BES, Baltimore Eye Survey,[2] Baltimore, Md; BMES, Blue Mountain Eye Study, [5] Sydney, New South Wales, Australia; KEP, Kongwa Eye Project,[15] Tanzania; Melbourne VIP, Vision Impairment Project,[6] Melbourne, Victoria, Australia; NA, not applicable; POAG, primary open-angle glaucoma; Proyecto VER, Vision Evaluation Research, [9] Nogales and Tucson, Ariz; RS, Rotterdam Study,[10] Rotterdam, the Netherlands.

*The data from these studies were not included in the prevalence estimates for black subjects.

†The prevalence of POAG is 1.4% if individuals with probable POAG are included. Definite POAG could not be diagnosed in 475 nursing home residents for whom visual field data were not available.

‡The number of participants reported for each study herein reflects the number that contributed to our estimates in the present report, not necessarily the total number of participants in the original study as published.

§Percentages have been rounded and may not sum to 100.

disc ratio and visual field defects to define the disease.[10,12] For the purposes of this research, studies were eligible to contribute data if the determination of glaucoma was made using both visual field and photographically obtained optic nerve head data. The definitions used in the included studies are presented in **Table 2**.

To be included, studies had to contribute data believed to be directly applicable to the US population. Some recent publications from populations outside the United States were not included because it is not clear that the findings from those populations are representative of what one would expect in those minority populations who have emigrated to the United States.[4,9,12,15,16] Furthermore, we were unable to obtain data from some studies meeting inclusion criteria within the time allocated to this project.[7,11]

The age-specific prevalence proportions were derived in 2 steps. First, pooled prevalence proportions were estimated for each race-, gender-, and age-specific stratum using minimum variance linear estimation. Stratum-specific proportions from each study were transformed using a logarithm odds transformation, and proportion variances were based on the binomial distribution. Second, logistic regression models were fitted to the pooled prevalence proportions using the midpoint of each age interval as the independent variable. Models were fit separately by race and gender. Prevalence estimates for black and Hispanic persons were based on modeled rates from a single study. No prevalence data were available for other minority US populations; therefore, estimates for other races were based on modeled rates using the unweighted average of the pooled stratum-specific rates for white, black, and Hispanic persons.

Age and race effects in the models were evaluated using logistic regression and the Wald $\chi^2$ test statistic. Odds ratios for gender differences were based on Mantel-Haenszel $\chi^2$ tests for the $2 \times 2$ tables of observed rates, adjusting for age and the study effect.

The number of people with OAG in the United States in each race, gender, and age category were generated by applying the modeled prevalence rate for each year of age to the 2000 US census population and summing across the age range for each 5-year age category. Projected estimates were derived in the same manner, using US Census middle series population projections for the year 2020. Stratum-specific US prevalence rates were computed by dividing the total number of estimated cases for each stratum by the stratum-specific US population. Estimates for glaucoma in Western Europe and Australia were based on applying the gender- and age-specific rates for white persons to their respective populations 40 years and older.

## RESULTS

The age-specific prevalence of OAG among white, black, and Hispanic persons from each of the studies is presented in the **Figure**. Focusing separately on each of the race/ethnic groups, we found the following results.

### WHITE SUBJECTS

Pooled data for European-derived individuals from the Baltimore Eye Survey, the Blue Mountains Eye Study, the Beaver Dam Eye Study, the Rotterdam Study, and the Melbourne Visual Impairment Project found a strong increase in the prevalence of OAG with age ($P<.001$, $\chi^2$ test). In the 50- to 54-year age range, 0.89% of white women had OAG compared with 2.16% of those in the 70- to 74-year age range and 6.94% of those 80 years and older (**Table 3**). After controlling for age, there were no significant differences by gender (odds ratio [OR] for

**Table 2. Glaucoma Definitions***

Baltimore, Md
- Stage 1: Physician conducting a definitive examination concludes on the basis of available data (includes VF, disc photographs, and, for 52 subjects, past medical records) that the subject had or was suspected of having OAG.
- Stage 2: All data for the subject reviewed by the PI (Dr Sommer). All VF graded as definite, probable, or unlikely to be abnormal, and, for abnormal fields, typical, compatible, or incompatible with glaucoma. Also graded as congruent or not congruent with other fields available for the subject, and with the subject's optic nerve examination results.
- Definite OAG based on:
  - ≥2 Abnormal VF results with excellent congruence between end-stage disease with VA ≤20/200 and 100% cupping
  - ≥1 Abnormal VF, without perfect congruence, C/D ≥0.8, or asymmetry ≥0.3
  - >1 Abnormal VF with some but not perfect congruence
  - 1 VF with typical field defects
  - 1 VF typically abnormal or consistent with glaucoma and cupping or NFL loss
  - Asymmetric cupping with a difference between eyes of ≥0.4
  - Patient unable to undergo VF testing, but consistent disc and NFL abnormalities

Beaver Dam, Wis
- Two of the following: VF defect consistent with glaucoma, abnormal disc (vertical C/D ≥0.8 or asymmetry ≥0.2) and IOP ≥22 mm Hg. No gonioscopy, but depth of AC was assessed, only 2 with definite history of ACG attack (excluded from OAG diagnosis).

Blue Mountains, Australia
- Reviewed by 2 glaucoma specialists and 2 general ophthalmologists, defined case as typical glaucomatous VF loss of HVF 30-2, combined with matching disc rim thinning and enlarged (≥0.7) cup or C/D asymmetry between eyes of ≥0.3, gonioscopy consistent with POAG.

Rotterdam, the Netherlands
- Glaucoma defined using an algorithm, without subjective final interpretation, if present in at least 1 eye of a subject with OAG and no history or sign of secondary glaucoma.
  1. Possible GON based on 97.5th percentile in population: a vertical C/D of ≥0.7, asymmetry in vertical C/D between both eyes ≥0.2, or neuroretinal rim width <0.1.
  2. Probable GON based on 99.5th percentile: a vertical C/D ≥0.9, C/D asymmetry ≥0.3, or narrowest neuroretinal rim <0.05.
  3. Definite OAG was defined as a glaucomatous VF defect combined with at least possible GON. Only definite OAG qualified for present analysis in this report.

*(continued)*

**Table 2. Glaucoma Definitions* (cont)**

Proyecto VER, Arizona
- Category 1 (structural and functional): ≥1 eye with disc damage (C/D ≥0.7, asymmetry ≥0.2, or narrowest rim <0.1) and a VF defect (Glaucoma Hemifield Test results outside normal limits and a cluster of ≥3 points at $P<5\%$ or worse on pattern deviation plot in the same eye).
- Category 2 (advanced structural damage with unproven field): ≥1 eye with C/D ≥0.85 (99.5th percentile for this population), unable to perform visual field testing.
- Category 3 (no disc/field information available): No visual field test could be performed, disc not visible, vision is legally blind, and IOP >99.5th percentile (27 for this population). There could be no alternate explanation for disc or field changes in all 3 definitions.

Melbourne VIP, Australia
- Consensus meeting that took into consideration all subjects with history of glaucoma, IOP >21 mm Hg in either eye, VF defects (nasal step >5 dB in 3 adjacent points or >10 dB in 2 adjacent points, any bundle-type defect, or enlarged blind spot), C/D ≥0.7 in either eye, or asymmetry ≥0.3. Panel graded VF and disc masked and independently. Graders were then unmasked to patient data of IOP, glaucoma medication use, glaucoma surgery, and medical ocular history so that an open categorization of the patient could be made. Subjects were categorized as having definite, probable, possible, or no glaucoma. Each expert used his best clinical judgment, taking into account all the available information. Discrepancies of >2 steps were resolved by the group as a whole to reach consensus.

Abbreviations: AC, angle closure; ACG, angle-closure glaucoma; C/D, cup-disc ratio; GON, glaucomatous optic neuropathy; HVF, Humphrey visual field; IOP, intraocular pressure; NFL, nerve fiber layer; OAG, open-angle glaucoma; PI, principal investigator; POAG, primary OAG; VA, visual acuity; VF, visual field; VIP, Vision Impairment Project.
*Studies from which data are derived are described in Table 1.

women, 1.03; 95% confidence interval [CI], 0.83-1.27) in the prevalence of OAG in white subjects. The estimated US prevalence of OAG among white individuals 40 years and older is 1.69% (95% CI, 1.53%-1.85%).

## BLACK SUBJECTS

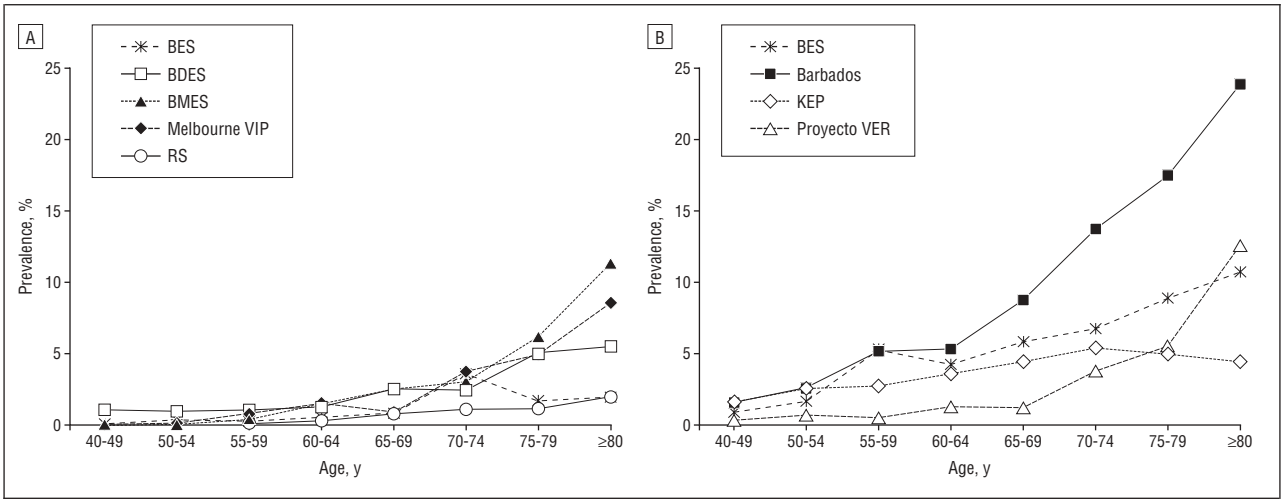
Data for black subjects were derived from a single study, the Baltimore Eye Survey. The prevalence of OAG increased with age, and OAG was consistently more prevalent than in white subjects (Table 3). Black women aged 50 to 54 years had a prevalence of OAG of 2.24%, which increased to 5.89% for those aged 70 to 74 years, and to 9.82% for those 80 years and older. The age-adjusted prevalence of OAG was lower in women compared with men, but did not differ significantly (OR, 0.83; 95% CI, 0.55-1.25). Logistic regression including age, race, and gender in the model found that black subjects had almost 3 times the prevalence of OAG compared with white subjects (OR, 2.82; 95% CI, 2.14-3.72).

## HISPANIC SUBJECTS

The data on Hispanic subjects came from a single study of mostly Mexican-derived Latinos from Arizona.[8] Prevalence estimates showed similar increases with age, but with a markedly higher prevalence in the oldest Hispanic subjects (Table 3). After controlling for age and gender, rates of OAG in Hispanic subjects did not differ significantly from that among white subjects (OR, 1.06; 95% CI, 0.89-1.26), except for those older than 65 years, in whom the rates were higher (OR, 1.24; 95% CI, 1.10-1.41). After controlling for age and gender, Hispanic subjects had a significantly lower prevalence of glaucoma than black subjects (OR, 0.41; 95% CI, 0.27-0.60). Although women had somewhat higher age-adjusted rates of OAG than men, the difference was not statistically significant (OR, 1.11; 95% CI, 0.72-1.71).

## PREVALENCE AND PREDICTED PREVALENCE

The overall prevalence of OAG in the US population 40 years and older is estimated to be 1.86% (95% CI, 1.75%-




Prevalence of glaucoma in white (A) and black and Hispanic (B) subjects. BES indicates Baltimore Eye Survey,[2] Baltimore, Md; BDES, Beaver Dam Eye Study,[3] Beaver Dam, Wis; BMES, Blue Mountains Eye Study,[5] Sydney, New South Wales; Melbourne VIP, Melbourne Visual Impairment Project,[6] Melbourne, Victoria; RS, Rotterdam Study,[10] Rotterdam, the Netherlands; Barbados, Barbados Eye Study,[4] Barbados, West Indies; KEP, Kongwa Eye Project,[15] Tanzania; and Proyecto VER, Vision Evaluation Research,[8] Nogales and Tucson, Ariz.

1.96%), with 1.57 million white and 398 000 black persons affected (**Table 4**). Applying race-, age-, and gender-specific rates to the US population as determined in the 2000 US census, we estimate that OAG affects 2.22 million US citizens. Owing to the rapidly aging population, the number with OAG will increase by 50% to 3.36 million in 2020.

Applying the same age-, race-, and gender-specific rates, the number of affected individuals with OAG is estimated at 122 000 in Australia, and 3 million in Western Europe.

## COMMENT

Pooled data from population-based eye disease prevalence studies indicate that, at present, 2.22 million individuals in the United States have open-angle glaucoma. This estimate is similar to the one made almost a decade ago by Tielsch[1] for the 1990 United States population (2.0 million). Studies consistently find that about half of those with glaucoma are unaware they have the disease.[2,4-6] Recent reports indicate that lowering intraocular pressure prevents vision loss in patients with glaucoma and ocular hypertension,[17-19] so most of those individuals with undiagnosed OAG could potentially benefit from treatment. Furthermore, many more are eligible for care, since we did not estimate the prevalence of ocular hypertension without signs of glaucoma. We project that the number of individuals with potentially treatable OAG will increase from 2.22 million today to more than 3 million in 2020. This has implications for the health care system in the United States. Glaucoma was the fifth most common diagnosis for an office visit by Medicare recipients in 1992.[20] Western Europe has an even higher prevalence of OAG, largely because of the older age structure there.

These numbers are particularly concerning because glaucoma leads to irreversible vision loss. Recent research indicates that those with mild-to-moderate glaucomatous visual field loss have decreased mobility,[21] and those with visual field loss due to any cause are more likely to report falling.[22] Those with more severe forms of the disease are often highly dependent on others. In addition, glaucoma management is expensive and not without risk. Medications can lead to breathing and cardiac problems,[23-26] and surgery to lower eye pressure is associated with ocular discomfort,[27] cataract formation,[28,29] and endophthalmitis.[30,31]

The present research has several limitations. First, although this is a meta-analysis of population-based studies, none of the studies enrolled all eligible subjects. On average, about 20% of those eligible did not participate, which may cause bias in the estimates. Nonparticipants may include more individuals with known disease, as these per-

**Table 3. Prevalence of Glaucoma by Age, Gender, and Race***

| Age, y | Prevalence/100 Population (95% CI) | | |
|---|---|---|---|
| | White Subjects | Black Subjects | Hispanic Subjects |
| Women | | | |
| 40-49 | 0.83 (0.65-1.06) | 15.1 (0.94-2.41) | 0.34 (0.15-0.72) |
| 50-54 | 0.89 (0.78-1.02) | 2.24 (1.59-3.14) | 0.65 (0.37-1.15) |
| 55-59 | 1.02 (0.89-1.16) | 2.86 (2.16-3.78) | 0.98 (0.61-1.58) |
| 60-64 | 1.23 (1.07-1.41) | 3.65 (2.83-4.69) | 1.49 (0.97-2.28) |
| 65-69 | 1.58 (1.37-1.82) | 4.64 (3.54-6.05) | 2.24 (1.43-3.49) |
| 70-74 | 2.16 (1.87-2.49) | 5.89 (4.28-8.05) | 3.36 (2.00-5.60) |
| 75-79 | 3.12 (2.68-3.63) | 7.45 (5.06-10.84) | 5.01 (2.68-9.15) |
| ≥80 | 6.94 (5.40-8.88) | 9.82 (6.08-15.48) | 10.05 (4.35-21.52) |
| Men | | | |
| 40-49 | 0.36 (0.27-0.47) | 0.55 (0.31-0.95) | 0.39 (0.18-0.85) |
| 50-54 | 0.61 (0.50-0.74) | 1.71 (1.25-2.32) | 0.69 (0.39-1.25) |
| 55-59 | 0.85 (0.72-1.00) | 3.06 (2.30-4.04) | 1.00 (0.61-1.64) |
| 60-64 | 1.18 (1.02-1.37) | 4.94 (3.69-6.59) | 1.44 (0.92-2.24) |
| 65-69 | 1.64 (1.40-1.91) | 7.24 (5.40-9.63) | 2.07 (1.32-3.23) |
| 70-74 | 2.27 (1.90-2.72) | 9.62 (7.29-12.59) | 2.97 (1.79-4.89) |
| 75-79 | 3.14 (2.53-3.90) | 11.65 (8.81-15.25) | 4.23 (2.32-7.60) |
| ≥80 | 5.58 (4.15-7.47) | 13.21 (7.85-21.38) | 7.91 (3.53-16.77) |

Abbreviation: CI, confidence interval.
*Glaucoma indicates primary open-angle glaucoma.

**Table 4. Estimated Prevalence of Glaucoma in the United States by Age, Gender, and Race**

| Age, y | No. of Subjects ×1000 | | | Total US Population | |
|---|---|---|---|---|---|
| | White | Black | Hispanic | No. of Subjects ×1000 (95% CI) | Prevalence/100 Population (95% CI) |
| Women | | | | | |
| 40-49 | 131 | 41 | 8 | 202 (165-240) | 0.94 (0.77-1.12) |
| 50-54 | 60 | 22 | 5 | 96 (84-107) | 1.07 (0.94-1.19) |
| 55-59 | 54 | 20 | 6 | 87 (77-96) | 1.25 (1.11-1.38) |
| 60-64 | 54 | 21 | 7 | 88 (78-97) | 1.55 (1.38-1.72) |
| 65-69 | 65 | 23 | 9 | 102 (91-114) | 1.99 (1.76-2.22) |
| 70-74 | 90 | 25 | 11 | 132 (116-147) | 2.66 (2.34-2.97) |
| 75-79 | 121 | 24 | 11 | 163 (142-183) | 3.72 (3.24-4.20) |
| ≥80 | 439 | 48 | 25 | 525 (429-640) | 8.57 (7.01-10.13) |
| **Subtotal** | **1014** | **224** | **82** | **1395** (1286-1502) | 2.19 (2.02-2.36) |
| Men | | | | | |
| 40-49 | 57 | 14 | 8 | 88 (70-106) | 0.42 (0.34-0.50) |
| 50-54 | 40 | 14 | 4 | 64 (55-74) | 0.74 (0.63-0.85) |
| 55-59 | 44 | 18 | 5 | 71 (62-80) | 1.09 (0.95-1.23) |
| 60-64 | 49 | 23 | 5 | 82 (72-92) | 1.59 (1.40-1.79) |
| 65-69 | 60 | 27 | 6 | 97 (85-110) | 2.22 (1.94-2.49) |
| 70-74 | 76 | 28 | 7 | 116 (100-131) | 2.96 (2.56-3.36) |
| 75-79 | 84 | 24 | 6 | 119 (100-138) | 3.91 (3.28-4.54) |
| ≥80 | 143 | 26 | 10 | 186 (140-232) | 6.08 (4.57-7.58) |
| **Subtotal** | **553** | **174** | **51** | **823** (764-882) | 1.48 (1.37-1.58) |
| Both | | | | | |
| 40-49 | 188 | 55 | 16 | 290 (249-332) | 0.68 (0.59-0.78) |
| 50-54 | 100 | 36 | 9 | 160 (145-175) | 0.91 (0.82-0.99) |
| 55-59 | 98 | 38 | 11 | 158 (145-171) | 1.17 (1.07-1.27) |
| 60-64 | 103 | 44 | 12 | 170 (156-184) | 1.57 (1.44-1.70) |
| 65-69 | 125 | 50 | 15 | 199 (183-217) | 2.09 (1.92-2.27) |
| 70-74 | 166 | 53 | 18 | 248 (225-269) | 2.79 (2.54-3.04) |
| 75-79 | 205 | 48 | 17 | 282 (253-310) | 3.80 (3.41-4.18) |
| ≥80 | 582 | 74 | 35 | 711 (605-817) | 7.74 (6.58-8.89) |
| **Total** | **1567** | **398** | **133** | **2218 (2094-2340)** | 1.86 (1.75-1.96) |

Abbreviation: CI, confidence interval.
*Glaucoma indicates primary open-angle glaucoma. All estimates are based on US Census 2000 population.
†Estimates for the prevalence of glaucoma in the total US population include estimates for other races (Asian, American Indian, Alaska Native, Native Hawaiian, other Pacific Islander, and any other race) and those designating more than 1 race on the Census 2000 form.

sons may not see any benefit to participating. Conversely, nonparticipants may have had better ocular health and did not participate because they saw no value in a free eye examination. Furthermore, to diagnose glaucoma, most studies relied on visual field and optic nerve head data and results of a definitive eye examination. Some did not attend the final eye examination and were therefore excluded from a diagnosis. If these individuals were more likely to have glaucoma than those who attended the examinations, then estimates may be lower than the true prevalence.

A second limitation is the lack of a gold standard for diagnosing glaucoma in prevalence surveys. Each investigative team used its own approach to define the disease. However, even with this variation in methods, the results were remarkably similar across studies, indicating that researchers were capturing the same condition (on average) or that rates were actually more variable but that variation was missed owing to the different definitions. In either case, we assumed that if both disc and visual field data were used in defining glaucoma without regard to intraocular pressure, then the definition was likely to be accurate.

A third limitation is the relatively sparse data on black and Hispanic subjects. We elected to exclude data from well-designed studies in black populations from outside the United States. Prevalence rates from Barbados and St Lucia,[9] both Caribbean populations originating in West Africa, were substantially higher than those found in a US black population, and were therefore excluded. If these populations more accurately reflect the true prevalence of glaucoma in the United States than the Baltimore Eye Study data, then we would have underestimated the prevalence of OAG among black subjects in the present report. The prevalence data from Tanzania, although similar to that found in the United States, were also not included because most African Americans who are descendents of the slaves trace their origins to West Africa, an area with different ethnic groups from East Africa.[32] In addition, the study population was derived from a single ethnic group from this region.

To assess the possible underestimation that resulted from excluding those studies, **Table 5** shows the prevalence of OAG among black subjects and the number affected in each age-, race-, and gender-specific category, using data from Baltimore alone, data from Barbados alone, and combined data from Baltimore, Barbados, and Tanzania. Although we believe that the most applicable estimate for the United States comes from the Baltimore data,

**Table 5. Estimated Prevalence of OAG Among US Black Subjects Using 3 Calculation Strategies**

| | BES | | Barbados | | BES, Barbados, and KEP | |
|---|---|---|---|---|---|---|
| Age, y | Subjects* | Rate, % | Subjects* | Rate, % | Subjects* | Rate, % |
| Women | | | | | | |
| 40-49 | 41 | 1.57 | 31 | 1.18 | 47 | 1.81 |
| 50-54 | 22 | 2.29 | 20 | 2.11 | 27 | 2.77 |
| 55-59 | 20 | 2.82 | 22 | 3.16 | 26 | 3.70 |
| 60-64 | 21 | 3.58 | 27 | 4.67 | 29 | 4.90 |
| 65-69 | 23 | 4.60 | 34 | 6.82 | 32 | 6.46 |
| 70-74 | 25 | 5.76 | 43 | 9.90 | 37 | 8.48 |
| 75-79 | 24 | 7.08 | 48 | 14.07 | 37 | 11.00 |
| ≥80 | 48 | 10.57 | 115 | 25.36 | 79 | 17.35 |
| **Subtotal** | **224** | 3.40 | **341** | 5.17 | **314** | 4.76 |
| Men | | | | | | |
| 40-49 | 14 | 0.61 | 46 | 2.00 | 31 | 1.36 |
| 50-54 | 14 | 1.71 | 32 | 3.89 | 22 | 2.74 |
| 55-59 | 18 | 3.11 | 34 | 5.83 | 24 | 4.16 |
| 60-64 | 23 | 4.98 | 39 | 8.35 | 27 | 5.95 |
| 65-69 | 27 | 7.32 | 42 | 11.42 | 30 | 8.04 |
| 70-74 | 28 | 9.72 | 43 | 15.02 | 30 | 10.33 |
| 75-79 | 24 | 11.74 | 39 | 18.89 | 26 | 12.57 |
| ≥80 | 26 | 13.09 | 50 | 25.14 | 31 | 15.46 |
| **Subtotal** | **174** | 3.34 | **324** | 6.22 | **221** | 4.25 |
| Both | | | | | | |
| 40-49 | 55 | 1.12 | 76 | 1.56 | 78 | 1.60 |
| 50-54 | 36 | 2.02 | 52 | 2.93 | 49 | 2.76 |
| 55-59 | 38 | 2.95 | 56 | 4.36 | 50 | 3.91 |
| 60-64 | 44 | 4.20 | 66 | 6.29 | 56 | 5.37 |
| 65-69 | 50 | 5.75 | 76 | 8.78 | 62 | 7.13 |
| 70-74 | 53 | 7.34 | 86 | 11.95 | 67 | 9.22 |
| 75-79 | 48 | 8.83 | 86 | 15.89 | 63 | 11.59 |
| ≥80 | 74 | 11.34 | 165 | 25.29 | 109 | 16.78 |
| **Total** | **398** | 3.37 | **665** | 5.63 | **535** | 4.54 |

Abbreviations: Barbados, Barbados Eye Study,[4] Barbados, West Indies; BES, Baltimore Eye Survey,[2] Baltimore, Md; KEP, Kongwa Eye Project,[15] Tanzania.
*Thousands. Totals, therefore, are not a direct sum of above numbers.

had we pooled the data from Barbados and Tanzania with those from Baltimore, the estimated number of affected black persons in the United States in 2000 would be 583000 (a prevalence of 4.9% as opposed to our estimate of 3.4%). For Hispanic persons, all estimates were based on a single study of a select population from Arizona. These results may be different from those that would be found if other Hispanic populations were studied.

A final important limitation is the lack of data on other minority US populations. Given the total absence of data on these US populations, we estimated the rates for this group on the basis of an unweighted average of the rates found for black, white, and Hispanic subjects. These estimates will therefore have to be revised as more data are collected in these populations. Other recent studies from Asia have findings that may be relevant to US populations. We have chosen not to include data from Chinese populations in Singapore and elsewhere, as US census data do not clearly distinguish among the different Asian populations.

## CONCLUSIONS

This report gives the best available estimate for the magnitude of the problem of OAG in the United States based on a meta-analysis of population-based data. The number of US population affected by OAG is large, including more than 2 million people at present, and the aging population will increase this substantially in the years to come. Previous work indicates that more than half of these individuals are unaware that they have the disease and will likely suffer unnecessary vision loss. Better detection and effective, safe, and early interventions are needed to minimize the impact that glaucoma will have on our aging population.

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