

Prevalence of Age-Related Macular Degeneration in the United States

The Eye Diseases Prevalence Research Group*

Objective: To estimate the prevalence and distribution of age-related macular degeneration (AMD) in the United States by age, race/ethnicity, and gender.

Methods: Summary prevalence estimates of drusen ≥ 125 μm or larger, neovascular AMD, and geographic atrophy were prepared separately for black and white persons 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 drusen and AMD.

Results: The overall prevalence of neovascular AMD and/or geographic atrophy in the US population 40 years and older is estimated to be 1.47% (95% confidence interval, 1.38%-

1.55%), with 1.75 million citizens having AMD. The prevalence of AMD increased dramatically with age, with more than 15% of the white women older than 80 years having neovascular AMD and/or geographic atrophy. More than 7 million individuals had drusen measuring ≥ 125 μm or larger and were, therefore, at substantial risk of developing AMD. Owing to the rapidly aging population, the number of persons having AMD will increase by 50% to 2.95 million in 2020. Age-related macular degeneration was far more prevalent among white than among black persons.

Conclusion: Age-related macular degeneration affects more than 1.75 million individuals in the United States. Owing to the rapid aging of the US population, this number will increase to almost 3 million by 2020.

Arch Ophthalmol. 2004;122:564-572

*The Writing Group members for The Eye Diseases Prevalence Research Group who had complete access to the raw data needed for this report and who bear authorship responsibility for this report are David S. Friedman, MD, MPH (chairperson); Benita J. O'Colmain, MPH; Beatriz Muñoz, PhD; Sandra C. Tomany, MA; Cathy McCarty; Paulus T. V. M. de Jong, MD, PhD; Barbara Nemesure, PhD; Paul Mitchell, MD, PhD; John Kempen, MD, PhD; and Nathan Congdon, MD, MPH. The Writing Group for this article has no relevant financial interest in this article. A complete list of the members of the Eye Diseases Prevalence Research Group appears on page 571. A complete list of the affiliations for the Writing Group appears on page 572.

AGE-RELATED MACULAR DEGENERATION (AMD) is the leading cause of blindness among European-descended people older than 65 years.¹⁻⁶ While individual studies have arrived at estimates of both early AMD and more severe stages of the disease (advanced AMD), the numbers of persons identified with AMD, and the numbers of individuals in the oldest age groups are frequently small, yielding somewhat unstable estimates.

Recent research has demonstrated that the likelihood of vision loss from AMD can be reduced in individuals with high-dose vitamin supplementation⁷ and can be reduced with laser photocoagulation and photodynamic therapy in others with neovascular (NV) forms of the disease.⁸⁻¹¹ However, the reduction in visual loss using these treatments for persons with geographic atrophy (GA) and for most persons with NV AMD is limited. Policy planners require solid estimates of disease prevalence to determine the likely benefit of these and future therapies. This study

was undertaken to determine more accurately the prevalence of intermediate and advanced AMD in the United States by pooling findings from large population-based studies that have been conducted over the last 2 decades and applying the prevalence rates to the US population. Furthermore, we have estimated the expected increase in AMD in the future.

METHODS

DEFINITIONS

We focused on obtaining accurate estimates of the prevalence of NV AMD and GA as well as the presence of large drusen (ie, those ≥ 125 μm). Given the large overlap of pigmentary changes with large drusen, and data that show that large drusen are associated with an almost 6% risk of developing advanced AMD over 5 years in the involved eye (Ronald Klein, MD, MPH, written communication, September 16, 2002), and because it had been measured in all of the populations, we chose to look at large drusen as a manifestation of intermediate AMD. Therefore, the definitions used for this study are as follows.

Table 1. Studies Included in Estimates of Age-Related Macular Degeneration (AMD) Prevalence*

Variable	BES (n = 4361)†	Barbados (n = 3413)†	BDES (n = 4752)†	BMES (n = 3632)†	RS (n = 6774)†	SEE Project (n = 2387)†	Melbourne VIP (n = 4339)†
Years study conducted	1985-1988	1988-1992	1988-1990	1992-1994	1990-1993	1993-1995	1991-1998
Age, y							
40-49	24.3	34.2	17.2	NA	NA	NA	27.1
50-54	12.9	14.2	14.0	12.7	NA	NA	14.6
55-59	13.6	14.3	13.3	14.7	17.6	NA	14.2
60-64	15.0	12.6	14.0	17.6	21.1	NA	13.4
65-69	14.6	10.4	14.2	18.5	19.4	30.8	11.6
70-74	10.7	7.9	12.0	14.8	16.6	33.6	9.4
75-79	5.6	4.4	8.9	11.6	12.5	22.0	5.5
≥80	3.2	1.9	6.4	10.0	12.9	13.7	4.3
Gender							
Female	59.7	57.3	55.8	56.7	59.3	57.3	53.4
Male	40.3	42.7	44.2	43.3	40.7	42.7	46.6
Race/ethnicity							
Black	42.3	100.0	NA	NA	NA	25.7	NA
Hispanic	NA	NA	NA	NA	NA	NA	NA
White	57.7	NA	100.0	100.0	100.0	74.3	100.0
Crude prevalence							
Advanced AMD‡	0.80	0.59	1.64	2.06	1.65	2.85	0.69
NV AMD	0.49	0.48	1.20	1.35	0.95	1.55	0.41
GA AMD	0.50	0.12	0.66	1.16	0.69	1.44	0.28
Drusen in 1 eye§	5.80		10.31	5.35	6.54	6.15	4.07
Drusen in both eyes§	1.38		4.88	2.73	3.55	3.23	2.19

Abbreviations: Barbados, Barbados Eye Study, Barbados, West Indies; BDES, Beaver Dam Eye Study, Beaver Dam, Wis; BES, Baltimore Eye Survey, Baltimore, Md; BMES, Blue Mountains Eye Study, Sydney, New South Wales, Australia; Melbourne VIP, Vision Impairment Project, Melbourne, Victoria, Australia; NA, not applicable; NV, neovascular; RS, Rotterdam Study, Rotterdam, the Netherlands; SEE Project, Salisbury Eye Evaluation Project, Salisbury, Md.

*Data are given as percentages of persons unless otherwise indicated.

†Note that the number of participants reported for each study in this table reflects the number contributing to our estimates in the current article and not necessarily the total number of participants in the original study published.

‡Advanced AMD indicates NV or GA AMD in either eye.

§Drusen indicates the presence of at least 1 druse 125 µm or larger in diameter in either or both eyes.

||Data for drusen of 125 µm or larger in diameter are unavailable.

Age-related macular degeneration is defined as that named AMD by the International ARM Study Group, and includes the following 2 groups¹²: (1) those with GA, which is a discrete area of retinal depigmentation at least 175 µm in diameter with a sharp border and visible choroidal vessels in the absence of NV AMD in the same eye; and (2) those with NV AMD, which is serous or hemorrhagic detachment of either the retinal pigment epithelium or sensory retina, the presence of subretinal fibrous tissue, or minimal subretinal fibrosis and widespread retinal pigment epithelial atrophy. Or it is any AMD that represents the presence of GA or NV AMD in either eye.

Subjects were classified as having GA if either eye had GA. Similarly, subjects were classified as having NV AMD if either eye had NV, so some individuals were counted in both categories of AMD. Therefore, estimates for any AMD will be lower than the combined total of estimates for NV AMD and GA.

Large drusen were defined as drusen 125 µm or larger in diameter in the macula (defined as a region 3000 µm in diameter centered on the foveola) in either or both eyes.

INCLUSION CRITERIA FOR STUDIES

To be included in the present research, the studies contributing data had to (1) be population based, (2) provide data on the conditions being studied; and (3) use a standard photographic grading system for determining the prevalence of AMD and drusen. Since these studies were conducted when no preventive treatments were available for AMD, all known studies meeting these criteria (both published and unpublished) were included. These include the Baltimore Eye Survey, Baltimore, Md¹³; the Barbados Eye Study, Barbados, West Indies¹⁴; the Bea-

ver Dam Eye Study, Beaver Dam, Wis¹⁵; the Blue Mountains Eye Study, Sydney, New South Wales, Australia¹⁶; the Rotterdam Study, Rotterdam, the Netherlands¹⁷; the Melbourne Vision Impairment Project, Melbourne, Victoria, Australia¹⁸; and the Salisbury Eye Evaluation Project, Salisbury, Md¹⁹ (**Table 1**). The Baltimore Eye Survey enrolled 5308 black and white persons (75% of the intended population), 19% of whom had no gradable photographs for AMD.¹³ The Barbados Eye Study enrolled 4314 black persons (84% of the intended population), 17% of whom had no photographs gradable for AMD.¹⁴ The Beaver Dam Eye Study enrolled 4926 subjects (83% of the intended population, 4896 of whom were white), 2% of whom had no gradable photographs for AMD.¹⁵ The Blue Mountains Eye Study enrolled 3654 white persons (82% of the eligible population), 2% of whom had no gradable photographs for AMD.¹⁶ The Rotterdam Study had 6872 persons visit the study center (67% of the intended population), 0.9% of whom had no gradable photographs for AMD.¹⁷ The Salisbury Eye Evaluation Project enrolled 65% of the eligible population (all persons were ≥65 years), 2% of whom had no gradable photographs.¹⁹ The Melbourne Vision Impairment Project enrolled 4345 (92% of the eligible population) of 4744 persons.¹⁸

STATISTICAL ANALYSIS

The investigators from each study provided us with the number of individuals with gradable photographs in at least 1 eye and the number found to have NV AMD, GA, or any AMD in at least 1 eye, and at least 1 large druse in 1 or both eyes stratified by gender and race for groups aged 40 through 44, 45 through 49, 50 through 54, 55 through 59, 60 through 64, 65

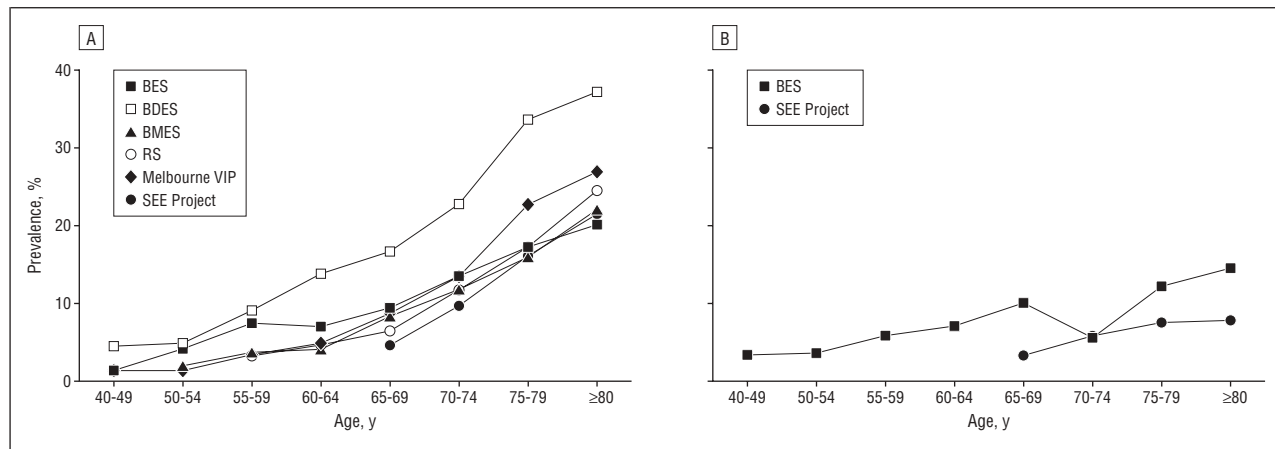


Figure 1. Prevalence of drusen 125 μm or larger in diameter in white (A) and black (B) persons according to study and age groups. BES indicates Baltimore Eye Survey, Baltimore, Md; BEDS, Beaver Dam Eye Study, Beaver Dam, Wis; BMES, Blue Mountains Eye Study, Sydney, New South Wales, Australia; RS, the Rotterdam Study, Rotterdam, the Netherlands; SEE, Salisbury Eye Evaluation Project, Salisbury, Md; and VIP, Vision Impairment Project, Melbourne, Victoria, Australia.

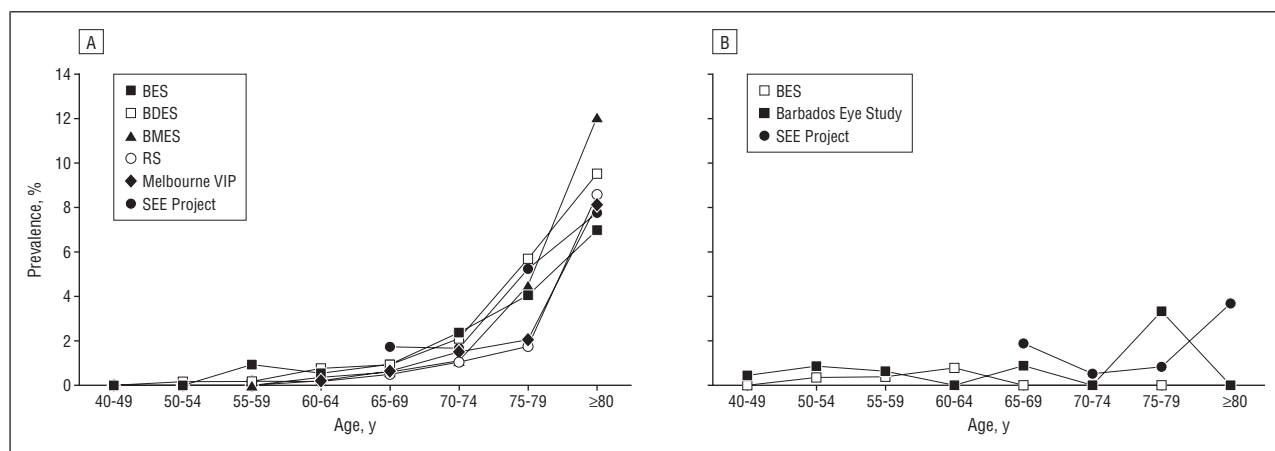


Figure 2. Prevalence of advanced age-related macular degeneration in white (A) and black (B) persons according to study and age groups. Advanced age-related macular degeneration is defined as the presence of neovascular age-related macular degeneration or geographic atrophy in either eye. BES indicates Baltimore Eye Survey, Baltimore, Md; BEDS, Beaver Dam Eye Study, Beaver Dam, Wis; BMES, Blue Mountains Eye Study, Sydney, New South Wales, Australia; RS, the Rotterdam Study, Rotterdam, the Netherlands; SEE, Salisbury Eye Evaluation Project, Salisbury, Md; and VIP, Vision Impairment Project, Melbourne, Victoria, Australia. The Barbados Eye Study was conducted in Barbados, West Indies.

through 69, 70 through 74, 75 through 79, 80 through 84, 85 through 89 years, and 90 years and older.

Age-Specific Prevalence Estimates

The age-specific prevalence proportions were derived in 2 steps. First, pooled prevalence proportions were estimated for each race/ethnic-, 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 estimated assuming the binomial distribution. Second, logistic regression models were fit to the pooled prevalence proportions using the midpoint of each age interval as the independent variable. Models were fit separately by gender for GA, NV AMD, any AMD, and the presence of drusen in white persons. Prevalence rates for drusen in the Beaver Dam Eye Study were significantly higher (**Figure 1**) than those found in the other studies and, thus, were excluded from the pooled prevalence estimates for drusen in white persons.

Age and race/ethnicity effects in the models were tested using the Wald χ^2 test statistic. Odds ratios for gender differences were based on Mantel-Haenszel χ^2 tests for the 2×2 tables of observed rates, adjusting for age and the study effect.

Owing to the few cases of AMD in black persons, models were only fit for any AMD and drusen. Age-specific prevalence rates for NV AMD and GA in black persons were estimated by applying a constant factor to the modeled age-specific rates for any AMD. These factors (0.73 for NV AMD and 0.27 for GA in women, and 0.59 for NV AMD and 0.41 for GA in men) were based on the observed proportion of all individuals with AMD who were identified with either GA or NV AMD in either eye. Prevalence rates for NV AMD, GA, any AMD, and drusen in Hispanic persons and other races/ethnicities were assumed to be similar to rates found in black persons.

Estimates of Prevalence in the United States

The number of cases of AMD in the United States in each race/ethnicity, 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 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. Esti-

Table 2. Prevalence Rates for Advanced Age-Related Macular Degeneration (AMD) and Presence of Drusen of 125 µm or Larger in Diameter by Age, Gender, and Race/Ethnicity

Gender and Age, y	Prevalence per 100 Individuals (95% CI)			
	Any AMD	NV AMD	GA AMD	Drusen ≥125 µm*
White Participants				
Females				
40-49	NA	NA	NA	1.41 (1.24-1.60)
50-54	0.20 (0.17-0.24)	0.14 (0.10-0.19)	0.11 (0.09-0.13)	2.52 (2.29-2.78)
55-59	0.22 (0.20-0.24)	0.16 (0.14-0.19)	0.12 (0.11-0.13)	3.70 (3.41-4.00)
60-64	0.35 (0.33-0.39)	0.26 (0.20-0.30)	0.19 (0.17-0.21)	5.39 (5.03-5.78)
65-69	0.70 (0.64-0.76)	0.51 (0.45-0.59)	0.37 (0.34-0.40)	7.81 (7.30-8.34)
70-74	1.52 (1.41-1.64)	1.09 (0.96-1.24)	0.81 (0.74-0.88)	11.17 (10.39-12.00)
75-79	3.44 (3.22-3.69)	2.40 (2.14-2.70)	1.85 (1.72-1.99)	15.73 (14.48-17.06)
≥80	16.39 (14.97-17.91)	11.07 (9.46-12.91)	9.37 (8.53-1.29)	29.16 (26.34-32.15)
Males				
40-49	NA	NA	NA	1.56 (1.27-1.90)
50-54	0.34 (0.23-0.50)	0.23 (0.16-0.33)	0.15 (0.11-0.21)	2.65 (2.28-3.08)
55-59	0.41 (0.34-0.50)	0.28 (0.23-0.34)	0.22 (0.19-0.26)	3.77 (3.33-4.26)
60-64	0.63 (0.53-0.75)	0.42 (0.36-0.50)	0.37 (0.32-0.43)	5.32 (4.79-5.92)
65-69	1.08 (0.91-1.29)	0.73 (0.61-0.87)	0.66 (0.56-0.76)	7.48 (6.74-8.28)
70-74	1.98 (1.69-2.32)	1.33 (1.14-1.56)	1.19 (1.04-1.37)	10.40 (9.29-11.63)
75-79	3.97 (3.18-4.24)	2.49 (2.15-2.88)	2.16 (1.91-2.46)	14.30 (12.55-16.25)
≥80	11.90 (9.78-14.41)	8.29 (6.76-1.12)	6.60 (5.52-7.89)	25.62 (21.69-29.98)
Black Participants				
Females				
40-49	0.50 (0.40-0.63)	0.50 (0.40-0.63)	NA	3.01 (2.41-3.76)
50-54	0.68 (0.57-0.80)	0.49 (0.41-0.59)	0.19 (0.15-0.22)	4.03 (3.41-4.75)
55-59	0.82 (0.71-0.96)	0.60 (0.52-0.70)	0.22 (0.19-0.26)	4.88 (4.26-5.59)
60-64	1.00 (0.86-1.15)	0.73 (0.63-0.84)	0.27 (0.23-0.31)	5.91 (5.25-6.63)
65-69	1.21 (1.04-1.42)	0.89 (0.76-1.03)	0.32 (0.28-0.38)	7.13 (6.35-7.99)
70-74	1.47 (1.23-1.76)	1.08 (0.90-1.28)	0.39 (0.33-0.48)	8.58 (7.53-9.75)
75-79	1.79 (1.45-2.21)	1.31 (1.06-1.61)	0.48 (0.39-0.60)	10.29 (8.81-11.98)
≥80	2.44 (1.85-3.20)	1.78 (1.35-2.33)	0.66 (0.50-0.86)	13.66 (11.14-16.64)
Males				
40-49	0.31 (0.16-0.60)	0.31 (0.16-0.60)	NA	3.90 (2.79-5.43)
50-54	0.42 (0.25-0.70)	0.25 (0.15-0.41)	0.17 (0.10-0.29)	4.71 (3.67-6.03)
55-59	0.52 (0.33-0.80)	0.30 (0.20-0.47)	0.22 (0.14-0.33)	5.34 (4.35-6.53)
60-64	0.63 (0.42-0.95)	0.37 (0.25-0.56)	0.26 (0.17-0.39)	6.04 (5.06-7.19)
65-69	0.77 (0.50-1.18)	0.45 (0.29-0.70)	0.32 (0.20-0.48)	6.82 (5.73-8.11)
70-74	0.93 (0.57-1.53)	0.55 (0.33-0.91)	0.38 (0.23-0.63)	7.71 (6.32-9.37)
75-79	1.14 (0.63-2.05)	0.67 (0.37-1.21)	0.47 (0.26-0.84)	8.69 (6.84-10.97)
≥80	1.56 (0.72-3.35)	0.92 (0.42-1.98)	0.67 (0.29-1.38)	10.50 (7.63-14.29)

Abbreviations: CI, confidence interval; GA, geographic atrophy; NA, not applicable; NV, neovascular.
 *At least 1 druse 125 µm or larger in diameter must be present in either or both eyes.

mates for AMD in Western Europe and Australia were based on applying the age- and gender-specific rates found in white persons to their respective populations 40 years and older.

RESULTS

WHITE PERSONS

Pooled data for European-descended individuals from the Baltimore Eye Survey, the Blue Mountains Eye Study, the Beaver Dam Eye Study, the Rotterdam Study, the Melbourne Vision Impairment Project, and for those older than 65 years from the Salisbury Eye Evaluation Project found a strong age-related increase in the prevalence of large drusen, GA, NV AMD, and any AMD (Figure 1 and **Figure 2**). There were dramatic increases in rates for both men and women older than 80 years, with models showing a highly significant quadratic term for age. Of

white females in the 50- through 54-year-old range, 0.20% had AMD vs 1.52% of those aged 70 through 74 years and 16.39% of those older than 80 years (**Table 2**). Geographic atrophy was slightly less prevalent than NV AMD in all age groups. While large drusen were present in more than 1% of those aged 40 through 49 years, no cases of AMD were found in any of the studies for white persons in this age group. Rates were similar between men and women (age-adjusted odds ratio [OR] for men=1.01; 95% confidence interval [CI], 0.81-1.25).

BLACK PERSONS

Pooled data for black persons were derived from 3 studies—the Barbados Eye Study, the Baltimore Eye Survey, and the Salisbury Eye Evaluation Project. Drusen prevalence was strongly age related, while the prevalence of AMD increased less dramatically with age (Table 2). Black

Table 3. Estimated Prevalence of Advanced Age-Related Macular Degeneration in the United States by Age, Gender, and Race/Ethnicity

Age, y	No. of Cases (in Thousands)		Total US Population*	
	White Participants	Black Participants	No. of Cases (in Thousands) (95% CI)	Prevalence per 100 Individuals (95% CI)
Female Participants				
40-49	NA	13	13 (10-16)	0.06 (0.05-0.07)
50-54	14	6	29 (26-31)	0.32 (0.29-0.35)
55-59	12	6	25 (23-27)	0.36 (0.33-0.38)
60-64	16	6	28 (27-30)	0.50 (0.47-0.53)
65-69	29	6	42 (39-44)	0.81 (0.76-0.87)
70-74	63	6	76 (71-81)	1.53 (1.44-1.63)
75-79	129	6	141 (132-149)	3.22 (3.02-3.42)
≥80	801	11	821 (743-899)	13.41 (12.14-14.68)
Subtotal	1064	60	1175 (1096-1253)	1.84 (1.72-1.97)
Male Participants				
40-49	NA	7	7 (2-12)	0.03 (0.01-0.06)
50-54	23	3	31 (22-40)	0.36 (0.26-0.46)
55-59	21	3	28 (24-33)	0.43 (0.36-0.50)
60-64	26	3	32 (28-37)	0.63 (0.54-0.72)
65-69	39	3	45 (38-52)	1.03 (0.87-1.19)
70-74	65	3	71 (60-81)	1.81 (1.54-2.08)
75-79	95	2	100 (86-114)	3.28 (2.82-3.74)
≥80	254	3	260 (199-322)	8.50 (6.50-10.51)
Subtotal	523	27	574 (510-640)	1.03 (0.92-1.15)
All Participants				
40-49	NA	20	20 (15-26)	0.05 (0.03-0.06)
50-54	37	9	60 (50-69)	0.34 (0.29-0.39)
55-59	33	9	53 (48-58)	0.39 (0.36-0.43)
60-64	42	9	60 (56-66)	0.56 (0.52-0.61)
65-69	68	9	87 (80-94)	0.91 (0.84-0.99)
70-74	128	9	147 (135-158)	1.66 (1.53-1.78)
75-79	224	8	241 (224-257)	3.24 (3.02-3.46)
≥80	1055	14	1081 (982-1181)	11.77 (10.69-12.85)
Total	1587	87	1749 (1647-1852)	1.47 (1.38-1.55)

Abbreviations: CI, confidence interval; NA, not applicable.

*Estimates for the prevalence of advanced age-related macular degeneration in the total US population (based on the US Census 2000) include estimates for Hispanics and other races/ethnicities (ie, Asian, Native American, Alaska Native, Hawaiian and other Pacific Islander, and any other race/ethnicity) and those designating more than 1 race/ethnicity on the US Census 2000 form. These estimates were derived using the modeled age- and gender-specific rates for black participants. The age- and gender-specific estimates for the prevalence of advanced age-related macular degeneration (defined as having neovascular or geographic atrophy age-related macular degeneration in either eye) derived in this way are available at Web site: <http://www.nei.nih.gov/eyedata/>.

women aged 50 through 54 years had a 0.68% prevalence of AMD, which increased to 1.47% for those aged 70 through 74 years and to 2.44% for those aged 80 years and older. Five individuals younger than 50 years (all cases of NV AMD from the Barbados Eye Study) were identified among the 1705 evaluated, even though drusen were present in more than 2% of those in this age range. Although women had higher rates of AMD than men, differences were not statistically significant (age-adjusted OR for men=0.64; 95% CI, 0.31-1.32).

PREVALENCE AND PREDICTED PREVALENCE

Applying age-, race/ethnicity-, and gender-specific rates to the US population as determined in the 2000 US Census, we estimate that 1.75 million individuals (1.47%; 95% CI, 1.38-1.55%; **Table 3**) have AMD, 1.22 million (1.02%; 95% CI, 0.93-1.11%; **Table 4**) have NV AMD in at least 1 eye, 973 000 individuals (0.81%; 95% CI, 0.77-0.86%; **Table 5**) have GA in at least 1 eye, and 7.3 million individuals (6.12%; 95% CI, 5.93-6.31%; **Table 6**) have

large drusen (ie, ≥125 μm in diameter) in either 1 or both eyes (approximately 50% of these individuals have bilateral large drusen). These numbers are estimated to increase substantially in the coming decades. The number of individuals in the United States with AMD is estimated to increase more than 50% from 1.75 million in 2000 to 2.95 million in 2020. Applying the age-, race/ethnicity-, and gender-specific rates, Australia is estimated at present to have 130 000 cases of AMD; Western Europe has 3.35 million cases of AMD. Applying the higher rates for the prevalence of large drusen found in the Beaver Dam Eye Study, we would expect an additional 6.4 million white individuals in the United States to have large drusen in either 1 or both eyes.

COMMENT

From pooled data from population-based eye diseases prevalence studies, we estimate that, at present, 1.75 million individuals in the United States have either GA or NV AMD in at least 1 eye. Approximately 7.3 million persons are es-

Table 4. Estimated Prevalence of Neovascular Age-Related Macular Degeneration in the United States by Age, Gender, and Race/Ethnicity

Age, y	No. of Cases (in Thousands)		Total US Population*	
	White Participants	Black Participants	No. of Cases (in Thousands) (95% CI)	Prevalence per 100 Individuals (95% CI)
Female Participants				
40-49	NA	13	13 (10-16)	0.06 (0.05-0.07)
50-54	10	5	20 (17-23)	0.22 (0.18-0.25)
55-59	9	4	18 (16-19)	0.25 (0.23-0.28)
60-64	12	4	20 (19-22)	0.36 (0.33-0.39)
65-69	21	4	30 (27-33)	0.59 (0.53-0.65)
70-74	45	5	54 (49-60)	1.10 (0.98-1.21)
75-79	90	4	99 (88-109)	2.25 (2.02-2.49)
≥80	556	8	570 (479-662)	9.31 (7.82-10.81)
Subtotal	743	47	824 (731-916)	1.29 (1.15-1.44)
Male Participants				
40-49	NA	7	7 (2-12)	0.03 (0.01-0.06)
50-54	15	2	20 (14-26)	0.23 (0.17-0.30)
55-59	14	2	18 (15-21)	0.28 (0.24-0.33)
60-64	17	2	21 (18-24)	0.41 (0.35-0.47)
65-69	26	2	30 (25-35)	0.68 (0.58-0.79)
70-74	44	2	47 (40-54)	1.21 (1.00-1.43)
75-79	64	1	67 (58-77)	2.21 (1.90-2.53)
≥80	178	2	181 (137-226)	5.92 (4.47-7.37)
Subtotal	358	20	391 (346-440)	0.71 (0.62-0.79)
All Participants				
40-49	NA	20	20 (15-26)	0.05 (0.03-0.06)
50-54	25	7	40 (33-46)	0.23 (0.19-0.26)
55-59	23	6	36 (33-39)	0.27 (0.24-0.29)
60-64	29	6	41 (38-45)	0.38 (0.35-0.42)
65-69	47	6	60 (55-66)	0.63 (0.57-0.69)
70-74	89	7	101 (92-111)	1.15 (1.04-1.25)
75-79	154	5	166 (152-180)	2.24 (2.05-2.43)
≥80	734	10	751 (650-853)	8.18 (7.07-9.29)
Total	1101	67	1215 (1113-1320)	1.02 (0.93-1.11)

Abbreviations: CI, confidence interval; NA, not applicable.

*Estimates for the prevalence of advanced age-related macular degeneration in the total US population (based on the US Census 2000) include estimates for Hispanics and other races/ethnicities (ie, Asian, Native American, Alaska Native, Hawaiian and other Pacific Islander, and any other race/ethnicity) and those designating more than 1 race/ethnicity on the US Census 2000 form. These estimates were derived using the modeled age- and gender-specific rates for black participants. The age- and gender-specific estimates for the prevalence of advanced age-related macular degeneration (defined as having neovascular or geographic atrophy age-related macular degeneration in either eye) derived in this way are available at Web site: <http://www.nei.nih.gov/eyedata/>.

estimated to have the early stages of AMD defined by large retinal drusen in at least 1 eye. Individuals with at least 1 druse of 125 μm or larger in diameter had a 5.8% risk of progressing to advanced AMD in the same eye over 5 years in the Beaver Dam Eye Study (Ronald Klein, MD, PhD, written communication, September 16, 2002), indicating that they are, indeed, at high risk. Similar rates were recently published in the Rotterdam Study in which eyes with fewer than 10 drusen 125 μm or larger in diameter had a 5-year risk of GA of 2% and of NV AMD of 1%. Those with 10 drusen or more had a 14% risk for both GA and NV AMD.²⁰ We estimate that 2.95 million persons in the United States will have AMD in 2020. It is unknown what the effect of high-dose vitamin supplementation using a combination of zinc, beta-carotene, and vitamins C and E will be on these projected rates.⁷

Age-related macular degeneration is associated with severe reductions in quality of life as documented by clinical depression in almost one third of those who have this condition.²¹ Among individuals who have vision loss from AMD, 60% report significant declines in their ability to

participate in valued activities.²² Greater access to and use of rehabilitative services for those with irretrievable vision loss will be needed as advanced AMD affects a growing number of older Americans.

The current 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 persons 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 receiving a free eye examination.

A second limitation is the lack of gradable photographs. The number of ungradable photographs was higher in the 3 studies of black persons. The cameras used were different in those studies. While this higher rate of ungradable photographs may be attributable to cataract, it is also possible that those with poor central vision were harder to image, which would have led to un-

Table 5. Estimated Prevalence of Geographic Atrophy Age-Related Macular Degeneration in the United States by Age, Gender, and Race/Ethnicity

Age, y	No. of Cases (in Thousands)		Total US Population*	
	White Participants	Black Participants	No. of Cases (in Thousands) (95% CI)	Prevalence per 100 Individuals (95% CI)
Female Participants				
40-49	NA	NA	NA	NA
50-54	7	2	13 (11-14)	0.14 (0.12-0.15)
55-59	6	2	11 (10-12)	0.16 (0.15-0.17)
60-64	8	2	13 (12-14)	0.23 (0.21-0.24)
65-69	15	2	20 (18-21)	0.39 (0.36-0.42)
70-74	34	2	38 (35-41)	0.77 (0.72-0.83)
75-79	70	2	74 (69-79)	1.69 (1.57-1.80)
≥80	481	3	487 (441-534)	7.96 (7.20-8.72)
Subtotal	621	15	656 (609-702)	1.03 (0.96-1.10)
Male Participants				
40-49	NA	NA	NA	NA
50-54	10	1	14 (10-17)	0.16 (0.12-0.20)
55-59	11	1	14 (12-16)	0.22 (0.19-0.25)
60-64	15	1	18 (16-20)	0.35 (0.30-0.39)
65-69	24	1	26 (23-30)	0.60 (0.52-0.68)
70-74	39	1	42 (36-47)	1.06 (0.92-1.20)
75-79	56	1	58 (51-65)	1.90 (1.67-2.14)
≥80	142	1	145 (114-176)	4.74 (3.72-5.76)
Subtotal	297	7	371 (283-350)	0.57 (0.51-0.63)
All Participants				
40-49	NA	NA	NA	NA
50-54	17	3	27 (22-30)	0.15 (0.13-0.17)
55-59	17	3	25 (23-27)	0.19 (0.17-0.20)
60-64	23	3	31 (28-33)	0.28 (0.26-0.31)
65-69	39	3	46 (42-50)	0.48 (0.44-0.52)
70-74	73	3	80 (74-86)	0.90 (0.83-0.97)
75-79	126	3	132 (123-141)	1.78 (1.66-1.90)
≥80	623	4	632 (576-689)	6.89 (6.28-7.50)
Total	918	22	973 (915-1029)	0.81 (0.77-0.86)

Abbreviations: CI, confidence interval; NA, not applicable.

*Estimates for the prevalence of advanced age-related macular degeneration in the total US population (based on the US Census 2000) include estimates for Hispanics and other races/ethnicities (ie, Asian, Native American, Alaska Native, Hawaiian and other Pacific Islander, and any other race/ethnicity) and those designating more than 1 race/ethnicity on the US Census 2000 form. These estimates were derived using the modeled age- and gender-specific rates for black participants. The age- and gender-specific estimates for the prevalence of advanced age-related macular degeneration (defined as having neovascular or geographic atrophy age-related macular degeneration in either eye) derived in this way are available at Web site: <http://www.nei.nih.gov/eyedata/>.

derestimates in these populations. The Baltimore Eye Survey documented that those who were blind from AMD were less likely to have gradable photographs.¹³

A third important limitation is the lack of data on other minority US populations. For black persons the data in the younger ages were limited, and the numbers studied in the older age ranges were not particularly large. To date there are few data that provide stable estimates of AMD prevalence in Hispanic persons. In the National Health and Examination Survey (NHANES) III, rates were based on 1 photograph of 1 eye of each subject. Age-related macular degeneration was present in 0.5% of non-Hispanic white persons, 0.13% of non-Hispanic black persons, and 0.06% of Mexican Americans 40 years or older.²³ In the San Luis Valley Study, San Luis Valley, Colo, of the 571 Hispanic persons aged 43 through 74 years living in Colorado sampled for the study, the prevalence of early maculopathy (pigmentary changes and/or soft drusen) was 10%, slightly lower than that found for white persons (14%, $P < .05$), but AMD was found in only person.²⁴ Both of these studies suggest a low rate of AMD in

Hispanic persons compared with white and black persons. Based on these articles, it is possible that our estimates of AMD in Hispanic persons and those of other races/ethnicities, which assume the same prevalence rates as black persons, may overestimate the number of individuals with AMD in these populations. However, a recent report from Arizona near the Mexican border found that AMD was the second leading cause of visual impairment in that Hispanic American population, indicating that we may have underestimated AMD prevalence in this population.²⁵ These estimates will need to be updated as prevalence surveys are published in these populations. Caution must be taken in using our data to compare rates between racial/ethnic groups.

Fourth, differential misclassification may affect the estimated rates of AMD in black persons. For example, it is possible that eyes with polypoidal choroidopathy may be incorrectly classified as NV AMD in black persons compared with white persons, a possible explanation for the higher rates in younger blacks compared with younger whites.

Table 6. Estimated Prevalence of Drusen of 125 μ m or Larger in Diameter* in the United States by Age, Gender, and Race/Ethnicity

Age, y	No. of Cases (in Thousands)		Total US Population†	
	White Participants	Black Participants	No. of Cases (in Thousands) (95% CI)	Prevalence per 100 Individuals (95% CI)
Female Participants				
40-49	222	78	399 (365-432)	1.85 (1.70-2.01)
50-54	171	38	257 (238-276)	2.86 (2.65-3.07)
55-59	199	34	274 (257-291)	3.94 (3.69-4.19)
60-64	237	34	311 (294-328)	5.48 (5.18-5.79)
65-69	318	35	393 (371-415)	7.65 (7.23-8.08)
70-74	453	37	529 (496-562)	10.67 (10.00-11.34)
75-79	580	34	647 (599-695)	14.80 (13.70-15.91)
\geq 80	1432	63	1544 (1389-1699)	25.22 (22.69-27.75)
Subtotal	3612	353	4354 (4180-4526)	6.83 (6.56-7.11)
Male Participants				
40-49	238	88	452 (395-508)	2.15 (1.88-2.42)
50-54	172	38	262 (232-292)	3.05 (2.70-3.40)
55-59	189	31	260 (234-286)	4.00 (3.60-4.39)
60-64	211	28	274 (250-298)	5.34 (4.87-5.80)
65-69	260	25	316 (287-344)	7.17 (6.53-7.81)
70-74	329	22	377 (339-416)	9.67 (8.68-10.66)
75-79	359	17	396 (348-445)	13.02 (11.44-14.61)
\geq 80	578	21	620 (510-730)	20.25 (16.65-23.85)
Subtotal	2336	270	2957 (2809-3106)	5.31 (5.04-5.58)
All Participants				
40-49	460	166	851 (784-916)	2.00 (1.84-2.15)
50-54	343	76	519 (484-555)	2.95 (2.75-3.16)
55-59	388	65	534 (504-565)	3.97 (3.74-4.20)
60-64	448	62	585 (555-614)	5.41 (5.14-5.69)
65-69	578	60	709 (673-744)	7.43 (7.06-7.80)
70-74	782	59	906 (855-957)	10.23 (9.66-10.80)
75-79	939	51	1043 (975-1112)	14.07 (13.15-14.99)
\geq 80	2010	84	2164 (1974-2354)	23.56 (21.49-25.63)
Total	5948	623	7311 (7083-7539)	6.12 (5.93-6.31)

Abbreviations: CI, confidence interval; NA, not applicable.

*At least 1 druse 125 μ m or larger in diameter must be present in either or both eyes.

†Estimates for the prevalence of advanced age-related macular degeneration in the total US population (based on the US Census 2000) include estimates for Hispanics and other races/ethnicities (ie, Asian, Native American, Alaska Native, Hawaiian and other Pacific Islander, and any other race/ethnicity) and those designating more than 1 race/ethnicity on the US Census 2000 form. These estimates were derived using the modeled age- and gender-specific rates for black participants. The age- and gender-specific estimates for the prevalence of advanced age-related macular degeneration (defined as having neovascular or geographic atrophy age-related macular degeneration in either eye) derived in this way are available at Web site: <http://www.nei.nih.gov/eyedata/>.

Members of the Eye Diseases Prevalence Research Group

The members of The Eye Diseases Prevalence Research Group are as follows: *The Baltimore Eye Survey, Baltimore, Md*: James M. Tielsch; Alfred Sommer; Joanne Katz; David S. Friedman; Harry A. Quigley. *The Barbados Eye Studies, Barbados, West Indies*: M. Cristina Leske; Suh-Yuh Wu; Barbara Nemesure; Anselim Hennis; Leslie Hyman; Andrew Schachat. *Beaver Dam Eye Study, Beaver Dam, Wis*: Barbara E. K. Klein; Ronald Klein; Kristine E. Lee; Scot E. Moss; Sandra C. Tomany. *Blue Mountains Eye Study, Sydney, New South Wales, Australia*: Paul Mitchell; Jie Jin Wang; Elena Rochtchina; Wayne Smith; Robert G. Cumming; Karin Attebo; Jai Panchapakesan; Suriya Foran. *The Melbourne Visual Impairment Project, Melbourne, Victoria, Australia*: Hugh R. Taylor; Cathy McCarty; Bickol Mukesh; LeAnn M. Weih; Patricia M. Livingston; Mylan Van Newkirk; Cara L. Fu; Peter Dimitrov; Matthew Wensor. *Proyecto VER (Vision Evaluation Research), Nogales and Tucson, Ariz*: Sheila West; Beatriz Muñoz; Jorge Rodriguez (deceased); Aimee Broman; Daniel Finklestein; Robert Snyder. *Rotterdam Study, Rotterdam, the Netherlands*: Paulus T. V. M. de Jong; Johannes R. Vingerling; Roger C. W. Wolfs; Caroline C. W. Klaver; Albert Hofman; Redmer van Leeuwen; M. Kamran Ikram; Simone de Voogd. *Salisbury Eye Evaluation Project, Salisbury, Md*: Sheila West; Gary Rubin; Karen Bandeen Roche; Beatriz Muñoz; Kathy Turano; Oliver D. Schein; Donald Duncan.

CONCLUSIONS

This article gives the best available estimate for the magnitude of the problem of AMD in the United States based

on a meta-analysis of population-based data. The number of US population affected by AMD is increasing as the population ages. More than 1 in 10 white individuals 80 years and older has advanced AMD. A deter-

mined effort to identify effective preventive strategies will be needed if we are to avoid a large increase in the numbers of persons having this condition.

Submitted for publication June 26, 2003; final revision received October 31, 2003; accepted December 8, 2003.

From the Dana Center for Preventive Ophthalmology, Wilmer Eye Institute, Johns Hopkins University, Baltimore, Md (Drs Friedman, Muñoz, Kempen, and Congdon); Department of Epidemiology and Biostatistics, School of Public Health and Health Services, George Washington University Medical Center, Washington, DC (Ms O'Colmain); Macro International, Inc, Calverton, Md (Ms O'Colmain); Department of Ophthalmology and Visual Science, University of Wisconsin, Madison (Ms Tomany); the Centre for Eye Research Australia, University of Melbourne, East Melbourne, Victoria (Ms McCarty); Ophthalmogenetics, The Netherlands Ophthalmic Research Institute KNAW, Amsterdam (Dr de Jong); Department of Epidemiology and Biostatistics, Erasmus Medical Center, Rotterdam, the Netherlands (Dr de Jong); Department of Ophthalmology, Academic Medical Center, Amsterdam, the Netherlands (Dr de Jong); Department of Preventive Medicine, School of Medicine, Stony Brook University, Stony Brook, NY (Dr Nemesure); and Department of Ophthalmology, University of Sydney, Sydney, New South Wales, Australia; Centre for Vision Research, Westmead Hospital, Westmead, New South Wales, Australia (Dr Mitchell).

Dr Friedman is supported in part by the Robert E. McCormick Award from Research to Prevent Blindness Inc, New York, NY.

Corresponding author: David S. Friedman, MD, MPH, Wilmer Eye Institute, Wilmer 120, 600 N Wolfe St, Baltimore, MD 21287 (e-mail: david.friedman@jhu.edu).

REFERENCES

1. Sommer A, Tielsch JM, Katz J, et al. Racial differences in the cause-specific prevalence of blindness in east Baltimore. *N Engl J Med*. 1991;325:1412-1417.
2. Klein R, Wang Q, Klein BE, Moss SE, Meuer SM. The relationship of age-related maculopathy, cataract, and glaucoma to visual acuity. *Invest Ophthalmol Vis Sci*. 1995;36:182-191.
3. Klaver CC, Wolfs RC, Vingerling JR, Hofman A, de Jong PT. Age-specific prevalence and causes of blindness and visual impairment in an older population: the Rotterdam Study. *Arch Ophthalmol*. 1998;116:653-658.
4. Wang JJ, Foran S, Mitchell P. Age-specific prevalence and causes of bilateral and unilateral visual impairment in older Australians: the Blue Mountains Eye Study. *Clin Exp Ophthalmol*. 2000;28:268-273.
5. Muñoz B, West SK, Rubin GS, et al. Causes of blindness and visual impairment

- in a population of older Americans: the Salisbury Eye Evaluation Study. *Arch Ophthalmol*. 2000;118:819-825.
6. Weih LM, VanNewkirk MR, McCarty CA, Taylor HR. Age-specific causes of bilateral visual impairment. *Arch Ophthalmol*. 2000;118:264-269.
7. A randomized, placebo-controlled, clinical trial of high-dose supplementation with vitamins C and E, beta-carotene, and zinc for age-related macular degeneration and vision loss: AREDS Report No. 8. *Arch Ophthalmol*. 2001;119:1417-1436.
8. American Academy of Ophthalmology. Photodynamic therapy with verteporfin for age-related macular degeneration. *Ophthalmology*. 2000;107:2314-2317.
9. Bressler NM. Photodynamic therapy of subfoveal choroidal neovascularization in age-related macular degeneration with verteporfin: two-year results of 2 randomized clinical trials: TAP Report 2. *Arch Ophthalmol*. 2001;119:198-207.
10. Macular Photocoagulation Study Group. Laser photocoagulation of subfoveal neovascular lesions of age-related macular degeneration: updated findings from two clinical trials. *Arch Ophthalmol*. 1993;111:1200-1209.
11. Macular Photocoagulation Study Group. Laser photocoagulation of subfoveal neovascular lesions in age-related macular degeneration: results of a randomized clinical trial. *Arch Ophthalmol*. 1991;109:1220-1231.
12. Bird AC, Bressler NM, Bressler SB, et al. An international classification and grading system for age-related maculopathy and age-related macular degeneration: the International ARM Epidemiological Study Group. *Surv Ophthalmol*. 1995;39:367-374.
13. Friedman DS, Katz J, Bressler NM, Rahmani B, Tielsch JM. Racial differences in the prevalence of age-related macular degeneration: the Baltimore Eye Survey. *Ophthalmology*. 1999;106:1049-1055.
14. Schachar AP, Hyman L, Leske MC, Connell AM, Wu SY. Features of age-related macular degeneration in a black population: the Barbados Eye Study Group. *Arch Ophthalmol*. 1995;113:728-735.
15. Klein R, Klein BE, Linton KL. Prevalence of age-related maculopathy: the Beaver Dam Eye Study. *Ophthalmology*. 1992;99:933-943.
16. Mitchell P, Smith W, Attebo K, Wang JJ. Prevalence of age-related maculopathy in Australia: the Blue Mountains Eye Study. *Ophthalmology*. 1995;102:1450-1460.
17. Vingerling JR, Dielemans I, Hofman A, et al. The prevalence of age-related maculopathy in the Rotterdam study. *Ophthalmology*. 1995;102:205-210.
18. Van Newkirk MR, Nanjan MB, Wang JJ, Mitchell P, Taylor HR, McCarty CA. The prevalence of age-related maculopathy: the visual impairment project. *Ophthalmology*. 2000;107:1593-1600.
19. West SK, Muñoz B, Rubin GS, et al. Function and visual impairment in a population-based study of older adults: the SEE Project. *Invest Ophthalmol Vis Sci*. 1997;38:72-82.
20. van Leeuwen R, Klaver CC, Vingerling JR, Hofman A, de Jong PT. The risk and natural course of age-related maculopathy: follow-up at 6½ years in the Rotterdam study. *Arch Ophthalmol*. 2003;121:519-526.
21. Brody BL, Gamst AC, Williams RA, et al. Depression, visual acuity, comorbidity, and disability associated with age-related macular degeneration. *Ophthalmology*. 2001;108:1893-1900.
22. Rovner BW, Casten RJ. Activity loss and depression in age-related macular degeneration. *Am J Geriatr Psychiatry*. 2002;10:305-310.
23. Cruickshanks KJ, Hamman RF, Klein R, Nondahl DM, Shetterly SM. The prevalence of age-related maculopathy by geographic region and ethnicity: the Colorado-Wisconsin Study of Age-Related Maculopathy. *Arch Ophthalmol*. 1997;115:242-250.
24. Klein R, Klein BE, Jensen SC, Mares-Perlman JA, Cruickshanks KJ, Palta M. Age-related maculopathy in a multiracial United States population: the National Health and Nutrition Examination Survey III. *Ophthalmology*. 1999;106:1056-1065.
25. Rodriguez J, Sanchez R, Muñoz B, et al. Causes of blindness and visual impairment in a population-based sample of US Hispanics. *Ophthalmology*. 2002;109:737-743.